Optimizing User Experience in 5G

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1. Executive Summary

Providing a superior user experience (Ux) for wireless customers has become an important consideration for network operators offering competitive wireless services. ATIS' 5G initiative considers unique approaches to the delivery and optimization of services for wireless customers. This report outlines breakthrough use cases related to optimized user experiences and addresses service and ecosystem models that enable them to be delivered. This report also introduces a solution-based approach to enable implementation and delivery of the capabilities identified here. This approach includes end-user opt-in/opt-out and control functions to insure end-user privacy and awareness of how personal data may be used.

In the context of this document, the term "optimized" user experience relates to meaningful improvements in measured user experience that may be achieved by applying the tools and processes described. The scope of this report is focused on user experience measurement based on ratings provided by the user. It is recognized that there are other measurement and optimization techniques beyond the scope of this document that may be applied to assess and improve the user experience of 5G networks.

2. Introduction and Goals

In support of the 5G initiative, ATIS formed a "Breakthrough" Team with the purpose of creating and defining high-level use cases to enhance the ICT Industry's ability to create value and to accelerate the sector's growth and competitive position in the rapidly growing information and content service segments utilizing wireless delivery. The objective of this work was to identify breakthrough approaches to optimize the end user experience without being constrained by limitations of the current generation carrier network architecture, service offerings, and business models.

User Experience as a Foundation for Breakthrough Use Cases

The ability to accurately measure the user experience and use this to improve services offered by the network and the allocation of network resources is at the heart of the breakthrough use cases described in this report.

The breakthrough use cases leverage user experiences in two broad areas:

- Creating value by delivering optimized, world-class user experiences.
- Developing new service and business models via the creation and enablement of expanded collaboration models and broader ecosystems.

What Does Quality of Experience (QoE) Mean?

To optimize Ux, it is important to measure the Quality of Experience (QoE) that end users ***perceive*** they are receiving. Since Ux is inherently subjective, measuring it includes subjective factors. Assessing Ux should use a process including a mix of information that can be directly measured by networks, devices, and applications, along with inferences drawn from applications (e.g., abandoned downloads) and, most importantly, direct input from the end user.

When assessing the QoE that an end user is receiving, such assessments should consider:

- The overall acceptability of services and applications as perceived subjectively by the end user.
- User-centric input and automated measurement mechanisms are needed to determine how well the end-user's expectations are being met.
- The scope of such assessments should include third party applications and content.
- A device presence is essential to successful assessment of QoE.

Assessment of QoE should also include "soft" factors such as:

- Application-centric measures – Availability, responsiveness, infrastructure and device transparency, wasted time factors, etc.
- "Intuitiveness" – How obvious it is to learn and use an application or service.

Assessment of QoE should:

- Take into account each end user's stated priorities for applications and content.
- Be based upon a combination of direct end-user input and data that can be measured or inferred by devices, networks, and applications.
- Be evaluated over target populations of appropriately related users and include direct user input.
- Make use of analytics-based crowdsourcing techniques to identify key trends in both direct end-user input and the correlated data associated with Ux collected via automated means.

To properly determine the end user's perception of QoE, it is also important to understand the impact of multiple parties on the overall perceived QoE including:

- Application providers
- Content service providers
- Network operators

User Experience – An Ecosystem Approach

Successful, end-user-focused experiences have evolved to include enabling end users to select a set of applications, content, and services tailored to their specific needs and interests. As a result, an ecosystem approach covering both content and delivery is essential for market-leading user experiences. The key factors for a sustainable Optimized User Experience (OUx) ecosystem include:

- An anchor in a strong base service set and brand.
- Effective mechanisms for creating and sharing the value created by the Ux ecosystem.
- Willingness to invest in the development of the OUx ecosystem until it becomes sustainable on its own.
- Constant, ongoing development of a rich set of third-party participants to create a wide set of content, applications, and service choices for end users.

Data from End-User Input and Automated Measurements

The collection, analysis, and appropriate anonymization/protection of end-user data are essential factors for the model and associated solution described here to achieve prescribed goals. The most important source of such data is direct input from end users on the Ux that they are receiving in real-time. Collection of this type of data will require a presence on the end-user's device.

Automated measurements will also be used to collect data about the end-user's Ux from multiple sources including:

- End-user devices.
- Applications that run on these devices.
- Service provider networks including supporting infrastructure such as caching systems.
- Third party servers and associated infrastructure on the Internet.

Different types of end-user Ux data outlined above can be combined via analytics to create a ***Crowdsourced View***[1] of the Ux being received by related users. The analytics platform

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[1] The term ***Crowdsourced*** in this document is defined to mean the creation of views of Ux data via analytics directly related to the Ux being delivered to end users and are of direct value to network operators, third-party providers or the individual end user. The data used to create a ***Crowdsourced View*** is a combination of direct end-user input on

associated with the solution (described later in this report) will have the responsibility to group end users into meaningful related groups to create useful crowdsourced views of Ux. Such crowdsourced views should be tailored to recognize the needs of all stakeholders in the OUx ecosystem, including:

- End users.
- Applications providers.
- Content service providers.
- Network operators.

There may be competing objectives among these stakeholders. The perception of who has the primary relationship with the end user and who has access to relevant data about the end user's tastes and usage patterns could be the center of such concerns. Securing the cooperation of all parties to provide the data necessary to create a world class OUx is not an easy task. Creating the level of cooperation necessary to do this requires a combination of investment and business development activities on the part of the OUx ecosystem owner. Later sections of this report address in more detail what is needed to be successful in this ecosystem approach.

Necessary Linkage to Network Evolution and Platforms

The OUx breakthrough use cases will greatly benefit from capabilities more easily deployed using 5G platforms. Some relevant capabilities being discussed for 5G networks include:

- Improved latency and bandwidth performance.
- Peer-to-peer delivery of content.
- The ability to create networks that appear homogenous to end users from a mixture of network elements provided by multiple network operators.
- The capability to optimize access network efficiency through link/path aggregation as well as link selection based upon content and service requirements and volume of data consumed by a particular end user.

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the Ux received in real-time coupled with automated measurements ***that are directly related to the Ux being delivered***. Each scenario involving the use of ***Crowdsourced Views*** will define the mix of direct end-user sourced and end-user related measured data that will be used to make up a specific ***Crowdsourced View***. It is generally expected that direct end-user entered data correlated (which is enhanced with relevant measured data) will create enhanced value compared to ***Crowdsourced Views*** based upon direct end-user input data alone.

- Using cloud-based architectures to dynamically allocate bandwidth, processing, and storage capabilities so they are applied in areas that have the most impact on QoE.

The deployment of the OUx breakthrough use cases and associated models described in this report should not require 5G networks to be in place to begin their realization. Specifically, the target is a minimum platform consisting of a mix of 4G Networks (RAN and Core) and Wi-Fi networks as an initial platform to begin to realize the benefits of the OUx solutions described in this document.

3. Factors that Create and Sustain Value and Competitive Differentiation

An OUx business model and its associated ecosystem must create sustainable value growth to be successful. Essential factors for value creation include:

- Encompassing a scope for relevant services, which includes all factors that impact the end-user perception, including third-party applications and content.
- Availability of high-quality, real-time information about the QoE delivered by the specific applications, content, and services that are important to an individual end user.
- Accurate knowledge of where and when services and content are used in a form that can be used to predict how to best allocate network and other back-end resources in near real-time.
- The ability of the overall solution to accurately predict where platform resources must be applied to ensure continued delivery of a high-quality OUx.
- The ability to tailor the delivery of content, applications, and services to meet individual end-user specified QoE priorities.
- The ability to optimize operations, engineering, real-time performance of networks, and associated back-end platforms to consistently deliver high QoE as determined by a crowdsourced view of related end-user QoE priorities.
- The ability to share the information gained via the assessment and optimization of Ux (utilizing appropriate privacy and opt-in protections) with all parties who participate in the OUx ecosystem, including third parties and the end user.
- A ***workbench approach***[2] to realizing the OUx platform, associated analytics capabilities, and linkages to third-party applications/content to enable rapid, operator-specific

[2] It is important that the resulting implementation be crafted so as not to "over-standardize" key elements such as measurements, applications interfaces, analytics and optimization algorithms as such steps would likely stifle both

innovation and differentiation. This element is key to ongoing competitive differentiation and sustainable market leadership.

4. Model Participants, Value Created, & Value Obtained

End Users

The end user is the primary source and recipient of new value creation in the business model for the breakthrough OUx ecosystem envisioned here. The end user is the client for content, applications, and services enhanced by the OUx ecosystem. The end user creates value that is critical to the overall success of the model, including:

- An accurate measure of the Ux received via direct subjective evaluation and input. To be useful, this input must be granular enough to understand differences in QoE delivered by specific applications, content providers, and services.
- A crowdsourced view (both real-time and predictive) of Ux delivered by location, time of day, application/content/ service used, etc. This information is created by combining individual user inputs with automated measurements, location data, etc., via an analytics platform that is part of the OUx solution.
- Crowdsourced feedback on the performance of individual applications, content, and services that have high value to both the network operator who is hosting the ecosystem and third parties who are participating in it.
- Crowdsourced information on individual end-user priorities for specific applications, content, and services. This information needs to be both granular to a level of specific/applications/content/services and available in customizable summary form.

End users also receive value from the OUx ecosystem, including:

- Customized handling of their personalized priorities for applications and content to create and optimize a personalized Ux.
- Feedback on the performance of individual applications, content, and services that have high value. This could include a near real-time indication of the likely level of Ux received for the favorite applications and content (e.g., a more sophisticated version of the

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rapid innovation and competitive differentiation. It is expected that the solution that realizes the goals outlined in this document will be realized in a way that is easily extensible and customizable by individual operators. A fast-tracked approach to identify and incorporate broadly useful extensions into the core solution and any relevant associated standards will also be required. These elements constitute what is meant by a ***Workbench Approach***.

"coverage bars" shown on mobiles). This indication would allow the user to select applications and content that will provide the appropriate Ux.

- The ability to rate their applications/content experience in such a way that the providing network operator and associated third parties may directly understand and improve the user's experience. For full participation, end users must opt-in to ensure they understand how their feedback will be used before they can provide feedback. Anonymous, one-time feedback is also supported as an option.
- The possibility to have content they are expected to consume pre-positioned in network resources close to their expected location to reduce the latency required to access such content.
- Improved QoE for their content, by the network proactively adjusting the content delivery format based on the user's circumstances, with fewer halts and pauses due to congestion.
- Improved Ux for their applications/content and usage patterns as a result of the improved performance from more responsive updating of network capacity and performance.

Network Operator

The implementation of the overall OUx solution and development of the associated business model and ecosystem is done by the network operator. The network operator brings the following important, high-value assets to the business model:

- A market-leading anchor set of services and brand that is a fundamental pillar upon which the model and ecosystem are built.
- A presence on end-user devices used to enable end-user opt-in and Ux feedback. The device presence is also critically important in obtaining direct end-user input on granular Ux preferences and perception of the Ux received.
- Competitive differentiation in areas such as real-time optimization of Ux for individual users, real-time optimization of localized network performance, optimization of network planning and operation, and improved customer care. This is enabled in the OUx solution by taking a "workbench" approach to analytics, measurements, etc., enabling each network operator to innovate and differentiate in the areas outlined here.
- A mechanism for sharing crowdsourced information provided by the end user and the network with third parties participating in the ecosystem, subject to the appropriate end-user privacy protections and opt-in-based controls.
- Services and access to other value elements outlined here provided to the end user or third parties in exchange for their participation in the ecosystem.

- A high-quality 4G, 5G, and/or Wi-Fi network and associated managed spectrum assets that are the fundamental media over which applications, services, and content are delivered to end users.

The network operator may also receive benefits from the OUx solution, such as:

- The ability to use information about user behavior patterns (content consumption and location) to pre-stage content in appropriate network locations in anticipation of users' requests for content. By these means, the network operator can add value to users and content providers by reducing the latency to access content. This may also reduce operating expenses by improving network resource utilization.
- More efficient use of resources based on proactively adjusting the content delivery format based on the user's circumstances. Better adjusting content formats to users' circumstances would also add value to the network.
- More focused application of network upgrades that will directly improve Ux for their customers while minimizing costs.
- The ability to provide users with a better indication of their likely Ux for a particular application at a particular time, which will improve user satisfaction by better setting expectations and allowing users to choose to avoid using applications that will have a poor Ux.
- The ability to optimize network resource utilization and take dynamic and targeted actions to repurpose existing resources or add new resources that can very quickly improve the Ux. These measures will improve the efficiency of resource utilization.
- Data on delivered Ux can be used in advertising and other market-facing campaigns to emphasize the differentiated Ux delivered by the operator. Accurate projections of future Ux based upon planned network enhancements and other steps may be used to develop confidence in a continued high-level of delivered Ux.
- The ability to identify emerging applications and hence prepare the network for expected growth and optimize the Ux.
- The ability to identify emerging applications and content that enables marketing teams to understand important new opportunities and develop appropriate offers and effective go-to-market strategies early in the associated market lifecycles.
- The OUx ecosystem host may use Ux data to understand the customer experience being delivered by participating third party applications and content providers. This enables the ecosystem host to more effectively work with participating third-party providers to improve their Ux and thus deliver value and motivate third party participation in the OUx ecosystem.
- The ability to allow customer care personnel to view the relevant Ux data when interacting with a customer concerning Ux performance or other problems. The Ux data may enable

customer care to better understand the situation the user is facing and to assist the user in resolving problems.

- The ability to provide "alarm-like" reporting to customer care and operations personnel based on levels of Ux. The alarm-like capabilities may be used to proactively contact important large (e.g., enterprise) customers concerning potential degraded Ux situations.
- The ability to improve overall Ux by working in concert with third party application and content providers.
- The ability to use access to the OUx ecosystem as a mechanism to establish partnerships with third party application and content providers to add value to both organizations.

Application and Content Providers (Third Parties)

It has become increasingly difficult for any individual service provider to deliver a full suite of applications, content, and services that meet all the needs of an individual end user. Furthermore, each end user wants the ability to access a specific set of these elements that best meet individual needs. This situation creates a high-level of fragmentation among the multitude of players that offer the suite of applications, services, and content used by important groups of end users. The OUx breakthrough use cases are built, in part, upon the concept that the ecosystem described here creates an environment for the associated players to better understand and deliver high-QoE for their users. Specifically, third-party content and applications providers create value by:

- Participating in an ecosystem that contains other closely related services, content, and applications to enable a user-defined "bundle" of capabilities for each specific end user.
- Participating in an ecosystem that provides enhanced customer access and a lift from the ecosystem "brand", which is likely stronger than their individual brands alone.
- Measuring indicators of user experience using techniques similar to web analytics (i.e., dwell-time, repeat visits, click-though, percentage of video duration viewed by the user, A/B testing).
- Sharing of information about the Ux that their applications or content users are receiving that can be correlated and enhanced via analytics, and the closely related Ux measurements and inputs that are received directly from the end user and from other participants in the ecosystem.
- Real-time and other optimizations of their content and applications to improve their Ux as perceived by the end user based upon crowdsourced information generated by the ecosystem owner (i.e., the network operator).

Third party Content and Application providers may receive value by:

- Understanding the Ux performance of their applications/content and obtaining relevant service trend data through collaboration with the network operator. This will be especially valuable for small and mid-size players who may not have the ability to create as complete a view of their end-user's Ux as that provided by the OUx ecosystem.
- Becoming part of a "complete" package of applications, content, and services that satisfies large groups of specific end-user needs. This helps to address the fragmented market situation that many third-party providers face.
- Improvements in user experience for latency-sensitive content and applications by the pre-stating of content close to users based on network operator knowledge of user behavior patterns.
- Their resources can be allocated more effectively to deliver the Ux expectations of their end users on a near real-time basis.
- The ability to provide users with a better indication of their likely Ux for a particular application at a particular time, which will improve user satisfaction by better setting expectations and allowing users to choose to avoid using applications that will have a poor Ux.
- The ability to be notified (e.g., similar to an OA&M "alarm") if the predicted network performance drops below the pre-defined threshold required for good operation of their application.

To have access to the Ux information described here, a participating third-party application or content provider should do the following (at a minimum):

- Create a business relationship with the provider who hosts the OUx ecosystem that includes access to relevant Ux information.
- Provide a means for the OUx ecosystem host to identify the third party's end users so that only the information that is relevant to their end users is shared. The OUx ecosystem opt-in and end-user preferences for the identified customers will include opt-in/permission to share data with third parties.
- Provide a means for the OUx ecosystem host that can identify the applications or content delivered by the participating third party so that Ux information specific to the third-party's services may be identified and included in the views provided.
- Agree to properly use and appropriately protect the Ux information received.

5. Service Models

Elements of a Successful Service Model

Key elements for success via the service models envisioned include:

- An anchor in a set of base services and an associated service brand where the network operator enjoys a differentiated, market-leading position.
- Steps to create an ecosystem that brings additional third-party content, applications, and services to create a compelling package ***as perceived by individual end users***.
- Tools to identify and proactively expand and evolve the elements above as the end user's needs/preferences and the associated competitive landscape evolves.

An anchor service set and brand are important for creating the initial motivation for the end user, third party applications, and content providers to participate in the formation of the OUx ecosystem. It will likely be necessary to create an initial motivation for end users to opt-in and participate in the startup of the business model and associated ecosystem. Some potential end-user motivators might include:

- A certain amount of zero-rated and/or sponsored wireless broadband data or other services allocated for use of their specified high-priority content and applications.
- A clearer picture of how their broadband data plan is being consumed across their specified priority content and applications.
- Zero-rated and/or trial content or services from ecosystem partners who are participating in the launch of the OUx ecosystem.

As the ecosystem begins to function, the information created via crowdsourcing (based upon end-user direct Ux inputs and preferences), direct measurements, and the application of analytics creates the core value shared among the participants (including participating end users and third parties). It will be important to front-end load the distribution of value to the end users and third-party participants during the formation of the OUx ecosystem to help reach a scale where it becomes self-sustaining. ***Strategic value*** is created when service models and the associated ecosystems reach a scale where there is a ***primary exchange*** for closely related content, applications, and services. In a ***primary exchange*** situation, the creation of value around the content, services, and applications enjoy a level of competitive differentiation that cannot be easily duplicated outside the ecosystem.

Two scenarios have been identified in this report as candidates to meet these criteria.

Consumer Video and Content

Many network operators have made major investments in video content rights and distribution systems. These same operators have either built and/or acquired strong brands associated with their video services. Many operators have also amassed large bases of end-user customers for their content services. This provides the basis for a potential OUx ecosystem as described below.

Strong trends in the video content market have emerged around these important end-users' needs to:

- Be able to create custom lineups of video content tailored to their specific interests.
- Include over-the-top (OTT) free and paid video content in personalized video lineups.
- Have powerful, past-view based search capabilities to find video content of interest to them. This capability is important within their custom lineup and for discovering new sources of content.

The OUx ecosystem outlined here needs to accommodate these expanded service capabilities.

Business Communications and Collaboration

Communications and collaboration services for business end users is a leading component of a network operator's wireless service set. Network operators have both strong brands and large customer bases around a core set of these services.

This market segment is also being heavily impacted by important trends driven by business end users' desire to create customized service sets and associated experiences. These trends include:

- Inclusion of third-party collaboration tools specific to their employer's or their own business needs.
- OTT communications services providing capabilities such as enhanced conferencing/collaboration, instant messaging, email marketing, time and resource scheduling, etc.
- Use of business-oriented social networking services (e.g., LinkedIn, Facebook, Google) to create a business network and to market products and services.

The OUx ecosystem outlined here needs to accommodate these expanded service capabilities as well.

6. Optimized User Experience Solution

A solution approach is being taken to realize the OUx breakthrough use cases and the associated models outlined in this report.

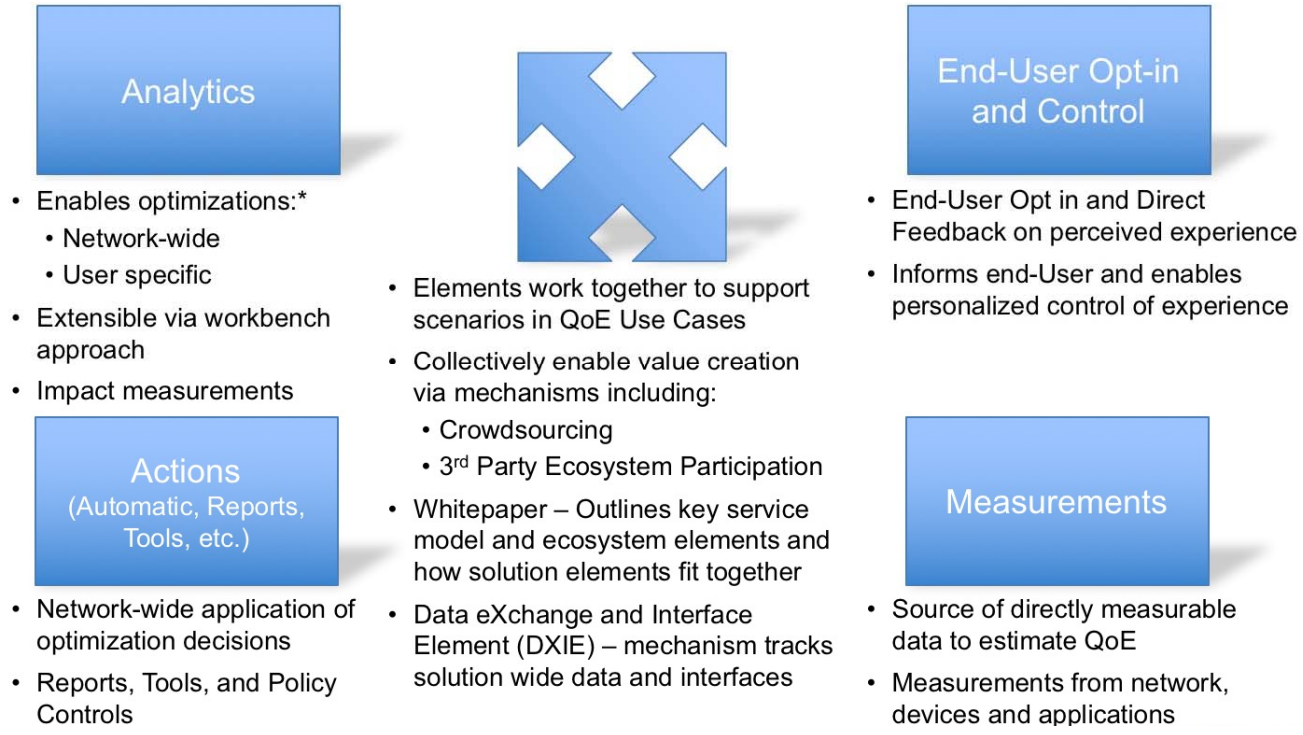


Figure 1: Optimized User Experience (OUx) Solution Elements

The four major elements of the OUx solution are shown in the figure above. Each element plays an essential part in the realization of the OUx breakthrough use cases and the associated OUx ecosystem. The elements in the solution interact via a common set of ***Data eXchange and Interface Elements*** (DXIE), which are general in nature. It is important that the solution can be easily extended and differentiated by individual network operators. To this end, the solution elements are based on a workbench approach that allows them to be easily customized and extended by individual operators. The DXIE elements will be a primary tool in realizing OUx goals and is referred to as the ***workbench approach***.

Optimized User Experience Solution – Measurements Element

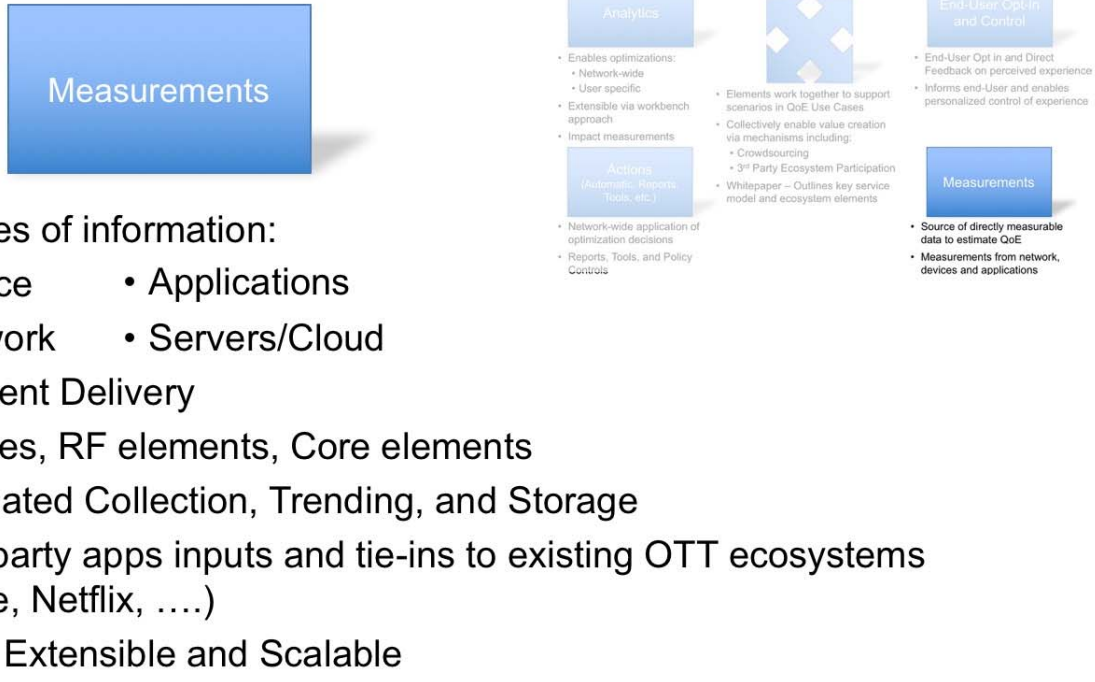


Figure 2: Measurements Element Capabilities

The measurements element provides a collection point and standard mechanism for programmatic and automatic collection of measurements related to QoE and Ux. It is used both inside networks and on the end user's devices. A key capability of this element is the support of interfaces to third-party applications and back-end systems to enable rich collection of measurement data. This element is intended to be extensible and customizable in each network operator's implementation of the solution.

Optimized User Experience Solution – End User Opt-In and Control Element

- End-User opt-in to control access to personal information
- Direct input from End-User to define goals for personalized QoE
- Proactive feedback to user on personalized QoE expected/delivered
- Direct Ux feedback from End-User
  - Key feed for crowdsourced analytics
- Includes APIs on device so apps can participate in ecosystem
- Device presence includes an app to enable these capabilities
- Opting-in to the solution should provide a seamless experience which does not negatively impact the participant's Ux

Figure 3: End-user Opt-in and Control Element Capabilities

The end-user opt-in and control element provides a number of direct end-user interface capabilities including:

- Support for end-user opt-in/opt-out and privacy controls.
- Mechanisms that enable an individual end user to specify Ux priorities for applications, content, and services from network operators and third parties. The user will be presented with the Ux priority profiles and choices that are available when specifying their priorities.
- Users will be able to enter or update preferences on any device and have the preferences apply to all applicable devices.
- A user interface (UI) that provides feedback to the user on the level of Ux being delivered or to be expected.
- The OUx solution shall include a device-based interface that enables end users to rate their experience at the end of, and *optionally* during, their use of specific applications and content. The interface is envisioned to provide an appropriate "pop-up" asking the user to rate the Ux received. Additional information on rating can be found in Annex C.1

This element includes a direct UI application that will be available on the end user's device. A key capability of this element is UI support for third party applications so that they can benefit from the Ux information collected by the solution. This element is intended to be extensible and customizable in each network operator's implementation of the solution.

Optimized User Experience Solution – Analytics Element

- Data and action generation for off-line and near real-time applications
  - Determination point for "super-SON" and "micro-SON" actions
- Assessment of "SON impacts" (view of "feedback around the loop", predictive analytics to avoid "tour boat problems")
- Personalized analytics to enable personalized QoE (near real-time "micro-SON")
- Extensible workbench approach enables future scenarios & operator differentiation
  - Facilitates "Special Sauce" including real-time analytics
- Access to metadata for external applications
- Tools to identify new service opportunities

Figure 4: Analytics Element Capabilities

The Analytics element provides Ux data reduction, correlation, and automated action decision-making and control for the solution. It is important to centralize the decision and action-taking functions in a device and network independent elements to enable solution-wide optimization actions, which affect multiple network, device, application, and content delivery components. This element is also responsible for monitoring the impacts of actions it initiates and making appropriate adjustments in optimization choices. This element stores and controls access to Ux metadata created as a product of its analytics capabilities. Finally, this element should be able to take near real-time and prediction-based actions on an individual end user or a solution/network-wide basis. A workbench approach is taken in this element as it is a key source of an individual network operator's ability to differentiate its solution and services.

The Ux ratings directly entered by end users will, in most cases, be the primary data source used for analysis. The end-user ratings may be normalized and "calibrated" based upon comparison with other users' ratings taken under similar circumstances.

- Additional information regarding analytics can be found in Annex G.1 and H.1.

The analytics that produce the Ux assessments based upon the end-user opt-in, sharing controls, and the generated data should be protected in compliance with appropriate regulation and user preferences.

Analytics functions include:

- Analysis of user location and application usage patterns to predict where it may be useful to pre-stage content for subsequent access by users.
- Generation of near-real time predictions of the likely Ux for the user's highest priority applications and content. Transfer of this information to the mobile for display to the user.
- Generation of projected trends in the usage of specific applications and content as measured over time. It should be possible to perform this analysis at different levels of granularity including the ability to structure the analysis by time, location, device characteristics, individual users, or user groups.
- Generation of projected traffic levels associated with the usage of specific applications and content. It should be possible to perform this analysis at different levels of granularity including the ability to structure the analysis by time, location, device characteristics, individual users, or user groups.
- Analyzing how the available and assigned network resources relate to the Ux obtained by the end user. From this analysis, it may be possible to generate a prioritization of where to allocate additional resources. Similarly, this analysis may show where resources are underutilized and redeployment (e.g., though changes to an SDN configuration) may improve the Ux.
- The ability to query relevant Ux data (past, present, and predicted future) for existing services, applications, and content, including those provided by participating third parties, to support customer care and marketing activities.
- The ability to identify emerging trends in applications/content and associated Ux data to support new market and service development activities.
- The ability to raise an "alarm" notification if the predicted or measured Ux falls below pre-defined criteria. These alarms may be configured on behalf of the network operator or on behalf of participating third-party application and content providers.

Optimized User Experience Solution – Actions Element

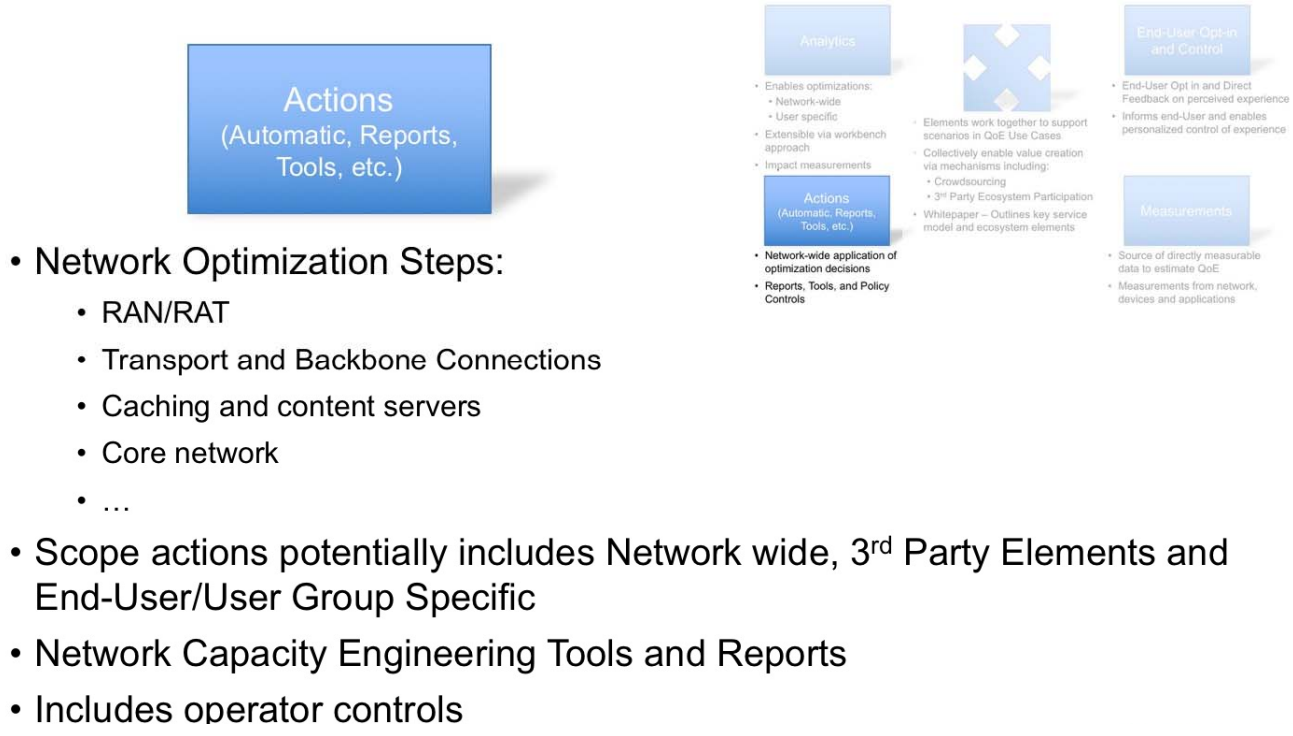


Figure 5: Actions Element Capabilities

The actions element is responsible for implementing or applying the actions determined by the analytics element across networks, back-end and outboard systems (e.g., content caches, backend applications servers), and third-party applications. It also provides capacity engineering tools and reports driven by the results of the analytics element to optimize network capacity investments to the maximum overall delivered Ux.

Functions of the actions element may include:

- Decisions based on patterns of user location and application usage to pre-stage content in particular network locations for subsequent access by users. These decisions may involve interaction between content providers and network operators.
- Decisions on the most appropriate available access technology and format to deliver content to the user.
- Decisions on the most appropriate media format and encoding (e.g., video resolution and frame rate) to deliver content to users based on the prevailing or expected conditions. These decisions may involve interaction between content providers and network operators.

- Decisions on how to apportion available resources between users or between different applications belonging to the same user.
- Decisions on how to configure (either in the short-term or long-range) network resources. For SDN-based networks, this will include how the SDN controller allocates resources.

Optimized User Experience Solution – Data eXchange and Interface Element

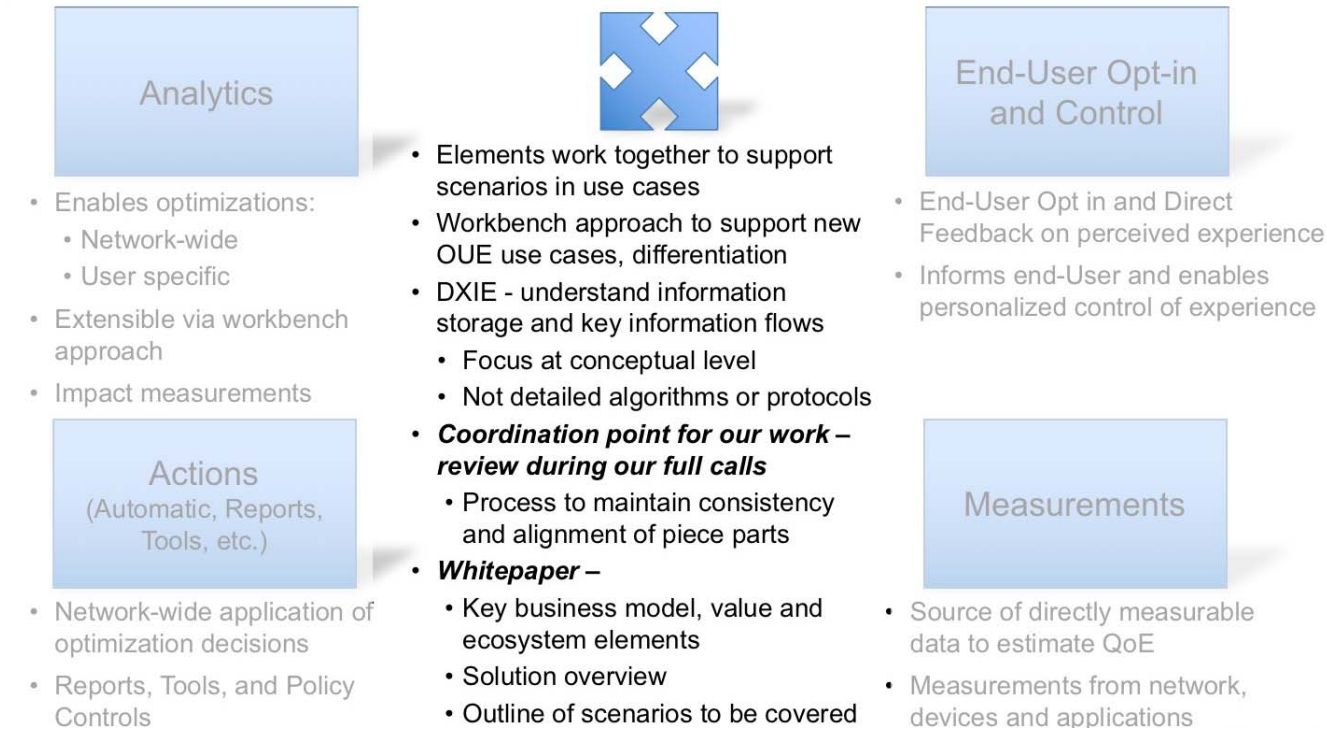


Figure 6 - Data eXchange and Interface Element Capabilities

The Data eXchange and Interface Element (DXIE) provide a set of mechanisms that enable the solution elements to work together to properly optimize delivered Ux. The overall approach to the solution relies on a careful use of flexible interface and data exchange approaches in this area to meet the following goals:

- Rapid extensibility of the overall solution to realize new use cases and associated scenarios.
- Rapid customization by individual network operators so that they may create differentiated, market-leading Ux capabilities.

Realizing these goals will require a flexible, collaborative approach to defining the associated interface and data exchange formats and mechanisms. A rapid decision-making mechanism (which enables customizations by individual network operators to become part of a common DXIE) is also required. To achieve this, the following items should be easily modified/customized by the OUx ecosystem owner:

- The list of available applications and content from the network operator and third parties participating in the OUx ecosystem.
- Criteria for deciding which applications/content should be rated by specific groups of end users.
- The criteria for identifying and characterizing applications/content from non-participating third parties.
- The ratings systems (multiple choices) that are applied to specific, or classes of, applications and content.
- The set of measured data collected that is directly associated with a specific end-user's use and Ux rating for a given application/content session.
- The system and categories used to prioritize applications and content.
- The categories to enable multiple priority sets based upon time of day, day of the week, user's current location, user's current role, or other factors as deemed appropriate by the ecosystem owner.
- The generic categories used to prioritize applications and content from non-participating third parties.
- The set of network elements and the associated Traffic Engineering analytics algorithms.

It is possible to measure the value elements that are created and exchanged in the OUx ecosystem. This shall include:

- Means to measure the direct participation of end users in the OUx ecosystem include direct ratings of Ux and applications/content/service priorities.
- Means to measure frequency and scope of automated optimizations performed by the OUx ecosystem in third-party elements and/or on behalf of third-party end users.
- Means to measure automated Ux optimization benefits delivered to specific end users. The results of these measurements can be used to generate periodic updates to end users so that they can more clearly see the benefits that they are receiving as a result of their participation in the OUx ecosystem and the associated optimized services.
- Means to measure frequency and scope of accesses to OUx-generated analytics by participating third parties.
- Additional mechanisms to measure consumption of other value elements created via workbench mechanisms as they are consumed. This aspect is critical to enable each

instance of the OUx ecosystem to be differentiated and to allow such differentiation to be used as an integral part of value creation and exchange.
- Means to measure user consumption of zero-rated applications, content, and access or other services offered in exchange for participation in the OUx ecosystem.

The effective operation of the DXIE element will require collection and maintenance of the following data:

- **OUx User Profile Database:** The system should maintain an end-user profile database that includes the storage of Ux preferences and opt-in/out choices.
- **OUx Ecosystem Database:** Information about the participating applications, content, and other third-party systems that require opt-in/out choices by end-users. In addition, this should also include information about available Ux priority profiles and choices available to the end user.
- **OUx Anonymized Ux Info Database:** Stores anonymized summary information about end-user experience. Information is filtered and anonymized by analytics based upon, in part, end-user opt-in/out choices.
- **OUx User Ratings Database:** Stores end-user ratings and associated measured information in an encrypted form. Appropriate access control shall be applied before the data can be viewed or utilized.
- **User's Location Data (Present and predicted next location)**: Data stored for end users who have opted into the OUx ecosystem. Current location information may be combined with historical data to predict future user locations.
- **OUx Performance Measurements and Trends Database**: This database stores predicted and actual measurements of Ux performance and traffic levels. The data needs to be granular enough to capture Ux performance trends by network location, time of day/day of year, applications used, class of end-user, and any other information deemed important to the OUx engineering and management processes used by a particular realization of the OUx ecosystem. The data stored should be time/location-stamped so that it can be correlated with network failure events and changes in network configuration, capacity, or interconnect structure.
- **Infrastructure Configuration and Network resources information Database:** Stores a logical model of the elements that make up the OUx ecosystem owner's and associated participating third parties' networks, servers, interconnect links, and other elements directly relevant to the traffic performance or delivered Ux. Information about the relationship between the elements in the database and their impact on traffic capacity and latency is also included. This information is used to make Ux and traffic performance improvements to the serving network and service elements.

- **OUx Value Exchange Database**: This database is used to track the creation and consumption of the value elements outlined above. Information includes data about operator, participating third-party and end-user Ux value and associated analytics information created and consumed as well as the consumption of zero-rated applications, content, and services in exchange for OUx ecosystem participation.

7. Summary

This report provides a starting point for understanding and realizing breakthrough user experience capabilities and an associated ecosystem and solution. The approach taken here assumes that any network operator implementing the model and solutions outlined in this document will want to differentiate their approach to maximize competitive advantage. In addition, this approach includes end-user opt-in/opt-out and control functions to insure end-user privacy and awareness of how personal data may be used.

The approach outlined could begin to be introduced with the current generation of wireless technology, but the increased capacity and flexibility offered by 5G systems would significantly enhance the service provider's ability to offer an optimized user experience. The requirements to support optimized user experience are much broader than "wireless standards" but it is likely that some of the requirements would have implications for 5G standards. Subsequent analysis will assess this aspect and provide input to the 5G standards process as appropriate.

Annex A: Example 5G OUx Use Cases

Annex A contains an informative set of operational scenarios that can realize the OUx model described in this report. These scenarios were created to guide the development of the OUx model and are presented without attempting to fully align terminology in the documentation.

The creation of the scenarios focused on the three key groups of participants in the ecosystem model defined here: user; third parties, and network operator. Each group's interaction and associated value creation by the OUx solution is described in the scenarios.

End-User:

A - Opt-in, Opt-out, Sharing Controls

B - Ux Preference Selection

C - Ux Ratings (from End-User)

D - Ux Feedback to End-User

E - User Information Protections

F - Ux Driven Marketing and Customer Care

G - Ux Centric Crowdsourcing via Analytics – Types and Sources

Third Party:

H – Back-end Ux Measurements

I - Access to Crowdsourced Ux Info.

Network Operator:

J - Micro-Optimization (per user Optimization.)

K - Macro-Optimization (network wide, localized optimization)

L - Predictive content and BW positioning

M - Network-Aware Content Adaptation for Third Party Content Providers

N - Ux Prediction/Ux Driven Traffic Prediction

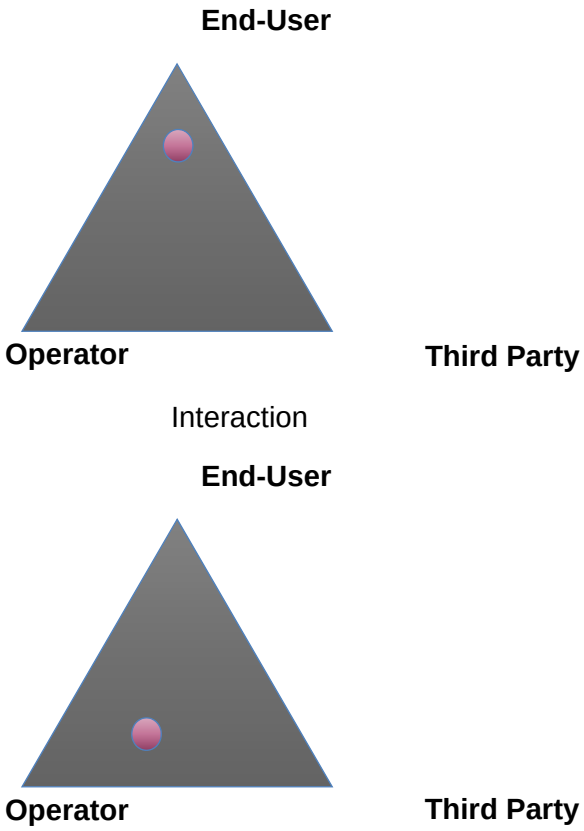
O - Ux Driven Capacity Engineering

Other

P - Ecosystem Partner Value Exchange

A Opt-in, Opt-out and Sharing Controls

A.1 Scenario Description



This scenario addresses important aspects of the end-user's interaction with the OUx ecosystem: opting in and out of the ecosystem; and control of how the information, derived from the end-user's participation, may be used.

The OUx solution shall include a device-based interface that enables the end-user to opt-in, opt-out, and set limits on how information is used. The process shall be granular enough to give the end user control at the level of individual applications or content. All collection of user-specific or anonymous data and rating requires that the end-user first opt-in to the process. The process should also make it clear to the end user how information may be used by participants in the OUx ecosystem. The set of capabilities shall include:

- Globally opt-in/out of the entire ecosystem.

- Opt-in/out for individual application or content services from the network operator or third parties participating in the OUx ecosystem.
- Opt-in/out of classes of applications that are not part of the OUx Ecosystem (e.g., all video applications, all communications applications).
- Opt-in/out of sharing location information along with Ux data.
- Opt-in/out of sharing specific usage information (e.g., specific content, time of use, and particulars of how it was consumed).
- Opt-in/out of measurements to help end users evaluate how their overall broadband plan capability is being consumed.
- Opt-in/out of option to provide anonymous, non-application/content specific experience feedback.
- Other options based upon extensions and customization via the OUx ecosystem workbench approach outlined later in this document.

All data from users who have opted in to any of these choices (or any additional ones created through workbench approaches) shall be anonymized before it is made available to the ecosystem owner or partnering third parties. The device-based interface provided to enable the end user to select these options shall also provide an indication of the types and degree of Ux optimization that will be gained or lost based upon their choices, along with the impact on any associated zero-rated or subsidized service impacts.

Changes in these settings shall be immediately visible on all end-users' devices.

Third parties who participate in the OUx ecosystem and the sponsoring network operator shall have access to anonymized information about the OUx opt-in preferences, measured data, and associated usage pattern information, which is limited and filtered based upon each end-user's choices as outlined above.

A.2 Value Proposition

End-User – has the ability to set granular controls on how information about individual Ux is collected and used to optimize overall experience. The user is also informed about the solution's ability to optimize the Ux and to provide other incentives and information (e.g., how the user's broadband plan is being consumed) based upon the user's choices.

Third Party – receives value from the end-user's participation in the OUx ecosystem that enables collaboration with the network operator to deliver a personalized, optimized Ux to users. The Third Party also receives crowdsourced information about its user's collective Ux to help improve the experience delivered by its applications and content.

Network Operator – receives permission to gather the information necessary to provide an optimized Ux for its customers and to coordinate with Third Party applications providers to use techniques such as content and bandwidth pre-positioning to deliver the best possible Ux, and to efficiently invest in network tuning and infrastructure.

A.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Review or change Ux opt-in/op-out permissions	End User	Device Client	Overall and/or specific opt-in/out status for applications, content, services, and other areas as outlined at the beginning of this report.
Retrieval of end-user Ux data	OUx Anonymized Ux Info Database	Network Operator or participating Third Party	Anonymized summary information about end-user experience.
Storage of end-user Opt-in/Out preferences	Device Client	OUx User Profile Database	User's OUx opt-in/out status for applications/content/services and other OUx ecosystem information use permissions.
Retrieval of participating and generic categories for apps, content and services	Device Client	OUx Ecosystem Database	Specific operator and third-party applications, content, and services that are directly participating in the OUx ecosystem along with generic categories covering non-participants.

A.4 Summary of Data Derived or Used

OUx User Profile Database – The system should maintain an end-user profile database that includes the storage of Ux preferences and opt-in/out choices

OUx Ecosystem Database – Information about the participating applications, content, and other third-party systems that require opt-in/out choices by end users.

OUx Anonymized Ux Info Database – Stores anonymized summary information about end-user experience. Information is filtered and anonymized by analytics based upon, in part, end-user opt-in/out choices.

A.5 Timescales for Actions Taken and Data Generated

The data collection and storage of end-user opt-in/out information shall be done in real-time. Cloud-based storage shall allow end users with multiple devices to receive real-time updates if OUx opt-in/out information choices are changed.

Applications/content/service-specific and crowdsourced summary information about end-user opt-in/opt-out choices shall be updated on a near real-time basis for use by network operators and participating third parties.

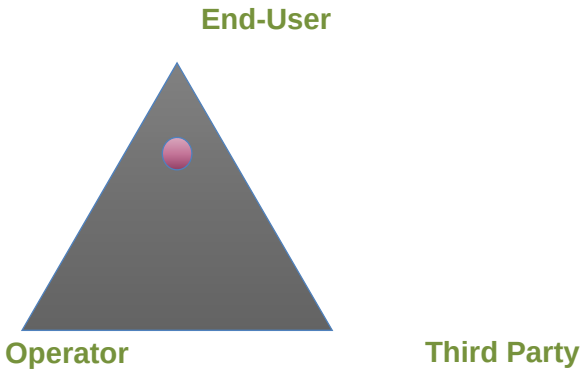
A.6 Extensibility via Workbench Approaches

The following items should be easily modified/customized by the OUx ecosystem owner:

- The list of participating applications and content from the network operator and third parties participating in the OUx ecosystem.
- The set of opt-in/out options for additional services.
- The set of opt-in/out options for end-user time, place, and type of usage data.
- Additional opt-in/out options as defined by the OUx ecosystem owner.

B UX Preference Selection

B.1 Scenario Description



This scenario describes interactions with end users specifying their Ux priorities for applications and content. This information is entered via a Ux preference client application on the end-user's device(s). Preferences set on one device should be visible and changeable across all the end-user's devices.

The end user is presented with a list of applications to prioritize that shall include:

- Carrier-provided applications and content.
- Applications and content from third parties participating in the OUx ecosystem.
- Generic traffic types for third-party applications not participating in the OUx ecosystem.
- A Ux profile to enable different priority sets based upon time of day, day of week, current location, current role (e.g., business, personal), or any carrier-defined partitioning to provide the capability for multiple priority sets based upon the profile configured and chosen by the end-user.

The client application can present the choices in any format desired including groupings (e.g., high, medium, low) in rank order or some other format determined by the network operator.

The implementation of the resulting prioritizations will be covered in other scenarios. The implementation will be done in accordance with applicable Network Neutrality regulations and will likely involve mechanisms that include pre-staging of content and supporting applications resources near the end-user's current and next point of use on the network.

Access to and modification of OUx preference data requires end-user authentication. The exact mechanism(s) to be used will be determined by the OUx ecosystem operator.

The data described earlier in this report shall be appropriately protected from unauthorized access and shall be anonymized via analytics before use by third parties.

The end-user shall opt-in to this system before the data outlined here may be collected.

B.2 Value Proposition

End-User – Customized handling of personalized priorities for applications and content to create and optimize a personalized Ux.

Third Party – Participating third parties in the OUx ecosystem can have their applications and content directly prioritized by end users and they can receive crowdsource feedback on how their end users are prioritizing their applications and content.

Network Operator – Gains an understanding of its end-user's preferences for various applications and content. This information is used to improve the effectiveness of a variety of operations and engineering tasks that are performed to enable creation of a personalized Ux for its customers. An example of this might be to identify that additional edge-caching stores in specific locations in a network would have a greater impact per CAPEX invested than increases in backhaul or other bandwidth-related investments.

B.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Review or change Ux priorities	End User	Device Client	Prioritized list of applications and content for a specific Ux priority profile.
Configure or Change current OUx Profile	End User	Device Client	Configure and change current OUx profile to select a different set of Ux priorities.
Storage of preferences	Device Client	OUx User Profile Database	User's Ux priorities (applications and content).
Retrieval of participating apps and content	Device Client	OUx Ecosystem Database	Specific operator and third-party applications and content that are directly participating in the OUx ecosystem along with generic categories covering non-participants.

Interaction	Source	Target	Info Exchanged
Setup of participating apps and content	APIs and administrative backend	OUx Ecosystem Database	APIs and administrative systems should exist to enable the OUx ecosystem operator and participating third parties to easily manage the set of participating applications and content. Third parties should be able to associate their specific on-device applications and content with what the end-user sees in terms of Ux priority choices.

B.4 Summary of Data Derived or Used

OUx User Profile Database – the system should maintain an end-user profile database that includes the storage of Ux preferences.

OUx Ecosystem Database – information about available OUx priority profiles and choices.

B.5 Timescales for Actions Taken and Data Generated

The data collection and storage of end-user preferences and profiles shall be done in real-time. Cloud-based storage shall allow end users with multiple devices to receive real-time updates if Ux priorities or profiles are changed.

Crowdsourced summary information about Ux priorities shall be updated on a near real-time basis for use by network operators and participating third parties.

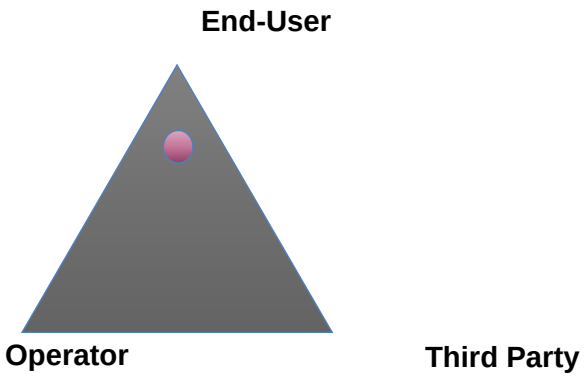
B.6 Extensibility Via Workbench Approaches

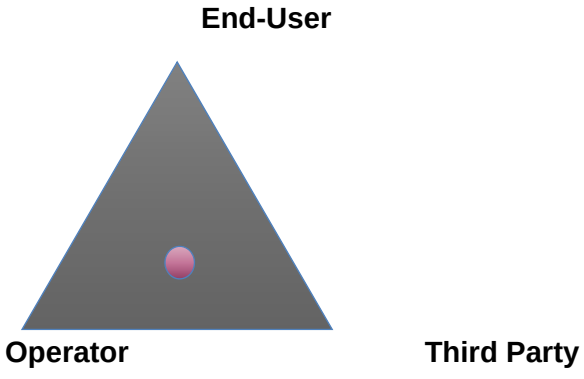
The following items should be easily modified/customized by the OUx ecosystem owner:

- The list of available applications and content from the network operator and third parties participating in the OUx ecosystem.
- The system and categories used to prioritize applications and content.
- The categories to enable multiple priority sets based upon time of day, day of the week, user's current location, user's current role, or other arrangements as deemed appropriate by the ecosystem owner.
- The generic categories used to prioritize applications and content from non-participating third parties

C Ux Ratings (by End Users)

C.1 Scenario Description





This scenario provides a means for end users to directly provide ratings input on their experience with a particular application or piece of content. The capabilities in this scenario provide the most useful feedback when the user is rating individual Ux from the network operator hosting the OUx solution or a third party that is directly participating in the associated OUx ecosystem. However, the solution can also derive less specific feedback on Ux directly from the end-user for other third-party applications and content. A given end user must opt-in to providing feedback per Scenario A in order to participate in any portion of the ratings process described here.

The OUx solution shall include a device-based interface that enables end users to rate their experience at the end of and *optionally* during their use of specific applications and content. The interface is envisioned to provide an appropriate "pop-up" asking the user to rate the Ux received. The following capabilities shall be provided as part of this interface:

- The ability to identify and rate the Ux received while using a specific application or piece of content. In the case of rating a content delivery experience, the device-based rating application will make it clear to users that they are rating the quality of the delivery of the

content, not the content itself. There may be an option to allow the user to provide textual feedback to further clarify the experience received.

- A specified rating scale (e.g., 1 – 5; Excellent – Poor; Good/Bad/Don't know). Different rating scales to be applied to a specific application or content use shall also be supported. When selecting a rating scale, the OUx ecosystem host should consider using a scale consistent with commonly used rating systems throughout the internet (e.g., 5 stars is best, 1 star is worst).
- The user shall be able to rate experiences delivered by both the hosting operator and third party.
- The point in the use of a specific application or piece of content when end users rate their Ux shall be configurable. Options to be included are:
  - Rate when the user is in a specific set of locations.
  - Rate periodically during an application/content session.
  - Rate at the end of an application/content session.
  - Rate only if the application is used for an amount of time shorter or longer than a specified interval.
  - Rate only when a specified set of other measurements or analytics may be a problem.
  - Rate based upon a trigger embedded in the application or content stream. This allows third parties that provide long duration applications (e.g., GPS navigator) to cause requests for end-user ratings to appear at appropriate times during the application/content flow.
  - Any additional criteria the OUx ecosystem chooses to define using workbench capabilities.
  - Rate on certain percentages of uses meeting a set of these criteria.
  - (Note that the set of the criteria used can be separate specified by application/content, location, group of users or other criteria defined by the OUx ecosystem host.)
- The option to embed an access "button" to trigger the ratings system shall be available to third-party applications and content providers. This would be included on an optional basis for participating applications and content providers.
- If feedback is received from the end users when their device is not connected to the network, the device-based interface shall store the feedback with appropriate time-stamp and other contextual information and transfer the information when the associated device next connects to a suitable access network.
- Participating third parties and the hosting operators will receive more specific feedback including the exact application/content the end-user's rating applies to.
- Non-participating third-party Ux ratings shall be collected and measured to the extent that the associated traffic can be uniquely identified. It may be the case that groups of third party

Ux data may be combined by basic application type (e.g., video, file transfer, communications) if a more specific characterization cannot be determined.

- The hosting network operator and the third parties participating in the OUx ecosystem may decide to limit the set of applications/content specific end users are asked to rate. Options shall exist to do this based upon a given end user's stated priorities for Ux for specific applications/content as well as based upon other criteria defined by the hosting companies.
- Ux ratings will be combined with other end-user measured data specific to the applications/content being rated. Examples of such data will include location information, path for traffic routing through associated networks, back-end connection used, and its associated real-time performance, and others as defined by the hosting operator and third parties participating in the OUx ecosystem. All ratings will be marked with timestamp and other contextual information so that they may be connected to other measured data via analytics.
- There will be the ability to optionally provide an anonymous rating of a recent Ux at any time. (Note that a user must still opt-in to provide anonymous ratings. Also note that anonymous ratings cannot be used to provide personal optimization of the user's applications and content – such ratings will only provide feedback to the hosting operator not associated with the user who provided it. A given operator hosting the OUx ecosystem may decide to include or not include anonymous ratings.)
- All of the raw data provided by the end-user's Ux rating will be stored securely (see Scenario E). This data will be combined with other measurements and information via analytic techniques and used for various optimization, business, and operational purposes in metadata form.

The analytics routines that project likely Ux experience levels (see Scenario E) will take into account the end-user Ux ratings derived via this scenario as crowdsourced input into the generated projections. The crowdsourced Ux ratings data will need to be correlated by characteristics around the entry of the associated Ux ratings, such as proximity of location, use of common network and backend resources, similar applications/content, time of day, etc.

All data from users who have opted in and provided ratings as outlined above, or any additional ratings provided through functional build from workbench approaches, shall be anonymized before it is made available to the ecosystem owner or partnering third parties.

Third parties who participate in the OUx Ecosystem and the sponsoring network operator shall have their access to anonymized information about their end-user's ratings, responses, and associated usage pattern information that is limited and filtered based upon each end-user's entered opt-in data as outlined above.

C.2 Value Proposition

End-User – Can rate their applications/content experience in such a way that the providing network operator and associated third parties may directly understand and improve the user's experience. Anonymous, one-time feedback is also supported as an option. End users must opt-in to ensure they understand how their feedback will be used before they can provide feedback.

Third Party – Receives value from the end-user's participation in the OUx ecosystem that allows them to collaborate with the network operator to measure and deliver their users a personalized optimized Ux. They also receive crowdsourced information about their user's collective Ux, which they can use to improve the experience delivered by their applications and content.

Network Operator – Receives the information necessary to provide an optimized Ux for their customers and to coordinate with third-party applications providers to use techniques such as content and bandwidth pre-positioning to deliver the best possible Ux and to invest efficiently invest in network tuning and infrastructure.

C.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Retrieval of OUx opt-in/op-out permissions	End-User	Device Client	Overall and/or specific opt-in/out status for applications, content, services and other areas as outlined in Scenario A.
Retrieval of end-user Ux data	OUx Anonymized Ux Info Database	Network Operator or participating Third Party	Anonymized summary information about end-user experience.

Interaction	Source	Target	Info Exchanged
Storage of raw end-user Opt-ratings	Device Client	OUx User Ratings Database	Specific end-user raw information rating the experiences they have received. This data must be encrypted with effective access controls strictly limiting its use to reduction analytics and other applications on a need to know basis.
Retrieval of participating and generic categories for apps, content, and services	Device Client	OUx Ecosystem Database	Specific operator and third-party applications, content, and services that are directly participating in the OUx ecosystem, along with generic categories covering non-participants.

C.4 Summary of Data Derived or Used

OUx User Profile Database – The system should maintain an end-user profile database that includes the storage of Ux preferences and opt-in/out choices.

OUx Ecosystem Database – Information about the participating applications, content, and other third-party systems that require opt-in/out choices by end-users.

OUx Anonymized Ux Info Database – Stores anonymized summary information about end-user experience. Information is filtered and anonymized by analytics based upon, in part, end-user opt-in/out choices.

OUx User Ratings Database – Stores end-user ratings and associated measured information in an encrypted form. Appropriate access control shall be applied before the data can be viewed or utilized.

C.5 Timescales for Actions Taken and Data Generated

The data collection and storage of end-user ratings information shall be done in real time. Cloud-based storage of both raw ratings and metadata views created by analytics shall allow applications to retrieve newly stored and historical versions of Ux ratings data in real-time

Applications/content/service-specific and crowdsourced (i.e., analytics based) summary information about end-user ratings shall be updated on a near real-time basis for use by network operators and participating third parties.

C.6 Extensibility via Workbench Approaches

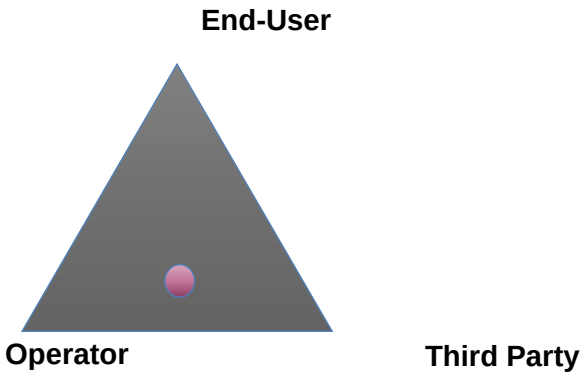
The following items should be easily modified/customized by the OUx ecosystem owner:

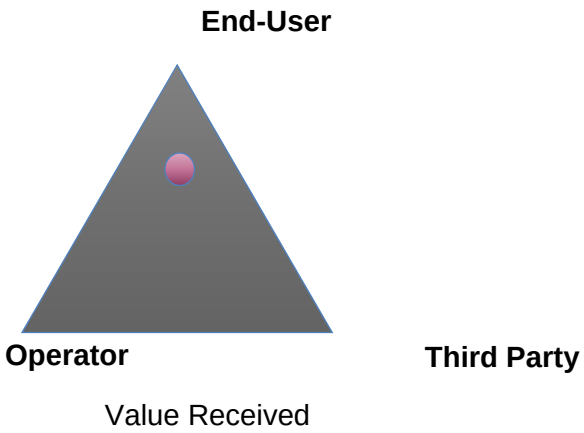
- The list of participating applications and content from the network operator and third parties participating in the OUx ecosystem.
- Criteria for deciding which applications/content should be rated by specific groups of end-users shall be extensible.
- The criteria for identifying and characterizing applications/content from non-participating third parties.
- The ratings systems (multiple choices) that are applied to specific or classes of applications and content.

- The set of measured data collected that is directly associated with a specific end-user's use and Ux rating for a given application/content session.

D Ux Feedback to End Users

D.1 Scenario Description





This scenario provides for real-time feedback to end users about the Ux that they are likely to receive when using their applications or content. The end user must opt-in to the OUx ecosystem for the analytics to provide the feedback outlined below (similar to an improved version of the signal strength bars that are available on many mobile devices). The feedback is provided in two forms:

- An on-screen badge that provides a summary of real-time Ux, which may be expended. The badge would have the ability to display projected Ux levels for various types of applications/content including:

    - Video
    - Audio
    - Real-time VR/gaming
    - Web browsing
    - Others to be added by the ecosystem host using the workbench system
- An app that provides more detailed Ux projections for individual applications and content specified as their priority one as outlined in Scenario B – User Preference Selection. This app also could be used to configure the summary information displayed by the on-screen badge

The OUx ecosystem would communicate on a periodic basis with the end-user's device to update the Ux projections displayed by the on-screen badge. The app would retrieve the more detailed Ux projections when it was invoked by the end user.

Analytics routines would use measurements as well as information about the applications and content ranked as a priority by the end user to determine the Ux projections. The analytics may also obtain measurements and other information about third party servers and connectivity to include in the Ux projections. Projections will likely be based upon location/time of day/etc., specific analytics adjusted to better reflect a user's projected experience. Additional thoughts on the balance between near real-time projections and end-user tailored, application specific views were expressed earlier in this report.

Scenario C End-User Ux Ratings will also use the projected experience ratings as an input to determine when to ask the end user to rate specific experiences with applications and content. For example, if the projected Ux for a video project appears to be less than "good", the Ux ratings application might ask end users using video to rate their experience more frequently to try to confirm the accuracy of the Ux projections.

Also, the analytics routines will consider end-user Ux ratings derived via Scenario C as crowdsourced input into the projections generated as part of this scenario. These crowdsourced Ux ratings data will need to be correlated by characteristics around the entry of the associated Ux ratings such as proximity of location, use of common network and backend resources, similar applications/content, time of day, etc.

The levels of projected Ux will be determined by the operator hosting the Ux ecosystem and might be metrics such as:

- Excellent, good, fair, poor
- 1-N
- Green, yellow, red

- Others as determined by the hosting operator

D.2 Value Proposition

End User – Can determine in near real-time what the likely level of Ux users will receive for the favorite applications and content. This allows them to select applications/content that will provide a good Ux. In addition to the on-screen summaries, they can receive Ux projections for specific applications and content.

Third Party – Receives value from the end-user's participation in the OUx ecosystem that allows them to collaborate with the network operator to measure and deliver their users a personalized optimized Ux. Their users can better determine how their favorite applications and content will perform in a given location, time of day, etc. third parties who engage in such collaborations and consistently deliver the best Ux will be recognized by their users.

Network Operator – Receives the information necessary to provide an optimized Ux for their customers and to coordinate with third party applications providers to use techniques such as content and bandwidth pre-positioning to deliver the best possible Ux and to invest efficiently invest in network tuning and infrastructure. They can proactively let their users know what sort of Ux to expect for various applications and content, so their users can make the best choices on which applications and content to use.

D.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Retrieval of OUx opt-in/op-out permissions	End-User	Device Client	Overall and/or specific opt-in/out status for applications, content, services, Ux projections and feedback, and other areas as outlined in Scenario A.
Retrieval of end-user Ux data	OUx Anonymized Ux Info Database	Network Operator or participating Third Party	Anonymized summary information about end-user experience.
Storage of raw end-user Ux ratings	Device Client	OUx User Ratings Database	Specific end-user raw information rating the experiences they have received. This data should be encrypted with effective access controls strictly limiting its use to reduction analytics and other applications on a need to know basis.
Retrieval of participating and generic categories for apps, content and services	Device Client	OUx Ecosystem Database	Specific operator and third-party applications, content, and services that are directly participating in the OUx ecosystem.
Analytics determine projected Ux for a given user	Other data elements outlined in this table plus measurements of network, application, and other performance parameters as well as relevant	Device on-screen Ux Badge and Application	Project Ux level summaries and listing for priority applications and content. Transfer of this information may be via push (for the on-screen badge) or pull (for use by the Ux application outlined above).

Interaction	Source	Target	Info Exchanged
	crowdsourced Ux ratings data.		

D.4 Summary of Data Derived or Used

OUx User Profile Database – The system should maintain an end-user profile database that includes the storage of Ux preferences and opt-in/out choices

OUx Ecosystem Database – Information about the participating applications, content, and other third-party systems that require opt-in/out choices by end-users.

OUx Anonymized Ux Info Database – Stores anonymized summary information about end-user experience. Information is filtered and anonymized by analytics based upon, in part, end-user opt-in/out choices.

OUx User Ratings Database – Stores end-user ratings and associated measured information in an encrypted form. Appropriate access control shall be applied before the data can be viewed or utilized.

OUx Performance Measurements Database – Store automated performance measurements from the network, applications servers, end-user devices, on-device and backend applications, etc.

D.5 Timescales for Actions Taken and Data Generated

Summary projections of expected Ux (for use by on-screen badges) should be updated in near real-time. These projections will typically be determined via analytics on a location and time of day, etc., basis for different classes of applications and users as groups. This crowdsourced view can then be modified by information based upon preferences and priorities for a given user (e.g., location, network conditions) to create end-user specific projections. Application or content-specific Ux projections will likely be computed as needed if the associated analytics can be performed with acceptable response times, which provide a high-quality Ux for the end user. These later projects may also be computed in near real-time and store if necessary.

D.6 Extensibility via Workbench Approaches

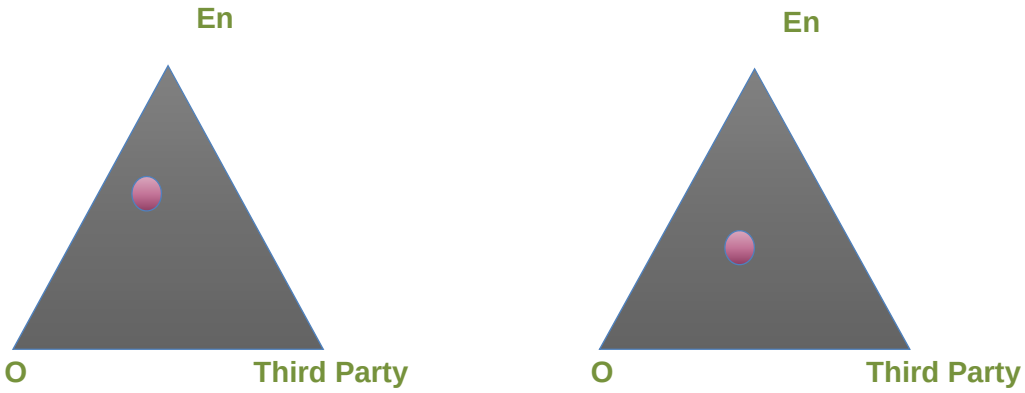
The following items should be easily modified/customized by the OUx ecosystem owner:

- The list of participating applications and content from the network operator and third parties participating in the OUx ecosystem.

- The ratings systems (multiple choices) used to communicate the projected level of Ux to the end user.
- The set of measured data collected for use in Ux projections. Ability to extend the measurement taken and used for Ux projections from sources both inside and outside of the hosting operator's network shall be possible.

E End-user Information Protection

E.1 Scenario Description



This scenario describes additional measures taken to ensure that the end-user's personal information needed to support the OUx is stored and communicated in a secure manner and privacy is maintained.

An important consideration for the end-user preferences needed to support opt-in or opt-out and sharing controls is that the end-user's personal information, which is provided directly to the mobile operator or gathered through analytics to support the end-user's OUx, shall be kept private and secure per the understanding between the end user and the mobile network provider, as well as between the mobile network provider and third parties participating in the OUx ecosystem. While personal information about a specific end user is needed, access to this information should be restricted. In other cases where information is shared with third parties participating in the OUx ecosystem, the information is anonymized (e.g., crowdsourcing over multiple third-party end users).

It is important to minimize the sharing of the end-user's private information and store information not needed for optimizing an experience on the end-user's device (e.g., using a cookie). This reduces the "surface area" of a potential attack and makes the information more difficult to target/access rather than storing it centrally (i.e., in the mobile operator's network).

The end-user's private information is appropriately viewed to be a "targeted asset" and should be stored and/or processed centrally when no other way of storage/processing is feasible. Bad actors are interested in obtaining millions of records at a time, when possible. Seeking a single end-user's information is not an attractive risk/reward proposition.

In general, what may be centrally stored in the operator's network is encrypted information needed to provide an optimized end-user's experience in real-time or near real-time. This may also include information required for analysis to project future OUx as part of Traffic Engineering, other OA&M processes, or other functions performed by the OUx solution. Viewing individual user's information shall have the explicit permission of the user.

In order to collect any end user information permission must be obtained per Scenario A.

Some examples are:

- End-user option settings, preferences, how they rated apps, their experience, etc.
- Measured data about given end-user experiences (end-user specific).
- End-user data that is derived through analytics (e.g., correlation of 1 and 2, end-user specific).

In addition, such information shall be encrypted when stored and the encryption keys shall be stored separately from the user's data. In general, the approach is to partition the information storage using standard security practices.

If such information is transmitted over the radio link, the transmission shall be encrypted.

Anything not encrypted due to access scale latency needs to be reduced via analytics to a metadata form that would not compromise an individual end user.

This derived metadata is the only information that can be shared with third parties participating in the OUx ecosystem.

E.2 Value Proposition

End User – The end user voluntarily provides personal information to the mobile operator that will be used to support the OUx with the expectation that this information will be kept private and secure. This includes measured data that the operators collect on the end-user's device as well as evaluation feedback. In return for providing this information, end users will expect that their personal information will be kept secure by both the network operator and the third parties participating in the OUx ecosystem.

Third Party – The third party receives value from the end-user's participation in the OUx ecosystem gaining access to anonymized data analysis provided by the network operator. This data analysis, when added to their own independent analysis, enhances their ability to determine how their user's favorite applications and content will perform in a given location, time of day, etc., allowing the third party to consistently deliver the best Ux. This enhanced capability is beneficial to third parties, especially small to mid-size players, that do not have the scope to independently develop these insights.

Network Operator – The network operator requires access to specific personal information and preferences from end users that participate in the OUx ecosystem. The network operator also requires permission to gather the information necessary to provide an optimized Ux for their customers and to coordinate with third-party applications providers to deliver the best possible Ux and to efficiently invest in network tuning and infrastructure. End users may have different expectations on what information they are willing to share, and different network operators may require access to a range of personal information depending on their specific implementation of the OUx ecosystem.

E.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
End User provides requested information for OUx	End User	Device Client/OUx User Profile Database	Information that supports OUx such as home/work location, service priorities, measurements, feedback, etc.
Encryption or anonymization of user information	End User	Network Operator	User provided information (see above).
Sharing of anonymized information.	End User	Participating Third Party (via the Network Operator)	Anonymized information for sharing with participating Third Party.

E.4 Summary of Data Derived or Used

OUx End User Personal Information – This is confidential information provided by the end user that is specific to the end user (e.g., identity, preferences, and opt-in/out choices). It is the information that requires the most protective measures available/feasible. This information also includes operator-measured data and evaluation feedback by the end user. The third party is responsible for the security and privacy of personal information exchanged between end users and third parties participating in the OUx ecosystem (e.g., over the application layer).

OUx Anonymized Personal Information – Only metadata that has been anonymized is shared with third parties participating in the OUx ecosystem. Information that is shared with third parties participating in the OUx ecosystem may be crowdsourced. Care needs to be taken to retain useful information while being anonymized. It is not easy to develop truly anonymized information that is still useful.

E.5 Timescale for Actions Taken and Data Generated

In some cases, personal information is needed in real-time, or near real-time, to react to situations where the operator's network needs to respond quickly to maintain the end user's Ux. This puts some reaction time constraints on where and how the information is stored

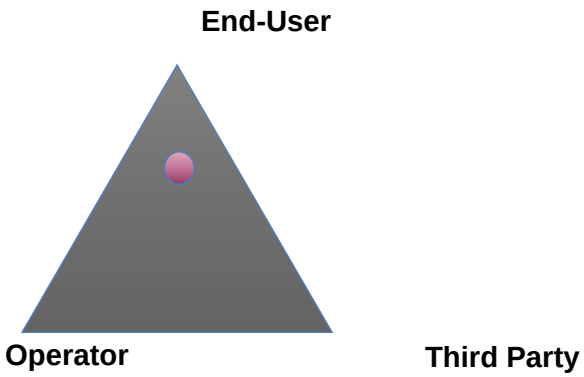
Other cases, such as performing analytics on raw data, do not require real-time processing.

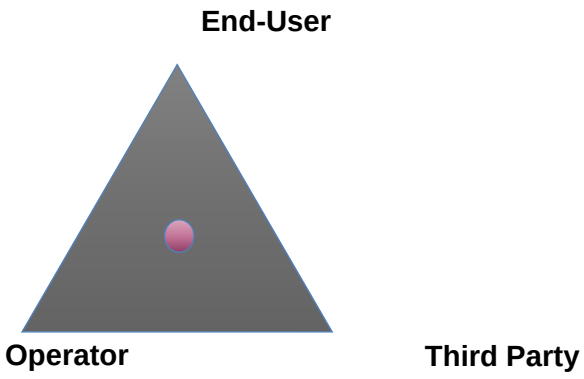
E.6 Extensibility via Workbench Approaches

- Depending on the service offerings provided by various network operators, there may be differences in what personal information is needed.
- The stored personal information should be extensible for carrier-specific use.
- The method used to anonymize personal information should be extensible for carrier-specific applications.
- The method of encrypting personal information or metadata should be extensible for carrier-specific use.

F Ux-Driven Marketing and Customer Care Scenario Description

F.1 Scenario Description





This scenario is about leveraging measured and predicted end-user experience (Ux) to enable more effective service/content marketing and customer care. The ability to measure and utilize direct end-user Ux ratings [coupled with localized, ***granular***[3] analytics that determine current and predict likely Ux into the future (see Scenario N Ux Prediction/Ux Driven Traffic Prediction)], enable better target marketing of content/services and more proactive and effective customer care.

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[3] ***Granular*** is a defined term used within this and other Scenarios to describe the level of specificity of measurements, end-user Ux ratings data, or trends collected or produced. Data and trends should be produced, collected and stored by network location, time of day/day of year, applications/content used, class of end-user, and by any other information that is deemed important to the Ux processes used by a particular realization of the OUx ecosystem. Such ***granular*** data shall be time and location stamped so that it can be correlated with network failure events and changes in network configuration, capacity or interconnect structure.

As explained in Scenario N, the following types of predicted present and future Ux and associated applications/content utilization levels are available to support Service/Content Marketing and Customer Care:

- Measured and projected trends in the usage of specific applications and content as measured over time. These projections will be trended at both a ***granular*** and on a shared network or third-party element level. Use of ***Granular*** measurements and projections will enable changes in the originating location of trended applications and content to be taken into account in the creation of projections for shared elements. This information will also be correlated with end-user Ux ratings data to produce ***granular*** views of present and projected Ux.
- Additional projections of applications/content usage including emergence of new or retirement of existing applications/content as entered by Traffic Engineering and network management personnel. The operator-entered projections may be ***granular*** in nature as well as applied to segments of the supporting elements using a policy-based format. The information outlined in this bullet will also be correlated with end-user Ux ratings data for emerging applications/content to produce ***granular*** views of present and projected Ux.

Support for Service Marketing

Marketing efforts can be enhanced as follows via Ux data:

- Projected trends of important applications and content coupled with the delivery of an OUx by the OUx ecosystem enables marketing efforts to focus on the services end users prefer to utilize and are growing most rapidly. Competitive differentiation is created by optimizing the Ux for these important services.
- Data on delivered Ux can be used in advertising and other market-facing campaigns to emphasize the differentiated Ux delivered by the operator. Accurate projections of future Ux based upon planned network enhancements and other steps may be used to develop high level confidence in delivered Ux.
- The ability to identify, trend growth, and optimize Ux for emerging applications and content enables marketing teams to better understand important emerging content/service opportunities and develop appropriate offers and effective strategies early in the associated market lifecycles.
- The OUx ecosystem owner may use Ux data to understand the customer experience being delivered by participating third party applications and content providers. This enables the ecosystem host to more effectively work with its participating third-party providers to improve Ux and deliver value that motivates third party participation in the OUx ecosystem.

- The operator hosting the OUx ecosystem may extend some or all of these capabilities for direct use by participating third party applications/content providers. The OUx ecosystem shall have the ability to create tailored customer care "views" of the Ux data and analytics that are specific to a given third party's applications/content and end-users.

Support for Customer Care

Customer care is an important element of the Ux for the applications, content, and services provided by the OUx ecosystem owner and their associated participating Third-Party Applications and Content providers. The Ux data derived via the OUx ecosystem is used to enhance customer care in the following ways:

- Customer care personnel should be able to view the relevant ***granular*** Ux data (see Scenario N) when interacting with a customer concerning Ux performance or other problems with that customer's services, applications, and content. The real-time, granular (time, location, application specific, end-user specific, etc.) Ux data (measured, predicted, and specific end-user entered ratings) relevant to the end-user's specific location and applications/content being used in the network shall be available to customer care personnel to enable them to better understand the situation the user is facing and to assist the user in resolving their problems.
- The OUx ecosystem shall provide policy based "alarm-like" reporting to customer care and operations personnel based upon levels of ***granular*** Ux. The policies that enable such reporting should take full advantage of the ***granular*** Ux detail outlined in Scenario N and shall also include the capability for different policies to be applied to different groups of users as defined by the OUx ecosystem owner and the workbench capabilities of the OUx ecosystem.
- The alarm-like capabilities may be used to proactively contact important large customers (example enterprise customers) concerning potential degraded Ux situations. Proactive notification of Ux issues and/or improvements could also be provided to consumer end users as an extension to or in conjunction with the Ux feedback mechanisms outlined as part of Scenario D Ux Feedback to End-User.
- The operator hosting the OUx ecosystem may extend some or all of these capabilities to participating Third Party applications/content providers. The OUx ecosystem shall have the ability to create tailored customer care views of the Ux data and analytics specific to a given third party's applications/content and end-users.

F.2 Value Proposition

End-User – The end-users' customer care experience is significantly improved by the abilities of the OUx ecosystem's host and participating third parties to better understand the level of Ux they are receiving. The option to proactively communicate potential Ux problems to large enterprise (and other groups of) end users is also a significant value-add.

Third Party – The ability to understand the Ux performance of their specific users' applications/content and to obtain relevant service trend data (including emerging new applications/content) can provide significant value to participating third parties. The same gains in overall Ux via improved customer care information may also be provided to participating third parties.

Network Operator – Customer care and its important role in the overall customer Ux is significantly enhanced via the mechanisms outlined above. The operator's ability to more effectively market existing and new applications, content, and service offerings is also significantly enhanced. Finally, the Ux information may be used to more effectively develop and manage the third-party aspect of the OUx ecosystem.

F.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Query relevant Ux data (past, present and predicted future) for existing services, applications, and content to support marketing activities	**Ux Performance Trends and OUx Anonymized Ux Info Databases**	Marketing capabilities outlined above.	Relevant past, present and future granular Ux levels for specific applications, content, and services.
View of the previous row filtered for a participating Third Party to support their marketing activities	As above plus information from the **OUx Ecosystem** Database to enable appropriate filtering of the Ux data	Third Party Marketing support capabilities outlined above.	Relevant filtered past, present and future Ux levels.
Query emerging applications/content and associated Ux data (past, present, and predicted future) to support new market and service development activities	**Ux Performance Trends and OUx Anonymized Ux Info Databases**	Marketing capabilities outlined above.	Relevant past, present and future granular Ux levels for specific applications, content, and services.
View of the previous row filtered for a participating Third Party to support their new market and service development activities	As above plus information from the **OUx Ecosystem** Database to enable appropriate filtering of the Ux data	Third Party Marketing support capabilities outlined above.	Relevant filtered past, present and near-future Ux levels.

Interaction	Source	Target	Info Exchanged
Query the current Ux performance for a specific network location, applications/content type, etc. to support a customer care event	**Ux Performance Trends and OUx Anonymized Ux Info Databases**	Customer Care capabilities outlined above.	Relevant past, present and near-future Ux levels.
View of the previous row filtered for a participating Third Party	As above plus information from the **OUx Ecosystem** Database to enable appropriate filtering of the Ux data	Third Party Customer Care capabilities outlined above.	Relevant filtered past, present, and near-future Ux levels.
Granular, policy-based alarming of Ux	**Ux Performance Trends and OUx Anonymized Ux Info Databases**	Customer Care alarming capabilities outlined above.	Relevant past, present, and near-future Ux levels.
View of the previous row filtered for a participating Third Party	As above plus information from the **OUx Ecosystem** Database to enable appropriate filtering of the Ux data.	Third Party Customer Care alarming capabilities outlined above.	Relevant filtered past, present, and near-future Ux levels.

F.4 Summary of Data Derived or Used

OUx Performance Trends Database – This database is managed by scenarios J, K, and N. It stores predicted and actual measurements of Ux performance levels. The data needs to be ***granular*** (see definition above). The data stored should be time and location-stamped so that it can be correlated with network failure events and changes in network configuration, capacity, or interconnect structure.

OUx Anonymized Ux Info Database – Stores anonymized summary information about end-user experience. Information is filtered and anonymized by analytics based upon, in part, end-user opt-in/out choices.

OUx Ecosystem Database – Stores information about the participating applications, content, and other third-party systems.

F.5 Timescales for Actions Taken and Data Generated

The analytics and Ux data update capabilities outlined here need to be executed frequently enough so that the associated measurements, trending, and predictions of Ux data remain accurate as new measured traffic data and Ux ratings become available. This is particularly important for the scenarios outlined above, so that customer care personnel may access current information relative to the specific end user with which they are interacting.

F.6 Extensibility via Workbench Approaches

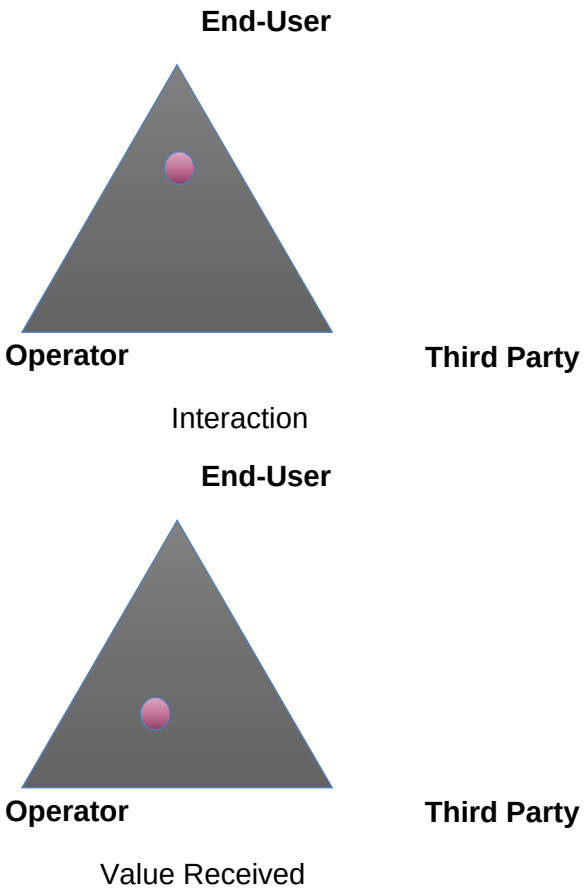
It is likely that significant additional value can be gained via custom analytics that correlate the Ux data outlined above with other relevant information for market analysis and customer care purposes. For example, it might be desirable to overlap Ux data with demographic, population, or other data to conduct an evaluation of the potential market plans for a new content offer or service. It may also be desirable to correlate customer care work levels with present and projected future Ux based upon different network engineering scenarios. The OUx ecosystem should support the utilization of outside databases and the creation of custom analytic packages to enable these and other enhanced analytics-based scenarios.

The ability to create appropriate views for third parties who participate in the OUx ecosystem will likely require a workbench system that enables the operator hosting the OUx ecosystem to create customized marketing and customer care views and associated value-added analytics

that limit the presentation of Ux and associated data as appropriate for a given third party situation.

G Ux Centric Crowdsourcing via Analytics – Types and Sources

G.1 Scenario Description



This scenario covers the sources used and results generated by analytics that determine end-user Experience (Ux) assessments for the Optimized User Experience (OUx) ecosystem. The ability to measure and utilize direct end-user Ux ratings coupled with localized, ***granular*** analytics that determine current and predict likely Ux into the future enable many of the functions and value creation mechanisms of the ecosystem.

The Ux ratings directly entered by end-users (see Scenario C) will, in most cases, be the primary data source used to product the assessments of Ux outlined below. The end-user ratings will be normalized and "calibrated" based upon analytics-based comparison to other users and direct applications, device, and network measurements to produce a ***crowdsourced view*** of Ux. The

data will be correlated and adjusted based upon measured sources (see below) to further normalize the resulting Ux assessments as well as to provide correlation factors to measured data to enable more effective network optimization, management, and engineering (see Scenario F).

The following sources are used by the Ux analytics algorithms to measure and predict Ux:

- Directly entered end-user ratings of Ux for their applications/content (see Scenarios B and C).
- Relevant measurements taken on end-user devices.
- Relevant measurements taken within Third Party Applications.
- Relevant measurements taken within Third Party Servers and associated transport networks (see Scenario H).
- Relevant measurements taken within the hosting operator's access, core, and transport. networks as well as the supporting systems such as backend servers, applications running on end-user devices, content caches (see Scenario L), etc.
- Other measurements added via workbench approaches by the OUx ecosystem owner.

There may be differing levels of detail and accuracy of some of the data outlined above. For example, location data might be very precise if device-based GPS information is available. Otherwise, less precise network derived location data could be used. The analytics algorithms should be robust enough to accommodate data of varying degrees of accuracy and availability. The analytics should also be able to provide relative estimates of the resulting Ux measurements based upon such uncertainties in the availability or accuracy of the input data. The Ux analytics combine and correlate the above-mentioned sources to provide three basics types of ***granular*** Ux data:

- **Present Ux Analytics** – The Ux analytics produce ***granular*** assessments of current Ux. The ***granular*** nature of these analytics makes Ux data available for specific locations, time of day/day of week/etc., specific applications/content, specific groups of related end-users, specific third-party applications/content, etc. The granularity of these Ux assessments are extensible using workbench approaches that enable the ecosystem owner to extend and customize the Ux assessment analytics
- **Historical Ux Analytics** – The Ux analytics will use the ***Present Ux Analytics*** along with correlations to network traffic patterns, applications/content usage, direct end-user Ux ratings, and other factors defined through workbench capabilities to produce a historical view of Ux at a ***granular*** level. The historical correlations and end-user entered data are important insights into the underpinning variables that determine the granular Ux assessments, and these correlations form a basis for predicting future Ux.

- **Future Ux Predictions** – The Ux analytics will produce ***granular*** predictions of likely future Ux based on the results and correlations generated via the previous two bullets. The future predictions are an essential element in many of the OUx functions and should be ***granular*** enough to support per-user functions (see Scenarios D and J for important examples of this) as well as other OUx ecosystem functions.

The Ux analytics shall have the following additional capabilities and characteristics:

- The Ux projections will be generated at a level ***granular*** for elements in both the ecosystem owner's and for participating third party's networks.
- Use of ***Granular*** measurements and projections will enable changes in the originating location of trended applications and content to be taken into account in the creation of projections for shared network elements.
- Ux analytics projections of applications/content usage shall include information about emerging new or declining existing applications/content. The emerging/declining applications/content projections shall also be ***granular*** in nature so that they may be correlated with users, network elements, etc.

All of the Ux analytics should be run frequently enough to create appropriate time-based levels of accurate assessments of ***Present***, ***Historical,*** and ***Predicted*** Ux on a ***granular*** basis. See the section related to *Timescales for Actions Taken* for the details.

The analytics that produce the Ux assessments are based upon the end-user opt-in and sharing controls outlined in Scenario A, and the generated data should be protected as explained in Scenario E. The Ux information may be used by both the OUx ecosystem owner and participating third party partners as explained in Scenario I.

G.2 Value Proposition

End User – The end-user's customer care experience is significantly improved by the abilities of the OUx ecosystem's host and participating third parties to better understand and predict the level of Ux they are receiving.

Third Party – The ability to understand the Ux performance of their specific users' applications/content and to obtain relevant service trend data (including emerging new applications/content) can provide significant value to participating third parties.

Network Operator – The ability to understand Ux performance and to plan/operate their network based upon Ux enables the operator to more directly focus on the service and management elements of their network that most contribute to end-user satisfaction and value.

G.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Query relevant Ux data (past, present, and predicted future) for existing services, applications, and content to support other OUx ecosystem functions.	**Ux Performance Trends Database**	OUx ecosystem functions	Relevant past, present, and future granular Ux levels for specific applications, content, and services.

G.4 Summary of Data Derived or Used

Ux Performance Trends Database – This database stores predicted and actual measurements of Ux performance levels. The data needs to be ***granular*** (see definition above). The data stored should be time and location stamped so that it can be correlated with network failure events, changes in network configuration, capacity, or interconnect structure.

G.5 Timescales for Actions Taken and Data Generated

The analytics and Ux data update capabilities outlined here need to be executed frequently enough so that the associated measurements, trending, and predictions of Ux data remain accurate as new measured traffic data and Ux ratings become available. This is particularly important in scenarios such as D, F, and J where near real-time views of measured Ux and Ux predictions are important. It is envisioned that the Ux analytics will be executed both on a periodic and demand-triggered basis. The periodic execution frequency intervals should be policy-based and granular to create an appropriate balance between real-time accuracy and network computing load. These automatic execution policies should be granular in nature such that the frequency of executing the Ux analytics can be flexibly tailored to the situation (e.g., the frequency might vary based upon the nature and level of end-user activity and other impacting traffic in a given location).

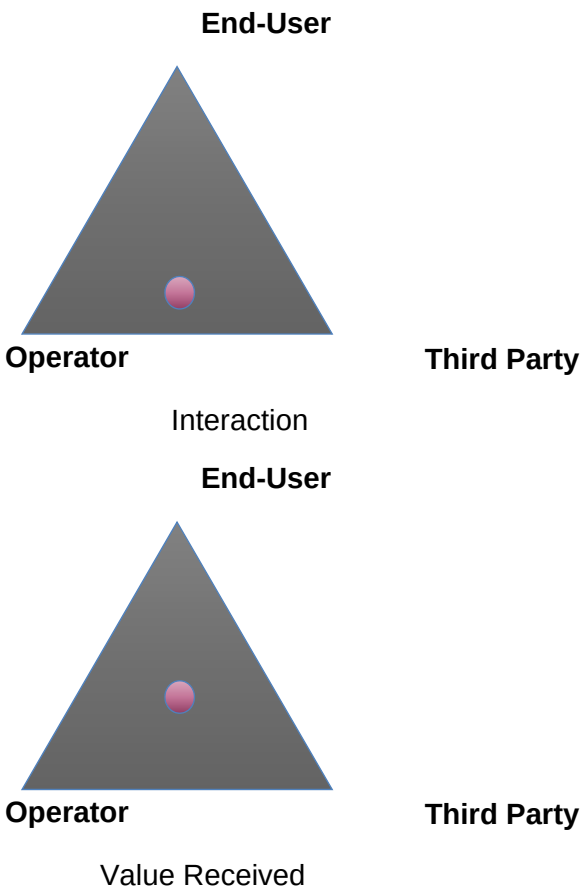
G.6 Extensibility via Workbench Approaches

It is likely that significant additional value can be gained via custom analytics that correlate the Ux data outlined above with other relevant information. The OUx ecosystem should support the utilization of outside databases and the creation of custom analytic packages to enable enhanced analytics-based scenarios.

The ability to create appropriate views for third parties who participate in the OUx ecosystem will require a workbench system that enables the operator hosting the OUx ecosystem to create customized views and associated value-added analytics that limit the presentation of Ux and associated data as appropriate for a given third party situation. See Scenario I for details.

H Backend Ux Measurements

H.1 Scenario Description



Applications and Content Backend Servers and the networks that connect them to end users play a critical role in the Ux for the end users they support. The infrastructure that supports the delivery of applications and content may be owned by third parties or the OUx ecosystem owner.

The following elements are in scope in terms of OUx ecosystem platform components that support backend measurements:

- Applications/content root servers and their associated data center interconnect and storage systems
- Applications/content specific Content Delivery Networks that may provide distributed caching of content, offload of script, and other programmatic execution to enhance performance and scale
- Wide area interconnect infrastructure performance that directly relates to the applications/content services being delivered)

It is to be expected that backend measurement systems will be somewhat unique to each specific applications/content provider's solution. This said, each customized measurement solution should all have the following characteristics:

- Measurements should be timestamped to allow them to be correlated with other measurements, end-user activities, and end-user ratings (see Scenario C)
- Measurements should be associated with specific end-users and their activities where possible. This might take the form of end-device IP addresses, session IDs, or some other indirect form enabling such associations of the measured data to specific users to be made.
- Measurements should be associated with specific applications or content being served where possible
- Measurements should be associated with the path taken by the associated traffic between its origination and terminating points. In the case of a participating third party's traffic traversing a path to the OUx ecosystem owner's network via a backbone connection, both the third-party provider and the OUx ecosystem owner may need to contribute information to enable a full understanding of the path taken and its impact on Ux.

The data generated by these measurements will be stored in a database within the OUx ecosystem and will be subject to the protections outlined in Scenario E. It is expected that the backend measurement data described here will be primarily used by analytics as outlined in Scenario F.

H.2 Value Proposition

End User – The end-user's experience is significantly improved by the OUx ecosystem's host and participating Third Parties ability to better understand, predict, and optimize the full scope of elements involved in the delivery of the applications/content Ux they are consuming.

Third Party – The ability to understand the impact that their infrastructure has on Ux performance of their users' applications/content is enhanced. Also, their ability to directly relate the performance of their backend and interconnecting infrastructure to delivered Ux enables them to better engineer and optimize their infrastructure.

Network Operator – In their role of delivering applications/content via their own backend systems, the network operator gains a better understanding of the impact that their infrastructure has on Ux performance for their users' applications/content. In their role as a wireless network provider, they also gain a clearer picture of how their network's performance impacts third party backend systems and the associated Ux that is delivered.

H.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Storage of backend measurements within the OUx ecosystem.	Backend systems and connectivity that support associated applications/content delivery and services.	**OUx Anonymized Ux Info Databases**	The measurements outlined above.
Obtain information that relates backend measurements to Third Party Users, Applications/ Content, etc. as outlined above.	**OUx Ecosystem Database**	Analytics and other OUx Ecosystem functions that utilize the measurements outlined here.	The relational information outlined above to enable association of the measurements with specific users, applications/content, and supporting elements.

H.4 Summary of Data Derived or Used

OUx Anonymized Ux Info Database – stores anonymized summary information about end-user experience. Information is filtered and anonymized by analytics based upon, in part, end-user opt-in/out choices.

OUx Ecosystem Database – stores information about the participating applications, content, and other third-party systems.

H.5 Timescales for Actions Taken and Data Generated

The measurements outlined here should be recorded frequently enough that the resulting data may be used to accurately understand and predict Ux. They may also be used to identify how the backend infrastructure's performance is impacting delivered Ux at the present time and into the future. The elements of the OUx ecosystem solution that support these measurements will need to have a policy-based component to vary the frequency of the measurements based upon factors such as time of day, day/week/month/year, type or ID of end-users, nature of the applications/content involved, etc. The control infrastructure for backend measurements should support on-going collection of data during "normal" operation as well as more frequent or detailed collection to enable specific analytics, associated Ux, and other studies.

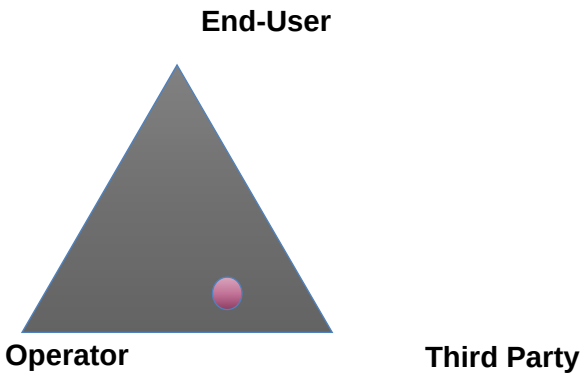
H.6 Extensibility via Workbench Approaches

As indicated above, the set of measurements taken will likely vary between different applications, content, and service providers. This will require that the backend measurements component of the OUx ecosystem be easily extended and customized for a given application while consistently gathering the associating information to enable the measurements to be correlated by analytics (see above). The components of the OUx solution that support backend measurements should provide the base set of time stamping and other functions common to all backend measurements as outlined above.

The ability to create appropriate analytics capabilities for third parties who participate in the OUx ecosystem will require a workbench system that enables the operator hosting the OUx ecosystem to create customized views and associated value-added analytics limiting the presentation of Ux and associated measured data outlined here as appropriate for a given third party situation. See Scenario I for details.

I Third Party Access to Crowdsourced Ux Information Scenario Description

I.1 Scenario Description



This scenario is about allowing controlled access to third party specific measured and predicted OUx to enable third parties who choose to participate in the OUx Ecosystem to provide an improved Ux to their customers. Measured and direct end-user Ux ratings have been appropriately:

- Filtered for a given Third Party's applications/content and users
- Anonymized and merged in a ***Crowdsourced*** format via analytics and coupled with ***Granular*** analytics and
- Verified with opt-in (see scenario A), privacy (see scenario B), and access/information protection controls (see scenario E).

These capabilities enable participating third-party players to provide a better and more consistent Ux for their users as well as more effective target marketing of their content/applications as well as more proactive/effective customer care.

To have access to the ***Crowdsourced*** Ux information described here, a participating third-party Applications/Content provider should do the following (at a minimum):

- Create a business relationship with the provider who hosts the OUx ecosystem that includes access to filtered Ux information
- Provide a means for the OUx ecosystem host to identify the third party's end users so that only the information relevant to their end-users is shared. OUx ecosystem opt-in and end-user preference choices (see Scenarios A and B) for the identified customers will include opt-in/permission to share data with third parties and will be used to determine what information may be used to create the ***Crowdsourced*** view of Ux for a participating third party.
- Provide a means so that the OUx Ecosystem host can identify the applications/content delivered by the participating third party for Ux information specific to the third party's services to be identified and included in the views provided.
- Agree to properly use and appropriately protect the Ux information received.

As explained in Scenario N, predicted present and future Ux for a third party's end users and the associated applications/content utilization levels are available to participating Third Parties in a ***Granular***, ***Crowdsourced*** format. This information includes measured and projected trends in the usage of third party specific applications/content as measured over time. These projections will be trended on a shared network element and a third-party element level. Use of ***Granular*** measurements and projections will enable changes in the originating location of trended applications and content to be taken into account in the creation of projections. The measured information will also be correlated with the relevant end-user entered Ux ratings data (see Scenario B) to produce ***Granular, Crowdsourced*** views of past, present, and projected future Ux.

The OUx ecosystem shall have the ability to create customized views of the relevant Ux data and associated analytics specific to a given third party's applications/content and its end-users. The OUx ecosystem will also provide an analytics workbench that enables a participating third party to develop its own analytics-based, ***Crowdsourced*** views of its customers subject to the protections and controls on individual customer opt-in and preference/privacy controls (Scenarios A and B).

The OUx ecosystem shall also have the ability to provide customized Ux-centric "alarming" to notify participating third-party players when the level of Ux being provided to end users drops below a specific level (see Scenario F for details). Such alarms would be useful for the third party's customer care, network management, and other OA&M activities.

I.2 Value Proposition

End User – The overall end-user's Ux is significantly improved by the participating third party's ability to better understand and optimize the level of Ux it is delivering. The option to proactively communicate potential Ux problems to participating third party's enterprise and/or other groups of end users is also a significant value-add.

Third Party – The ability to understand the Ux performance of the third party's specific users' applications/content and to obtain relevant service trend data provides significant value to participating third parties. This will be especially true for small and mid-size players who may not have the ability to create as complete a view of their end-user's Ux as that provided by the OUx ecosystem.

Network Operator – By working with participating Third-Party players to improve end-user Ux for their customers, the operator improves the overall experience for their customers as well. The value provided to Third Party and the users of their applications/content provides motivation for Third Party participation in the Operators OUx ecosystem.

I.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Query relevant Ux data (past, present, and predicted future) for Third Party applications/content to support the Third Party's OUx management, marketing, and customer care activities.	**Ux Performance Trends and OUx Anonymized Ux Info Databases**	Creation of Third Party filtered views of Ux.	Relevant filtered past, present, and future granular Ux levels for Third Party specific applications/content.
Policy-based alarming of Ux filtered in such a way as to be relevant for a participating Third Party.	**Ux Performance Trends and OUx Anonymized Ux Info Databases**	Third Party alarming capabilities outlined above.	Relevant past, present, and near-future Ux levels.
Analytics that generate filtered views and "alarming" of Ux data for Third Party specific applications, content, and customers.	**OUx Ecosystem Database**	Third Party filtering for Ux analytics and "alarming" functions.	Information needed to filter information to include only Third Party specific applications, content, and end-users.

I.4 Summary of Data Derived or Used

OUx Performance Trends Database – This database is managed by scenarios J, K, and N. It stores predicted and actual measurements of Ux performance levels. The data needs to be ***Granular*** (see definition above). The stored data should be time and location stamped so that it can be correlated with network failure events and changes in network configuration, capacity, or interconnect structure.

OUx Anonymized Ux Info Database – Stores anonymized summary information about end-user experience. Information is filtered and anonymized by analytics based upon, in part, end-user opt-in/out choices.

OUx Ecosystem Database – Stores information about the participating applications, content, and other third-party systems. This database also stores the information required to identify which end users, applications, and content are part of a given participating third party's customer and service set and to filter Ux information to make it specific to a participating third party's applications, content, and end users.

I.5 Timescales for Actions Taken and Data Generated

The analytics and Ux data update capabilities (outlined here) need to be executed frequently enough so that the associated measurements, trending, and predictions of Ux data remain accurate as new measured traffic data and Ux ratings become available. This is particularly important for the customer care and associated Ux alarming scenarios outlined above so that participating third party personnel may access current information relative to the specific end-user with which they are interacting.

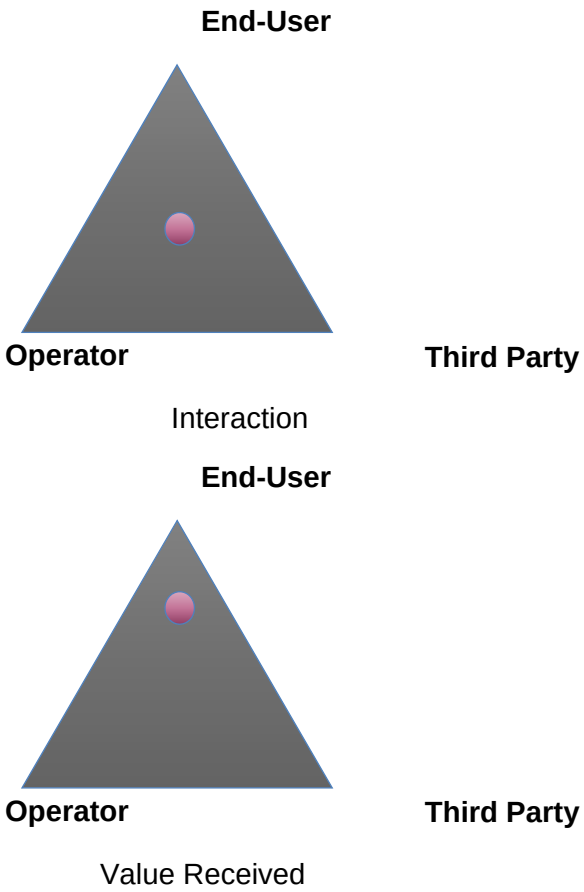
I.6 Extensibility via Workbench Approaches

The OUx ecosystem should support the utilization of outside databases and the creation of custom analytic packages to enable these and other enhanced analytics-based scenarios.

The ability to create appropriate views for Third Parties who participate in the OUx ecosystem will likely require a workbench system that enables the operator hosting the OUx ecosystem to create customized views and associated value-added analytics, which limit the presentation of Ux and associated data as appropriate for a given Third Party situation.

J Micro-Optimization (Per User Optimization)

J.1 Scenario Description



In this scenario, the operator's network and its supporting infrastructure, including that of third parties who participate in the OUx ecosystem, work together to provide a Ux tailored to the preferences of individual participating end users. The micro-optimizations are applied on top of the macro-optimizations outlined in **scenario K - Macro-Optimization (network wide, localized optimization)**. The micro-optimizations provided for a given end user are based upon:

- The end user's appropriate opt-in to the OUx ecosystem (see scenario **A - Opt-in, Opt-out, Sharing controls**).
- The preferences selected by the specific end user for Ux for their applications and contents (see scenario **B- Ux Preference Selection**)
- The specific applications/content the end user is using at the current time
- The overall traffic and other conditions on the network and the third-party servers in use at the time. The infrastructure elements targeted for "fine-tuning" associated with per-user micro-optimization should be as targeted as possible so as not to apply the user specific optimizations to elements that will not have an impact on the target end-user's desired Ux.

There are a wide range of potential micro-optimization that could be provided for a given end user to meet Ux goals. The specific set used will be different for each realization of the OUx ecosystem. The set of available optimizations should include:

- The ability to pre-position content and bandwidth for use by a given end user (see scenario **L -Predictive content and BW positioning**).
- The ability to adapt content to deliver the best possible Ux on a specific end-user's device and network connection at the time of use (see scenario **M - Network-Aware Content Adaptation for Third-Party Content Providers**).
- The ability to move a specific end-user's traffic to the best available access network based upon that end-user's Ux requirements and the applications/content in use.
- The ability to adjust the route taken for a specific end-user's traffic through the network including the selection of CDNs, servers and other elements used ***for each traffic type and associated user specific priority*** so that the end-user's specific Ux goals can be met.
- The ability for participating third party providers involved in meeting a specific end-user's Ux goals to adjust the allocation of their resources and associated traffic routing to meet the end-user's specific Ux goals.
- Other ecosystem owner defined optimizations should be easily included in this set using the workbench model for the OUx ecosystem.

Per-user analytics are required to monitor each participating end-user's Ux requirements based upon the applications and content in use at the current time. The analytics will then adjust the various targeted optimizations outlined above to do the best possible job of meeting each end-user's Ux goals. It is expected that the analytics will operate frequently enough to deliver the end-user's targeted Ux on a ***perceived*** (by the end user) near real-time basis. Note that this may not require the analytics to take an entirely real-time approach. Rather, the analytics will likely scale best if they use the information available to them, in part, to predict what resources and content a given end user will need and take advantage of pre-positioning and other optimizations outlined above.

These analytics will also provide predictions to the end-user with Ux feedback likely to be received as outlined in scenario **D - Ux Feedback to End-Users.**

The per-user analytic routines should also provide results to the following scenarios for use in algorithms that plan or adjust network-level capacity and optimizations to best meet the overall needs of the user base:

- K - Macro-Optimization (network wide, localized optimization).

- L - Predictive content and BW positioning.
- M - Network-Aware Content Adaptation for Third Party Content Providers (this will involve an interaction with the Third Party to understand the profile of video BW and buffer requirements along with triggers to optimize the loading of client-side buffers associated with the Third Party's application).
- N - Ux Prediction/Ux Driven Traffic Prediction.
- O - Ux Driven Capacity Engineering.
- P - Ux Driven Network OA&M.
- Other network optimization, management, and planning scenarios added to a given implementation of the OUx ecosystem using workbench approaches.

The controlling analytics are required to provide information about the optimizations they trigger in the form of anonymized measurements, trends, and statistics so that the OUx ecosystem host may understand and adjust the performance of these algorithms appropriately.

J.2 Value Proposition

End-User – The end-user who opts-into the OUx solution and provides their Ux priorities/preferences will receive an improved Ux via optimized adjustment of resource staging and controls as applied to the specific applications/content they are using at a given point in time.

Third Party – Third Parties receive value because their applications and content can be delivered in a way that meets their user's expectations. Also, their resources can be allocated more effectively to deliver the Ux expectations of their end-users on a near real-time basis.

Network Operator – The operator's ability to efficiently provide a superior Ux tailored to the needs of each of their customers is an important value item and competitive differentiator. The network operator receives significantly increased value for location related services when they are combined with historical information through analytics to predict and properly manage the pre-staging of content and applications along with other per-user optimizations. The operator also realizes significant gains via improvements in network utilization and associated OPEX reduction from a more targeted and time/actual usage specific application of network capacity and other resources.

J.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Network Gathers Data periodically to understand what participating end-users are doing and where they are doing it.	Device, cell or WiFi-based location updates, information from end-user applications, devices, and network-based measurements.	Analytics to optimize specific end-user's Ux.	Indication of applications/content being used, location of use, and time of use.
User Opt-in, Ux priority and ratings data.	OUx Databases (see below)	Analytics to optimize specific end-user's Ux.	User's specific Ux priority and ratings received for relevant applications and content.
Crowdsourced ratings data from other users for similar locations/ TOD/ applications/content.	OUx Databases (see below)	Analytics to optimize specific end-user's Ux	Crowdsourced view of other user's ratings for priority applications/ content that are relevant to the micro-optimization process.
Sharing of predicted Ux and associated predicted adjustments in resource staging, routing etc.	Analytics outlined here	Other scenarios outlined in the body of this report including predicted Ux performance feedback to individual end-users.	Statistics, trends and predictions of Ux resulting from the per-user optimizations provided as part of this scenario.

Interaction	Source	Target	Info Exchanged
Interaction with participating Third Parties to adjust applications/content delivery performance for specific users.	Analytics outlined here	Third Party-specific optimization actions. Examples include triggering of content or BW staging, backbone routing changes, sever/CDN re-allocations, determining video buffering, BW capabilities and requirements, etc.	Triggers of available optimizations. The set available will likely be somewhat dependent on the individual participating third party.

J.4 Summary of Data Derived or Used

User's location data (Present and predicted next location) – Data stored for end-user's who have opted into the OUx ecosystem. Location changes are trended via historical path and current path analytics to predict likely next location(s).

User Opt-in and Content Preferences Store – Data store for information about individual user's applications/content preferences and participation in the OUx ecosystem.

OUx User Ratings Database – Stores end-user ratings and associated measured information in an encrypted form. Appropriate access controls shall be applied before the data can be viewed or utilized.

OUx Anonymized Ux Info Database – Stores anonymized summary information about end-user experience. Information is filtered and anonymized by analytics based upon, in part, end-user opt-in/out choices.

OUx Ecosystem Database – Information about the participating applications, content, and other third-party systems that require opt-in/out choices by end-users.

J.5 Timescales for Actions Taken and Data Generated

- A combination of user-specific prediction and periodic assessment of specific users' Ux and the associated relationship to trends in near real-time network and third-party traffic patterns will be required to create a perceive "near real-time" level of user specific optimization.
- Unpredictable events (example element failure or major reconfiguration) should be able to controllably trigger appropriate adjustments in the operation of the analytics routines that manage the per user optimizations outlined in this scenario.

J.6 Extensibility via Workbench Approaches

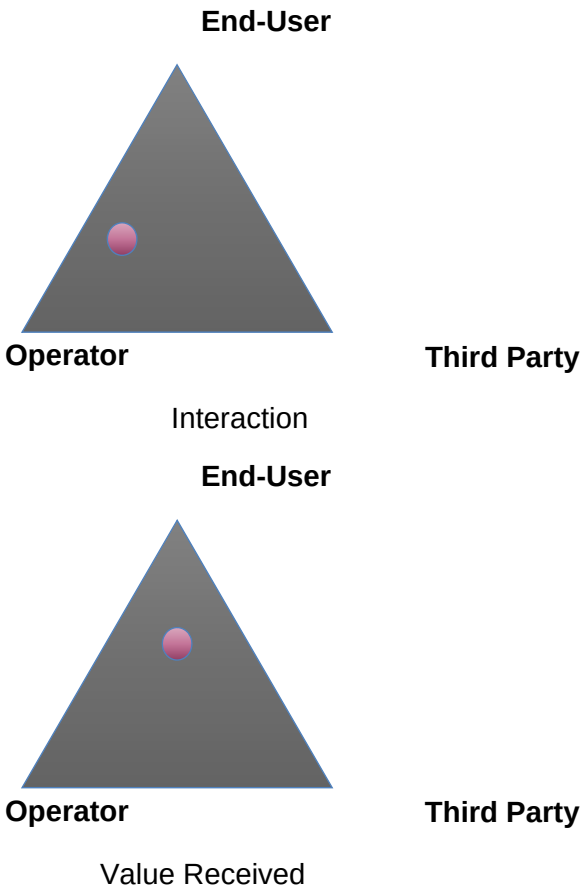
The set of available optimizations as well as the specific analytics routines used in this scenario should be extensible and customizable by the operator hosting the OUx ecosystem. These extensions should accommodate the needs of both the hosting operator, participating third party providers, and the evolving set of end-user applications and content.

The data provided for use by other scenarios is also an important area for extensibility. The network level automated macro-optimizations as well as OA&M and Traffic Engineering

scenarios will likely use statistics, trends, and other information produced by the analytics employed in this scenario.

K Macro Optimization (network wide, localized optimization)

K.1 Scenario Description



This scenario describes potential macro network optimizations that can be enhanced as a result of using additional OUx measurements derived from a combination of direct end-user ratings and other inputs. This enhances self-optimization and automatic configurations of network resources that the operator network will deploy with real time network conditions using, for example, SDN (software defined network) controllers. Although SDN technologies are one of the primary future network resource control mechanisms, it is possible to develop current scenario using other existing technologies, for example, application level service control using 3GPP defined PCC architecture (although the scope of that control is limited). This scenario covers end

to end elements and functions including UE, RAN, core network, packet data network, application servers, and third-party functions such as content servers. All of these elements can be viewed as network resources. An example of the use case would be to detect and remedy network issues that impacts user experience in real or near real time and the network adjust its resources to meet the demand of OUx. In addition, such mechanism can detect and act on each elements within the data path with a hierarchical service control architecture (global domain and local SDN controllers) Additional benefits for operators and third party is that the data can be used to enhance network elements and functions and historical data could also be used for predictive analysis (using big data and AI).

One aspects of the SDN is the centralized control of network resources. This enables network wide optimization because it centralized the decisions and actions that can affect multiple networks, devices, applications, and content delivery components. The SDN architecture allows hierarchical or federated partitioning of the network according to geographical, business, organizational, and other boundaries. This make it very flexible to have control both at wide network level and local network levels so both network wide and localized optimizations are possible. Centralized control is a logical design concept. It does not mean a single control entity in the network but rather, for example, a hierarchical control architecture where local domain can have its own control so local decisions can be made locally and efficiently.

For network wide optimization, the SDN controller is at the center of a feedback loop: it is aware of the network resources availability in real time and applies these resources based on the service requirements. It supports real time optimization of changes in the network resources and services requirements. This feedback loop involves wide network (depending on the controller's domain of control) and can react quickly to any changes in user experience if these experiences are quantified meaning that these feedback from users are actionable. For macro network optimization, the SDN controller acts autonomously based on operator polices where network resources and user experiences can be optimized. Implementing this scenario will require the following:

- A SDN like architecture in the network.
- Cross domain (operator and third party) service information exchange so E2E traffic management is possible.
- The system behavior is directed by policies. A policy framework that can manage network wide policies and is capable of communicating policies with third party.
- A feedback loop that include user experience indicator inputs in real time. This input shall include timestamps, user locations, application session identity information, and other contextual information related to the specific application and services.
- Inputs and measurements from scenarios such as J and N.

- An action shall be associated with each of the detected or user inputs impacts.
- This mechanism can also work together, as part of the control mechanism, with other scenarios outlined in this paper such as predictive content and BW positioning (L), Network aware content adaption for third party content providers (M), and Ux driven capacity engineering (O).

K.2 Value Proposition

End-User – It is assumed that other scenarios that related to end user inputs and information protections are deployed and user inputs in real time or near real time is available. End-users will receive an improved Ux for their applications/content and usage patterns as a result of the optimization from this scenario.

Network Operator – It is assumed that all scenarios related to an operator's obligations are deployed and user inputs are available. The Network Operator benefits from this scenario by optimized network resources utilization and be able to take dynamic and targeted actions that can very quickly improved Ux. Since this is an E2E optimization, issues can be identified across domain of controls (all user inputs are anonymized. For example, the content server is overloaded and with long latency, operator network can be scaled 'down' temporarily to conserve network resources and vis versa. In addition, with this E2E optimization mechanism, automated and real time E2E service management becomes available, which can result in OPEX reduction.

Third party – The third party can get real time feedback on the network conditions that can match their network conditions, so this helps manage their resources effectively. In addition, with this E2E optimization mechanism, automated and real-time E2E service management becomes available, which can result in OPEX reduction.

K.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
End user provides request inputs.	End user	Network	Input on delay, jitters, availability of contents, etc.
SDN controller receive status on network resources and dynamically manages resources based on policies and user inputs.	Feedback loop: controller (i.e., SDN) and the Network functions	All network functions and the controller.	Network resources information such as compute, storage, networking capabilities, congestions, delays, QoS information, etc.
Between SDN and service controllers in operator network and third-party network.	Controllers	Controllers	Service related information such as resource availabilities, bandwidth, QoS, etc.

K.4 Summary of Data Derived or Used

OUx End User Personal Information – This is information provided by the End User that is specific to the End User (e.g., identity, preferences and opt-in/out choices). This is the user inputs about their experience and it is used to identify network resources that support a particular user and a particular service.

OUx Anonymized Personal Information – Only metadata that has been anonymized is with shared with Third Parties participating in the OUx Ecosystem. This information may be used to feedback into third party on network resource availability, so they can choose to match these resources to enhance overall Ux.

Network resources information – This info is used to feedback, in real time or near real time, to the SDN controller to manage network resources to meet the needs of enhanced Ux.

Network and service policies – The policies will cover both network wide and local functions that can manage network behaviors to enhance Ux.

K.5 Timescale for Actions Taken and Data Generated

In some cases, personal information, in this case, user inputs, is needed in near real time for the E2E system (the operator's network, application servers, and third-party servers) to optimize (such as taking actions quickly) to maintain or enhance the End User's Ux.

In some other cases, such as performing predictive analytics on raw data do not require real-time processing. Depending on applications, the time scale would vary based on the type of inputs and actions that are needed.

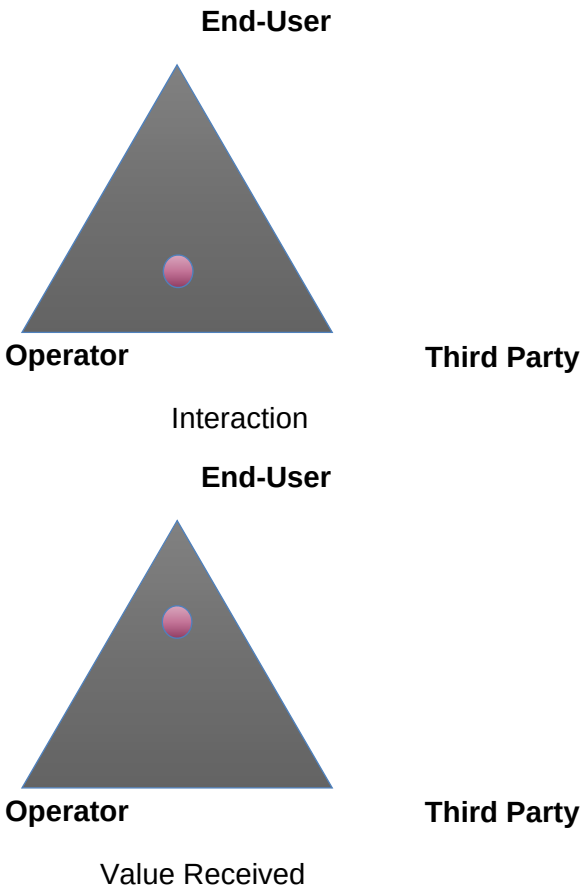
K.6 Extensibility via Workbench Approaches

- The resources being managed is totally extensible to include any new resources that is part of the managed domain or ecosystem.
- The architecture used are extensible to include any new policies, business models, business agreements, new services, etc.
- All user inputs data should be extensible to accommodate new user experiences.

This scenario does not work in isolation, rather, it will have to extend and work together with scenarios such as Ux prediction/Ux driven Traffic prediction (N) and Micro-Optimization (per user optimization, J) as inputs measurements to this mechanism, and as part of the control and influence mechanisms to other scenarios such as predictive content and BW positioning (L), Network aware content adaption for third party content providers (M), and Ux driven capacity engineering (O).

L Predictive Content and Bandwidth Positioning

L.1 Scenario Description



In this scenario, the network and its supporting infrastructure attempts to predict where content and access bandwidth will be needed in the network and pre-stage these resources to maximize Ux. This scenario also supports the staging of pre-purchased and real-time purchased content for rapid, close proximity delivery as described in the Proximity Point to Point Use Case in our OUx whitepaper. Implementing this scenario will require the following:

- A knowledge of impacted end-user's applications/content priorities as well as the content or applications that each end-user is currently using.
- A knowledge of where the user is physically located in the network along with their historical pattern of movement around their current location.
- Cooperation, via OUx ecosystem participation, with the content or applications provider associated with the user's current application to determine what content segments will be needed next by the end-user. This will allow the participating applications/content provider to trigger the pre-loading of content into the correct elements of the network so that it will be present when the end-user gets there.

- Analytics to determine when and where to trigger content or BW pre-staging and where in the network to pre-stage these resources. Note that these pre-staging actions will need to take number of end-user's applications latency needs into account. (ex. For content that is being streamed and buffered at the end-user's device, pre-staging might not be as high a priority as would be the case for pre-staging of Virtual or Augmented Reality content).
- The ability to exchange DRM related data where this is necessary to pre-stage content. Information about the content being viewed may also be shared between the Network Operator and third parties to improve effectiveness of the pre-staging.

Content could be pre-staged and served from caches or similar stores located close to the network edge or from another end-user's device in a peer-to-peer fashion.

L.2 Value Proposition

End-User – The end-user who opt-into the OUx solution will receive a much better Ux if content and bandwidth resources are appropriately pre-positioned. This is particularly true for latency sensitive content and applications. For some applications such as Virtual or Augmented reality and low-latency delivery of pre-purchase content, pre-positioning may be essential to delivering an acceptable Ux.

Third Party – Third Parties receive value because their applications and content can be delivered with a high Ux. For latency sensitive content and applications, this scenario may be the only practical way to deliver a consistently high Ux.

Network Operator – The network operator receives significantly increased value for location related services when they are combined with historical information through analytics to predict and properly manage the pre-staging of content and applications. The operator also realizes significant gains via improvements in network utilization and associated OPEX reduction.

L.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Network Gathers Data to Predict User's Next Location	Device, cell, or WiFi-based location updates.	Analytics to predict users next local	Generic form of user's coordinates. Derived or inferred from cell ID, GPS, IP address or other device specific location data.

			Analytics may be used to combine several of these items to produce more accurate Generic location information.
Predicted next location for user	Operator's Network	Third Party Content Provider	Trigger to pre-stage content or BW needed to meet the end-user target Ux.
Request to pre-stage content and/or BW	Third Party Application/ content provider.	Network Operator's network	Pointer to content pre-staging or BW requirements along with the target end-user ID(s). This interaction also serves to initiate or terminate location-based content or BW pre-staging for a given end-user.

L.4 Summary of Data Derived or Used

User's location data (Present and predicted next location) – Data stored for end-user's who have opted into the OUx ecosystem. Location changes are trended via historical path and current path analytics to predict likely next location(s).

Pre-staged Content/BW Applications Sessions – Used to track end-users currently engaged in an ecosystem application where pre-staging of content or BW is required.

Pre-staged Content Store(s) – Cache-like storage locations at the edge of the network and/or on peering user devices where content can be pre-staged.

User Opt-in and Content Preferences Store – Data store for information about individual user's applications/content preferences and participation in the OUx ecosystem.

L.5 Timescales for Actions Taken and Data Generated

- Analytics actions taken to trend end-user movement patterns will probably require averaging over a period of days, week or perhaps months
- Prediction of end-user's likely next location will need to be done in near-real time

L.6 Extensibility Via Workbench Approaches

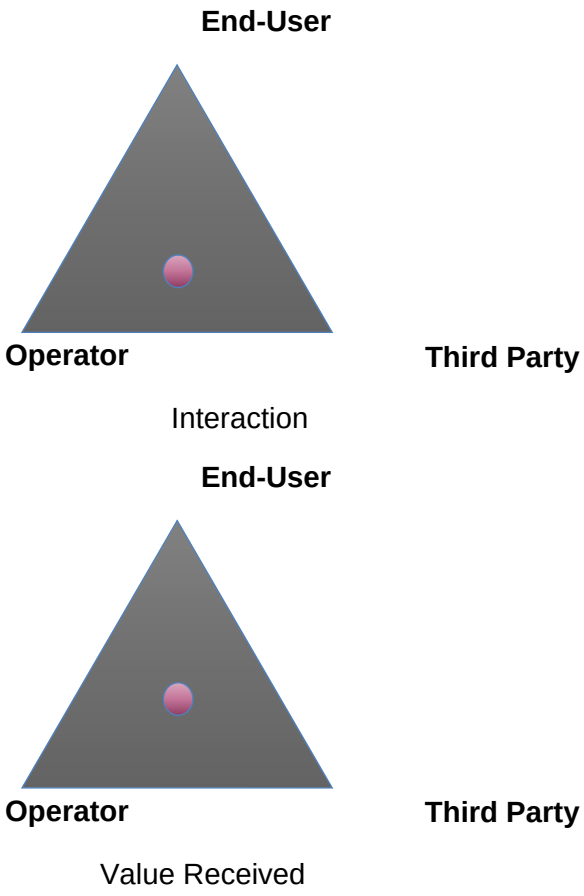
The algorithms used to determine when, where and how much (in the case of BW) will be a function of the type of content or applications that are being optimized. As an example, a video streaming application using per-session encryption use might have certain predictable relationship between BW requirements and an individual end-user's movements. An augmented reality application may do better if content pre-staging is predicted with more emphasis on likely nearby crowd movements. The OUx ecosystem workbench shall have a flexible means for defining the characteristics and algorithms associated with different applications and their associated content and BW pre-staging strategies.

It is likely that both the Network Operator and a Participating third party may share additional information about specific content use patterns, network congestion locations, and other analytics derived data so that both may better optimize their delivery platforms and associated applications. The OUx solution shall allow for the exchange of this additional information in a way that shall protect individual end-user privacy and other information that the participants in the ecosystem wish to appropriately protect.

It is likely that many different sources of location information will be available as new devices and network slice types become available. The OUx platform needs to have mechanisms to convert new location data formats to a common format that can be used by the rest of the platform.

M Network-Aware Content Adaptation for Third-Party Content Providers

M.1 Scenario Description



In this scenario, there is a 3-way interaction between the external content server, the user application, and the network infrastructure to optimize the delivery of video and/or other content – both real time as well as content delivered in advance for later viewing - through a combination of standard adaptive content techniques (e.g., ABR video), plus reasonable network management that can invoke information exchange and delivery negotiation between the content server and the user's network.

One important observation is that while video is the dominant source of content (measured in bits) flowing through today's networks, the vast majority of video streamed today is not true real-time video (i.e., with minimal latency). Almost all video is buffered within the application on time scales of several seconds to as much as several minutes (depending upon the device) in order to reduce video halts and improve the user experience. Indeed, such a buffering interval is an exceptionally simple and effective technique for improving the user's QoE. However, buffering has important consequences for both the video delivery as well as how QoE is measured:

- Content buffering means that the network's temporal flexibility for handling content delivery is on the time scale of the device buffer depth, which can be more than 1-2 orders of magnitude higher than the maximum defined latency per 3GPP QoS definitions (max 300 ms). Constraining the delivery to the time scales set by QCI means operators are missing important degrees of freedom for managing user contention and network congestion.
- The impact of retransmissions – whether due to the air interface or TCP – is only seen by the user when the content buffer is empty. Hence QoE scores based on traditional KPIs such as retransmissions may significantly underestimate user QoE for buffered video. Only the user's application knows the available buffer depth, and this it will be the most accurate measurement of the user's QoE.

Such negotiation of content delivery could include in-band messaging between the user application and the third-party content source, potentially mediated by a specific middle box or "proxy" function. An example of such functionality would be the experimental IETF protocol SPUD, or Session Protocol Underneath Datagrams. Such functionality could be aware of relevant user data and policies, network state, as well as content metadata and delivery options – and negotiate optimal delivery for the user and/or for multiple users that may be on the same cell of network region. The relevant data could be provided by the user application, by the content source, and from the network (e.g., perhaps via 3GPP AESE functionality).

There are several potential locations where such functionality could be positioned. Being in-band with the actual user flow provides important simplicity, otherwise side signaling is required. The functionality could reside in the service corridor (i.e., GiLAN), which when virtualized could be positioned wherever the mobile gateways are located. Connecting this with new concepts such as control/user-plane separation (CUPS), such functionality would reside on the user plane and could thus be placed at or near the network edge (e.g., for local breakout, lower latency, etc.). Another potential location could include some form of MEC platform, perhaps collocated with the CRAN controller or backhaul aggregation network.

Example use cases could include:

- Negotiation/selection of the initial audio/video rate for short audio/video clips, based upon criteria such as user plan, user device, user agreement, and network conditions. (While ABR video can adjust rates quickly, in practice applications 'low pass filter' the adaptation rate to perhaps once a minute, to reduce user distraction arising from frequent changes in video pixilation.)
- Negotiation/selection of the compression settings for graphics and photos, upon criteria such as user plan, user device, user agreement, and network conditions.

- Buffer-aware management of the audio/video delivery, taking into account both the various users sharing the key network resource, as well as their respective buffer depth. In essence, the middle box can become a "scheduler" for audio/video on time scales between the defined QCI latency (max 300msec) up to the application buffer depth (perhaps 10 sec to 100 sec, or more).
- Selection and/or management of user access network or technology, as well as selection of network paths and/or content source locations for the content being served.

Note that use of a negotiated approach can allow the operator to retain control of information that it may not want to share – e.g., user identifiers, location or preferences; network conditions; etc.

Similarly, the third party would only need to share certain metadata with the network, such as the audio/video rate manifest, and need not reveal potentially more private data regarding the actual content. As such, the scheme can be made compatible with encrypted content (which the majority of content is today).

M.2 Value Proposition

End-User – The end user would receive a higher quality of experience for their content, with fewer halts and pauses due to congestion.

Third Party – The third party would benefit from the higher content delivery quality for the viewers when carried over the supporting service provider's network.

Network Operator – The network operator would receive benefits from reasonable network management, which would translate into capex and opex savings from deferred capacity growth in their network. In addition, their subscribers would experience higher average QoE. The network operator can encourage the third-party content provider to support the arrangement to gain QoE benefits for their viewers – e.g., "Service X works best on our network". In addition, they operator can also potentially provide certain associated incentives to the third party for quid pro quo compliance – e.g., sponsored delivery.

M.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Device and user data	User application, via device OS APIs	Network proxy function	User identifier, user cell/location, RF link and signal conditions, device capabilities, etc.
Application data	User application	Network proxy function	Audio/video buffer state, user QoE, potentially options regarding deferred content delivery.
Network conditions	Network data sources: AESE, UPCON, MME, OSS, and/or network probes.	Network proxy function	Network conditions for relevant resource(s) – e.g., quantities related available capacity, cell load or congestion state, etc.
User policies	PCRF	Network proxy function	User plan, etc.
Content metadata	third party content source	Network proxy function	Valid identifier for content source, available formats & audio/video rates (e.g., rate manifest), content compression options, etc.

M.4 Summary of Data Derived or Used

Content information – Audio/video content format information (e.g., available bit rates, video frame sizes and resolutions, etc.) and/or Image format info (size, compression, etc.) for user-requested content.

User location (present, & potentially predicted/derived future location) – User location for correlating with network state for relevant resources, e.g., air interface (Cell ID, frequency carrier, etc.), potentially associated backhaul, etc.

Network state – Information related to the amount of available network resources available for serving the user's requested content – e.g., relevant access technology, cell or access point, air interface state, backhaul, transport resources, and content source available for servings the user's present (and optionally predicted future) location in the network.

User information – User's policy-related info (rate plan, opt-in preferences, etc.), for help in determining appropriate decisions regarding how best to serve the user's content request.

User application and device information – Device information (e.g., screen size), RF link information (for better estimating content delivery options based upon estimated implied network load), and application information (present content buffer depth, maximum available buffer memory, QoE-related information, etc.) that are relevant to the content selection and delivery decisions.

User Opt-in and Content Preferences Store – Data storage for information about individual user's applications/content preferences and participation in the OUx ecosystem.

M.5 Timescales for Actions Taken and Data Generated

When the user initially requests the content, the initial negotiation of delivery options needs to be made in real-time so that the user does not sense significant delay for the start of their requested content. However, not all the data used to make those decisions needs to be real-time – e.g., the network load data for the user's cell could be from network data taken a few minutes previous or appropriately processed historical load data, etc.

M.6 Extensibility via Workbench Approaches

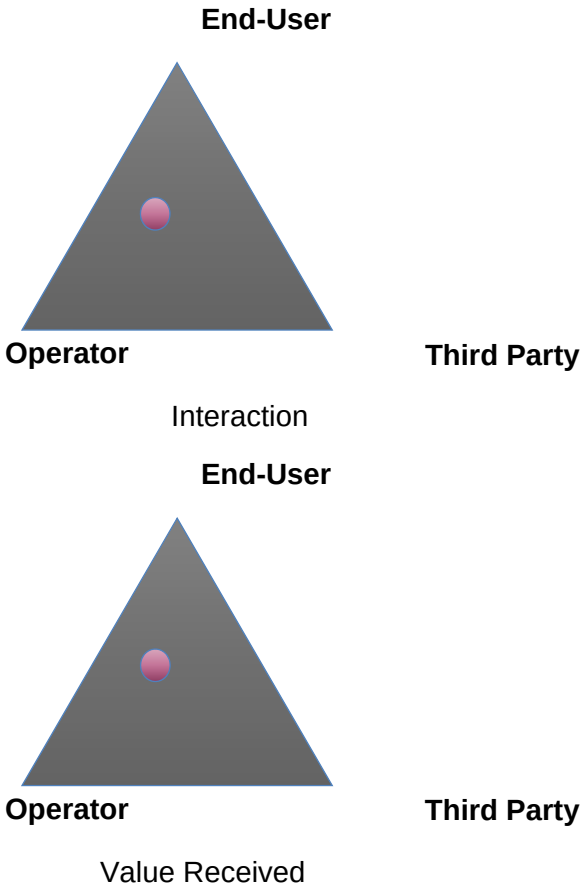
The framework discussed here provides several opportunities for extension, including

- Extension to access network technology selection (ANDSF), e.g., if the available access technology or layer is unable to adequately serve the content, a decision could be made to redirect the user to a different access layer or technology that is better able to serve the user's request. Also, today we see increasing industry evolution from the concept of an access *selection* choice to an access *aggregation* decision, i.e., instead of deciding between cellular vs. Wi-Fi, one might aggregate the two technologies using LTE-LAA, LWA, LWIP, MP-TCP, etc.
- Negotiation/selection of audio/video bitrates for multiple users sharing the same cell or constrained network resource, based upon the various users' available ABR rates (rate manifest), devices, and network conditions – to minimize video stalls and strive for best average video quality.
- Extension to future user location, based upon previously gathered user information regarding their pattern of trajectories through the network during the day or night. This is particularly relevant if the user is downloading content for later viewing, and/or if their

application buffer depth is particularly large (e.g., in excess of several minutes of content).

N Ux Prediction/Ux Driven Traffic Prediction Scenario Description

N.1 Scenario Description



This scenario encompasses the analytics that predict end-user Ux and the associated traffic levels on the network elements, service elements, and associated devices that comprise an instance of the OUx Ecosystem. The scope for these trends and predictions include:

- The hosting operator's network include cloud-based servers, content caches and accelerators, other service platforms and elements, and all associated interconnections.
- The end-user's applications and content as measured on the devices on which they are utilized. The measurements should also record the location in the network as well as other relevant device-based measurements.

- Utilization of end-user anonymized Ux ratings as defined in Scenario C
- Infrastructure (service and network) of Third Party providers who are participating in the associated OUx Ecosystem

Ux predictions shall be ***granular*** meaning they will be specific to end-user location in the network, applications/content used, time of day and day of year specific, etc. (see definition in the footnote below). These predictions shall further be able to provide a predicted Ux for specific applications and content. The quality and granularity of application/content specific predictions will be more accurate for operator and participating Third Party applications and content as there will be more information available to the analytics outlined here about the bandwidth and latency profile of such applications.

This scenario shall also support generic categories of applications traffic for non-participating Third-Party applications to the extent that the associated traffic can be identified. The set of categories and the associated applications and content shall be defined by the operator hosting the OUx Ecosystem. Typical generic categories might include – streaming video, file sharing, web traffic, collaboration apps, messaging apps, email, etc.).

The analytics that support this scenario will use a combination of historical data and near real-time measurements of applications/content usage, traffic levels, and end-user provided Ux ratings along with the knowledge of the traffic patterns of the associated applications/content to do the following:

- Correlate historical ***granular*** traffic performance measurements (bandwidth utilization, latency, etc.) with the specific end-user provided Ux ratings associated with the traffic
- Correlate historical traffic performance measurements on shared elements such as interconnect links, core network elements, cloud-based servers, etc. with the aggregate associated end-user provided Ux ratings for the traffic carried on or handled by these elements. These correlations should be done using knowledge of the ecosystem owner's infrastructure as well as information about participating Third Party infrastructure elements.
- Correlate negative Ux ratings with traffic and latency measurements on associated infrastructure elements
- Utilize additional traffic to Ux correlations as defined by the OUx Ecosystem host using the workbench system

The analytics will use the above correlations to predict current and near-future Ux on a ***granular*** basis using upon these correlations and real-time measurements of applications usage and traffic levels on impacting network and service elements. The near-future Ux predictions shall be

used by Scenarios D (Ux Feedback to End-User) and J (Micro-Optimization – per user optimization) to perform their functions.

The analytics associated with this scenario will predict future Ux performance and associated traffic levels based upon the following:

- Projected trends in the usage of specific applications and content as measured over time. These projections will be trended at both a ***granular*** and on a shared element level. Use of ***Granular*** projections will enable changes in the originating location of trended applications and content to be taken into account in the creation of projections for shared elements.
- Projected traffic levels associated with the usage of specific applications and content as measured and trended on a ***granular*** basis. These correlations will be used by analytics to model changes in traffic levels for specific applications and content over time. The projections may be done on a ***granular*** basis for specific or groups of applications and content.
- Additional projections of applications/content usage including emergence of new or retirement of existing applications/content as entered by Traffic Engineering and network management personnel. The operator entered projections may be ***granular*** in nature as well as applied to segments of the supporting elements using a policy-based format.

The predicted Ux performance and traffic levels will be updated at a frequency determined by the OUx Ecosystem owner on a periodic basis so as to more accurately account for the latest measured traffic performance and applications/content usage data.

Measured and predicted Ux and associated traffic performance may be shared with participating Third Parties in an anonymized format subject to participating end-user opt-in (see Scenarios A, C and E).

N.2 Value Proposition

End-User – The end-user's Ux may be more accurately understood, predicted and optimized using the approaches outlined here to manage optimization and engineering of the supporting network and service elements.

Third Party – The understanding of likely future Ux and traffic performance provided via this scenario enables participating Third Parties to better optimize and engineer their service platforms and applications to provide the best possible Ux.

Network Operator – The understanding of likely future Ux and traffic performance provided via this scenario enables operators to better optimize and engineer their networks to provide the best possible Ux. The operator also gains a clearer understanding of the likely impacts of various network investments on Ux and can more efficiently apply such to deliver the best possible Ux.

N.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Periodic sampling of Traffic performance measurements.	OUx Ecosystem Owner network and service elements, applications and Third-Party elements (Scenario H).	Analytics outlined in this Scenario	Bandwidth, latency and utilization levels.
Periodic sampling of applications and content usage on a ***granular*** basis.	Device-based measurements, server-based measurements (Scenario H), and network-based measurements	Analytics outlined in this Scenario	Applications/content usage levels measured on a ***granular*** basis. It is expected that the sources of these measurements will collect data over some time interval and report the data in summary form when requested.
Query of Ux ratings from end-users.	**OUx Anonymized Ux Info Database**	Analytics outlined in this Scenario	***Granular*** Ux ratings.
Access information about the elements, associated interconnections and traffic/service capacities for elements in the operator's and participating Third Party's infrastructure.	**Infrastructure Configuration Database**	Analytics outlined in this Scenario	Configuration and capacity data used to correlate and model traffic performance.

Interaction	Source	Target	Info Exchanged
Operator entered adjustments to applications/content usage trends or associated traffic patterns	Traffic engineering or network operations personnel	Analytics outlined in this Scenario	Policy-based adjustments to measured/trended applications/content usage and traffic levels.
Storage of ***granular*** applications/content usage trends and predicted Ux and traffic levels.	Analytics outlined in this Scenario	**Ux Performance Trends Database**	Historical trends and predicted present and future Ux performance and traffic levels.

N.4 Summary of Data Derived or Used

OUx Performance Trends Database – This database is managed jointly by this scenario and scenarios J, K and N. It stores predicted and actual measurements of Ux performance and traffic levels. The data needs to be ***granular*** (see definition above). The data stored should be time and location stamped so that it can be correlated with network failure events and changes in network configuration, capacity or interconnect structure.

OUx Anonymized Ux Info Database – Stores anonymized summary information about end-user experience. Information is filtered and anonymized by analytics based upon, in part, end-user opt-in/out choices.

OUx Ecosystem Database – Stores information about the participating applications, content, and other third-party systems.

Infrastructure Configuration Database – Stores a logical model of the elements that make up the OUx Ecosystem Owner's and associated participating Third Parties Networks, Servers, Interconnect Links, and other elements that are directly relevant to the traffic performance or delivered Ux. Information about the relationship between the elements in the database and their impact on traffic capacity and latency is also included. This information is used to make Ux and traffic performance to the serving network and service elements.

N.5 Timescales for Actions Taken and Data Generated

The analytics outlined here need to be executed frequently enough so that the associated trending and predictions of Ux and traffic levels remain accurate as new measured traffic data and Ux ratings become available. It is expected that different elements of the analytics outlined here will be configured by the OUx Ecosystem owner to run at different intervals. For example, analytics that trend usage and traffic levels for specific applications and content may be run on a daily or weekly basis whereas analytics to generate near-real time projections of ***granular*** Ux may be run at intervals measure in minutes.

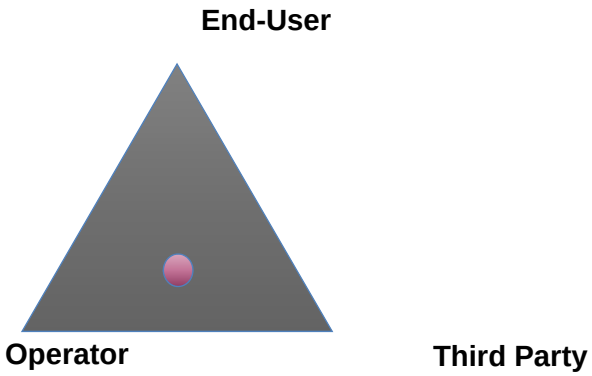
N.6 Extensibility via Workbench Approaches

The set of measurements to be correlated to trend and predict Ux as well as the relationship of these measurements to traffic levels and applications/content usage trends shall be able to be extended by the OUx Ecosystem owner. Also, the structure of the ecosystem owner's and participating Third Party's network and service elements shall be configurable by the ecosystem

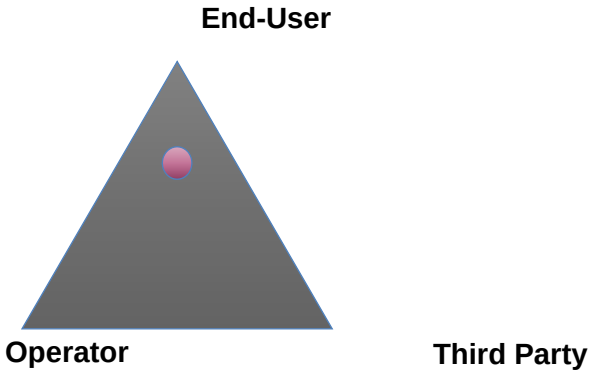
owner. Finally, the exact algorithms used to realize the analytics outlined as part of this scenario are expected to be a key area for differentiation among OUx Ecosystem providers.

O Ux Driven Capacity Engineering

O.1 Scenario Description



Interaction



Value Received

This scenario describes potential network engineering analysis and enhancements that can be achieved as a result of using Ux measurements derived from a combination of direct end-user ratings, measurements and analytics. An example of this use case would be to detect where extra network capacity may be needed and use this information to update the network topology as necessary. The network elements that can be enhanced using this scenario include: cell site location and antenna tuning, backhaul, core network, application servers, backend internet

connections, CDNs, etc. In other words, the network engineering choices to produce the best Ux should be done in an end-to-end manner, including tradeoffs between the elements mentioned earlier.

Furthermore, this technique could be used to predict when and where additional capacity will be needed to maintain a given set of OUx performance targets. Note that, time, location, application, and other attributes should be associated with this enhancement, as well as a predictability as to how Ux may change if traffic trends continue for a specified period of time without adding capacity.

Further enhancements could include the ability to constrain specific levels of traffic capacity by location, cost, and/or application/content that would be impacted so as to create a flexibility "what-if" set of end-to-end analysis tools.

Implementing this scenario will require the following:

- A knowledge of impacted end-user's applications/content priorities as well as the content or applications that each end-user is actively using
- A knowledge of where the user is physically located in the network at a given time when these measurements are taken, along with their historical pattern of movement around their current location
- Cooperation, via OUx ecosystem participation, with the content or applications provider associated with the user's current application to determine what content segments will be needed next by the end-user. This will allow the network design to accommodate the user's needs.

This information would be collected over a period of time prior using analytics and crowdsourcing techniques to create a view of traffic trends by location and/or class of users/applications/content used.

O.2 Value Proposition

End-User – The End User voluntarily provides personal information to the mobile operator that will be used to support the OUx with the expectation that this information will be kept private and secure. This includes measured data that the operators collect on the End User's device as well as evaluation feedback. In return for providing this information, End Users will expect that their personal information will be kept secure by both the Network Operator and the Third Parties participating in the OUx Ecosystem. End-users will receive an improved Ux for their

applications/content and usage patterns as a result of the improved performance resulting from this scenario.

Network Operator – The Network Operator requires access to specific information and preferences from End Users that participate in the OUx Ecosystem. The Network Operator also requires permission to gather the information necessary to provide an optimized Ux for their customers and to coordinate with Third Party applications providers; in order to deliver the best possible Ux and to invest efficiently invest in network tuning and infrastructure. End User's may have different expectations on what information they are willing to share, and different Network Operators may require access to a range of personal information depending on their specific implantation of the OUx Ecosystem. The Network Operator benefits from this scenario by the more focused application of network upgrades that will directly improve Ux for their customers.

Third Party applications providers – The Third-Party applications providers receive value because their applications and content can be delivered in a way that meets their user's expectations. Their resources can be allocated more effectively to deliver the Ux expectations of their end-users on a near real-time basis.

O.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Sharing of predicted Ux and associated predicted adjustments in resource staging, routing etc.	Analytics outlined in Scenarios J, K, and N.	This scenario	Statistics, trends and predictions of Ux resulting from the per-user and macro optimizations provided as part of the referenced scenarios.
Operational goals on target network Ux performance over time	Personnel responsible for traffic engineering.	This scenario	Location, application and timeline specific goals for Ux performance.
A graphical representation of the structure and interactions between key resources that influence Ux performance.	Personnel responsible for traffic engineering.	This scenario	Model includes RAN and Core elements, backhaul links, caches, backbone connections, cloud resources, relevant third-party elements, etc.).
Graphical Output of recommended network enhancements and re-engineering actions to achieve Ux performance goals.	This scenario	Personnel responsible for traffic engineering	Recommended capacity increases and/or re-engineering steps to achieve Ux performance goals. Format should enable "what-if" analysis of different resource allocations and their projected impact on Ux performance vs. goals over time.

Interaction	Source	Target	Info Exchanged
Reports correlating actual Ux performance over time vs. predicted performance.	This scenario plus data from J, K, and N.	Personnel responsible for traffic engineering.	These reports are intended to provide both a view of the accuracy of the Ux performance predicted by trends from J and K as well as a means to evaluate the applied network resources based upon the analysis performed via this scenario.

O.4 Summary of Data Derived or Used

OUx Performance Trends Database – This database is managed jointly by this scenario and scenarios J, K and N. It stores predicted and actual measurements of Ux performance and traffic levels. The data needs to be granular enough to capture Ux performance trends by network location, time of day/day of year, applications used, class of end-user, and any other information deemed important to the OUx engineering and management processes used by a particular realization of the OUx Ecosystem. The data stored should be time and location stamped so that it can be correlated with network failure events and changes in network configuration, capacity or interconnect structure.

OUx Anonymized Ux Info Database – Stores anonymized summary information about end-user experience. Information is filtered and anonymized by analytics based upon, in part, end-user opt-in/out choices.

OUx Ecosystem Database – Information about the participating applications, content, and other third-party systems.

Infrastructure Configuration Database – Stores a logical model of the elements that make up the OUx Ecosystem Owner's and associated participating Third Parties Networks, Servers, Interconnect Links, and other elements directly relevant to the traffic performance or delivered Ux. Information about the relationship between the elements in the database and their impact on traffic capacity and latency is also included. This information is used to make Ux and traffic performance to the serving network and service elements.

O.5 Timescales for Actions Taken and Data Generated

- The range of timescales that can be applied to Traffic Engineering via this scenario should be in the range of a few weeks out to perhaps 12 months. The practical timescales will be determined by the effectiveness of the analytics applied via Scenarios J, K, N and their ability to predict longer term traffic trends in specific locations of the operator's and third party's networks.
- Unpredictable events (e.g., Element or broader failure) that could have a short-term impact on Ux performance should be able to be evaluated for their potential impact and to test the effectiveness of redundancy or over-engineering of network capacity in terms of mitigating potential impact on Ux performance.

In some cases, personal information is needed in real time or near real time to react to situations where the operator's network needs to respond quickly to maintain the End User's Ux. This puts some reaction time constraints on where and how the information is stored

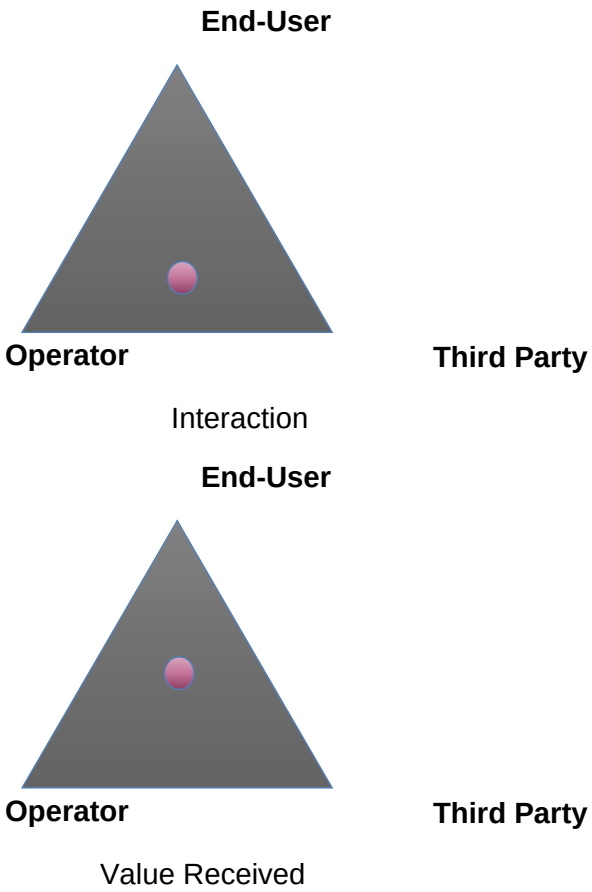
Other cases, such as performing analytics on raw data do not require real-time processing.

O.6 Extensibility via Workbench Approaches

- Depending on the differences in service offering provided by different network operators, there may be differences in what end-user information and the associated analytics routines to reduce it to a form that can be used by this scenario is needed.
- The stored end-user information should be extensible for carrier specific use.
- The method used to anonymize end-user information should be extensible for carrier specific applications.
- The method of encrypting personal information or metadata should be extensible for carrier specific use.
- The set of network elements and the associated Traffic Engineering analytics algorithms should be easily extensible.

P Ecosystem Partner Value Exchange

P.1 Scenario Description



Creation and exchange of value among End-Users, the Operator hosting the OUx Ecosystem and participating Third Parties is fundamental to the success of the OUx Business Model and the solution that supports it. The Breakthrough Optimized User Experiences whitepaper identifies many of the categories of value created via the OUx Ecosystem:

- Availability of high quality, real-time information about the QoE delivered by specific applications, content, and services important to an individual End User.
- Accurate knowledge of where and when services and content are used in a form that can be used to predict how to best allocate network and other backend resources in near real-time.
- The ability of the overall solution to accurately ***predict*** where platform resources should be applied to ensure continued delivery of a high-quality Ux.
- End-user direct feedback on the performance of individual applications, content, and services that has high value to both the network operator who is hosting the ecosystem and third parties who are participating in it.
- Crowdsourced information on individual end-user priorities for specific applications, content, and services. This information needs to be both granular to a level of specific/applications/ content/services and available in customizable summary form.

- The ability to tailor the delivery of content, applications and services to meet individual End User specified QoE priorities.
- The ability to optimize operations, engineering and real-time performance of networks and associated backend platforms to consistently deliver high QoE as determined by a crowdsourced view of related end user-QoE priorities.
- The ability to share the information gained via the assessment and optimization of Ux (utilizing appropriate privacy and opt-in protections) with all parties who participate in the OUx Ecosystem including third parties and End-Users.
- A ***workbench approach*** to realizing the OUx platform, associated analytics capabilities, and linkages to third party applications/content to enable rapid, operator specific innovation and differentiation.
- End-user motivation for participation and information sharing (with appropriate protections and controls as outlined in Scenario E). Motivation is provided by access to a greatly enhanced Ux and by zero-rated applications, content, and service models. The later are especially important in the start-up phase of a new OUx Ecosystem deployment.

These areas of value creation can be generalized in the following categories:

- Direct, End-User inputs that indicate their applications, content, and service priorities as well as their ratings of individual Ux with the same are the most important value created by the OUx Ecosystem. The OUx Ecosystem shall have mechanisms to record metrics about such direct End-User participation and to associate it with specific applications, content, and services being rated or prioritized.
- Automated network optimizations and operations (either directly delivered via access to management APIs or indirectly delivered via data recommending targeted actions on Operator or Third-Party network and server elements).
- End-user specific enhancements to Ux based upon priorities specified by the individual end-user who benefits.
- Crowdsourced data generated via analytics indicating end-user applications and content consumption trends, patterns, locations, etc., that can be used for a variety of marketing, customer care, and operations purposes.
- Zero-rated access to applications, content, and other services exchanged for one or more of the previous items.

It is expected that unique business arrangements will exist between the parties (Operator, Third Party Providers and the End-Users) will exist for each instantiation of the OUx Ecosystem.

It is also likely that these arrangements will not prescribe a fixed business model for value exchange among the participants in the OUx Ecosystem. Because of this, the OUx Ecosystem will

require mechanisms to meter the value elements that are created and exchanged. These mechanisms will likely take the form of APIs or similar automated constructs that measure such exchanges. The mechanisms shall include:

- Means to measure the direct participation of End-User's in the OUx Ecosystem include direct ratings of Ux, applications/content/service priorities and other data directly entered by End-Users (Scenarios A, B, C and D).
- Means to measure frequency and scope of automated optimizations performed by the OUx Ecosystem in Third Party Elements and/or on behalf of Third Party End-Users
- Means to measure automated Ux Optimizations benefits delivered to specific end-users. The results of these measurements can be used to generate periodic updates to End-Users so that they can see more clearly the benefits that they are receiving as a result of their participation in the OUx Ecosystem and the associated optimized services.
- Means to measure frequency and scope of accesses to OUx generated analytics (Scenarios G and S.2.3) by participating Third Parties.
- Additional mechanisms to measure consumption of other value elements created via Workbench mechanisms as they are consumed. This aspect is critical to enable each instance of the OUx Ecosystem to be differentiated and to allow such differentiation to be used as an integral part of value creation and exchange.
- Means to measure consumption of zero-rated applications, content, and access or other services exchanged for participation in the OUx Ecosystem.

The above listed measurements shall be stored in a database (the **OUx Value Exchange Database)** used to generate reports and to drive automated reconciliation and settlement systems.

All access to information by participating Third Parties will be governed by the nature of the business relationship between a participating Third Party and the operator hosting the OUx Ecosystem. The access rights will be stored in a database (the **OUx Ecosystem Database**) that governs the use of the information and value elements outlined above.

P.2 Value Proposition

End-User – The end-user can receive a view of the zero-rated services and improved Ux they are receiving in exchange for their participation in the OUx Ecosystem.

Third Party – Participating Third Parties can measure the level of participation by their End-Users as well as the nature and scope of optimizations that they and their end-users receive as a result of their participation in the OUx Ecosystem. They also can receive an account of the

delivery of zero-rated applications, content, and services exchanged in connection with the OUx Ecosystem. Finally, the can use customized analytics (Scenarios G and I) to better understand their End-User's preference and consumption of related applications, content, and services.

Network Operator – The hosting operator's primary benefit comes from the increased satisfaction of their End-Users and the associated competitive differentiation that they create via the OUx ecosystem. They also benefit from improvements in network engineering, operations and customer care resulting from analytics produced by the OUx Ecosystem (Scenarios E, N, O).

P.3 Summary of Key Interactions

Interaction	Source	Target	Info Exchanged
Recording of direct, End-User specific participation in the OUx ecosystem and the associated direct Ux ratings and priorities	End-Users	**OUx Value Exchange Database**	User opt-in levels, applications/ content/ service priorities and direct Ux ratings.
Recording of End-User and Third-Party Optimizations performed by the OUx Ecosystem	OUx Ecosystem analytics and optimization control systems (Scenarios J, K, L, and M)	**OUx Value Exchange Database**	Records of automated optimizations including measurements of the participating Third Party and end-user(s) who benefit as appropriate.
Access to crowdsourced information about End-User applications, content, and service usage patterns, locations, and associated data	**OUx Value Exchange Database** **OUx Anonymized Ux Info Database**	Participating Third Parties, the OUx Ecosystem hosting operator or indirectly by End-Users via data on Ux benefits they have received.	Result of analytics and anonymized usage patterns and associated information.
Recording of consumption of zero rated applications, content, and services by an End-Users	End-User applications, content/application servers, or network operator billing systems	**OUx Value Exchange Database** **OUx Anonymized Ux Info Database**	Type and levels of zero-rated applications, content, or services consumed in exchange for OUx Ecosystem participation.

Interaction	Source	Target	Info Exchanged
Participating Third Party Access Controls	**OUx Ecosystem Database**	Controls utilization of the other mechanisms in this table by participating Third Parties.	Access rights specific to a given participating Third Party.

P.4 Summary of Data Derived or Used

OUx Value Exchange Database – This database is used to track the creation and consumption of the value elements outlined above. Information includes data about operator, participating Third Party and End-user Ux value and associated analytics information created and consumed as well as the consumption of zero-rated applications, content, and services in exchange for OUx ecosystem participation.

OUx Anonymized Ux Info Database – Stores anonymized summary information about End-User Ux. Information is filtered and anonymized by analytics based upon, in part, end-user opt-in/out choices.

OUx Ecosystem Database – Stores information about the participating applications, content, and other Third-Party systems.

P.5 Timescales for Actions Taken and Data Generated

The information exchanges outlined here do not generally rely on real-time data. It is possible, however, that additional value exchange scenarios may be defined via workbench approaches that have near real-time data availability requirements. As with other scenarios involving near real-time information, policy-based mechanisms are required to control the frequency at which value capture and exchange data is updated.

P.6 Extensibility via Workbench Approaches

It is likely that the operator hosting the OUx Ecosystem and the associated participating Third Parties will want to create additional elements to measure value generation and consumption. The OUx Ecosystem solution components and the associated databases should be designed to facilitate the definition of these new elements as well as the management of any associated access controls.

The ability to create appropriate views for Third Parties who participate in the OUx ecosystem will likely require a workbench system that enables the operator hosting the OUx ecosystem to create customized views of the value exchanged and the End-User benefits derived from the OUx Ecosystem.