ATIS-0700042

Enhancing Location-Based Routing of Emergency Calls

TECHNICAL REPORT

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ATIS-0700042, *Enhancing Location-Based Routing of Emergency Calls*

ATIS-0700042

ATIS Technical Report on

Enhancing Location-Based Routing of Emergency Calls

Alliance for Telecommunications Industry Solutions

Approved July 12, 2019

Abstract

This Technical Report is a feasibility study that analyzes the Location-Based Routing (LBR) methods, identifies gaps and makes recommendations for potential standards activity.

Foreword

As a leading technology and solutions development organization, the Alliance for Telecommunications Industry Solutions (ATIS) brings together the top global information and communications technology (ICT) companies to advance the industry's most-pressing business priorities. ATIS serves the public through improved understanding between carriers, customers, and manufacturers.

This Technical Report was developed jointly between ESIF, PTSC, and WTSC.

The Emergency Services Interconnection Forum (ESIF) provides a forum to facilitate the identification and resolution of technical and/or operational issues related to the interconnection of wireline, wireless, cable, satellites, Internet and emergency services networks.

The Packet Technologies and Systems Committee (PTSC) develops and recommends standards and technical reports related to services, architectures, and signaling, in addition to related subjects under consideration in other North American and international standards bodies. PTSC coordinates and develops standards and technical reports relevant to telecommunications networks in the U.S., reviews and prepares contributions on such matters for submission to U.S. ITU-T and U.S. ITU-R Study Groups or other standards organizations, and reviews for acceptability or per contra the positions of other countries in related standards development and takes or recommends appropriate actions.

The Wireless Technologies and Systems Committee (WTSC) develops and recommends standards and technical reports related to wireless and/or mobile services and systems, including service descriptions and wireless technologies. WTSC develops and recommends positions on related subjects under consideration in other North American, regional, and international standards bodies.

Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, WTSC, 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time of initiation or issuance of the letter ballot for this document, the committees responsible for its development had the following leadership:

R. Marshall, ESIF Chair (Comtech)
J. Green, ESIF First Vice Chair (Sprint)
R. Hixson, ESIF Second Vice Chair (NENA)

M. Dolly, PTSC Chair (AT&T)
V. Shaikh, PTSC Vice-Chair (Perspecta Labs)

D. Zelmer, WTSC Chair (AT&T)
M. Younge, WTSC Vice Chair (T-Mobile)

R. Sherry, Technical Editor (West C)

The WTSC SN, ESIF NGES, and IMSESINET Subcommittees were responsible for the development of this document.

Table of Contents

Table of Figures

Table of Tables

Enhancing Location-Based Routing of Emergency Calls

1 Scope, Purpose, & Application

1.1 Scope

The Scope of this Technical Report is an analysis of improved Location-Based Routing (LBR) methods using the Communications Security, Reliability and Interoperability Council (CSRIC) V Location-Based Routing Report as the basis.

1.2 Purpose

This Technical Report is a feasibility study that analyzes the Location-Based Routing methods for Commercial Mobile Radio Service (CMRS) wireless emergency calls as described in the CSRIC V LBR Report and any other methods to enhance LBR that have been identified since the publication of the CSRIC V report. Criteria for the analysis is developed. The Technical Report includes analysis of whether existing standards support a particular LBR method, and if not, what standards gaps exist to support a particular LBR method.

1.3 Application

This Technical Report applies to the investigation of the improvement of CMRS wireless routing techniques based upon the location of the caller.

2 References

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

[Ref 1]: CSRIC V - Final Report – Task 2: 911 Location-Based Routing, September 2016.
[Ref 2]: Wireless E911 Location Accuracy Requirements, FOURTH REPORT AND ORDER, PS Docket No. 07-114, FCC, February 3, 2015.
[Ref 3]: Notice of Inquiry, Location-Based Routing for Wireless 911 Calls, FCC, March 23, 2018.
[Ref 4]: ATIS-0500001[Revised in 2011], *High Level Requirements for Accuracy Testing Methodologies*.
[Ref 5]: ATIS-0700015, *ATIS Standard for Implementation of 3GPP Common IMS Emergency Procedures for IMS Origination and ESInet/Legacy Selective Router Termination*.
[Ref 6]: NENA-STA-010.3, NENA i3 Standard for NG9-1-1 (to be issued).

3 Definitions, Acronyms, & Abbreviations

For a list of common communications terms and definitions, please visit the *ATIS Telecom Glossary*, which is located at < https://glossary.atis.org/ >.

3.1 Definitions

Cold Start – In a cold start, the wireless network or handset shall not make use of any location assistance information and positioning knowledge retained from a previous attempt. Such information would not be available to a handset that was originating a 9-1-1 call and that had been turned off for an extended period. See ATIS-0500001[Revised in 2011], *High Level Requirements for Accuracy Testing Methodologies*, for further details.

41   **DBH** – Device-Based Hybrid. An estimation method that typically utilizes either a selection or a combination of
42   location methods available to the handset in a given environment – including crowd-sourced Wireless Fidelity (Wi-
43   Fi), Assisted-Global Navigation Satellite System (A-GNSS), and possibly other handset-based sensors. It also
44   includes an associated uncertainty estimate reflective of the quality of the returned location.

45   **Hot Start –** In a hot start, data from a recent position fixes may retained from one or more previous attempts and
46   may be utilized in subsequent location fixes. For Global Positioning System (GPS), this would mean almanac,
47   ephemeris, fine time and accurate position are retained. See ATIS-0500001[Revised in 2011], *High Level*
48   *Requirements for Accuracy Testing Methodologies*, for further details.

49

50   ## *3.2 Acronyms & Abbreviations*

51

A-GNSS	Assisted-Global Navigation Satellite System
A-GPS	Assisted-GPS
ALI	Automatic Location Identification
ATIS	Alliance for Telecommunications Industry Solutions
CLIP	Common Location Interworking Protocol
CMRS	Commercial Mobile Radio Service
CSRIC	Communications Security, Reliability and Interoperability Council
DBH	Device-Based Hybrid
ECID	Enhanced Cell Identification
ECS	Emergency Call Server
EED	Enhanced Emergency Data
ELS	Emergency Location Services
EPDU	External Protocol Data Unit
E-SMLC	Evolved Serving Mobile Location Center
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
ESIF	Emergency Services Interconnection Forum
ESInet	Emergency Services IP network
ESRK	Emergency Services Routing Key
ESRP	Emergency Service Routing Proxy
FLP	Fused Location Provider
GMLC	Gateway Mobile Location Center
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HELO	Hybrid Emergency Location
HTTPS	Hyper Text Transfer Protocol Secure
IMS	IP Multimedia Subsystem
IP	Internet Protocol
LBR	Location-Based Routing
LbyR	Location by Reference
LCS	LoCation Services
LIS	Location Information Server
LOCIWF	Location Interworking Function
LoST	Location-to-Service Translation
LPG	Legacy PSAP Gateway

LPP	LTE Positioning Protocol
LRF	Location Retrieval Function
LS	Location Server
LTE	Long-Term Evolution
MDN	Mobile Directory Number
MME	Mobility Management Entity
MPC	Mobile Positioning Center
MSC	Mobile Switching Center
MSISDN	Mobile Station International Subscriber Directory Number
NEAD	National Emergency Address Database
NEAM	National Emergency Address Manager
NENA	National Emergency Number Association
NG	Next Generation
NILR	Network Initiated Location Request
NOI	Notice of Inquiry
NSI	Non-Service Initialized
OEM	Original Equipment Manufacturer
OMA	Open Mobile Alliance
OS	Operating System
OTDOA	Observed Time Difference of Arrival
PTSC	Packet Technologies and Systems Committee
PSAP	Public Safety Answering Point
RDF	Routing Determination Function
SLP	Secure User Plane Location Platform
SMS	Short Message Service
SMS-C	Short Message Service Center
SUPL	Secure User Plane Location
TIA	Telecommunications Industry Association
UE	User Equipment
UMTS	Universal Mobile Telecommunications Service
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
WSP	Wireless Service Provider
WTSC	Wireless Technologies and Systems Committee

4   Background

CSRIC V Working Group 1, in the context of its Task 2 activity, documented its efforts to identify and evaluate location-based routing methods. In the resulting report, characteristics and considerations for each method are outlined, along with any specific architectural, technical, operational and security requirements. In addition, the role and responsibilities of stakeholders associated with each LBR method are outlined. The entire report may be found at < https://transition.fcc.gov/bureaus/pshs/advisory/csric5/WG1_Task2_FinalReport_092016.docx >.

The following quote is taken from Section 6 – Key Considerations of Location-Based Routing of the CSRIC V report regarding effective location-based routing.

 "In order for location-based routing to be effective in delivering the 9-1-1 call to the jurisdictionally appropriate Public Safety Answering Point (PSAP), the location needs to be calculated in 5 seconds or less with a fairly high-degree

62 of accuracy. This is more challenging for technologies utilizing location techniques from a "cold start" than those
63 relying on long-term location tracking of callers, also known as "hot start" location methodology."

64 The CSRIC V report noted "Location-based routing of wireless 9-1-1 calls can be accomplished using a number of
65 different methods. Each location-based routing method has its own pros and cons, among other considerations.".

66 The CSRIC V report evaluated five alternatives to support LBR as noted below and identified pros, cons and
67 recommendations.

68

69 **1.   Hold Call until Phase 2 Available**

70 "Option 1: Hold call at Wireless Mobile Switching Center (MSC) or Hold call at the MSC based on delaying routing
71 info from Mobile Positioning Center (MPC)/Emergency Call Server (ECS).

72 "Option 2: Hold call at the PSAP gateway."

73

74 **2.   Interim or Quick Fix**

75 "In this LBR method, the 9-1-1 call can be routed using an Interim or Quick Fix that is delivered by the Wireless
76 Service Provider (WSP) in 5 seconds or less. The X/Y coordinates delivered with the Interim or Quick Fix, are
77 plotted on a geospatial shape file of one or more PSAP jurisdictional boundaries and delivered to the PSAP in
78 which the X/Y coordinates are plotted. Generally, this method necessitates holding the 9-1-1 call at one of the
79 points outlined in Section 7.1[1], utilizing a timer of up to 6 seconds."

80

81 **3.   Geo-code Registered/Provisioned Civic Address**

82 "Registered or provisioned civic address options:

83 "Option 1: Static or nomadic consumer home device that has customer register location of device.

84 "Option 2: Semi-permanent devices or cells installed by carrier or other commercial entity – addresses provisioned
85 by entity.

86 "Option 3: Dynamic geo-code registration – nomadic device that can update its registered civic address in real time
87 through reverse geo-coding."

88

89 **4.   Device-Based Hybrid Location**

90 "Device-Based Hybrid (DBH) location is an estimation method that typically utilizes either a selection or a
91 combination of location methods available to the handset in a given environment, including crowd-sourced Wi-Fi,
92 A-GNSS, and possibly other handset-based sensors. It also includes an associated uncertainty estimate reflective
93 of the quality of the returned location."

94

95 **5.   Wireless 9-1-1 Location Accuracy Emerging Technologies**

96 "Wireless carriers are in the process of implementing the FCC's Fourth 4th Report and Order[2] on 9-1-1 location
97 accuracy that includes provisions for an independent Test Bed to assess the indoor location accuracy of carrier-
98 deployed location solutions and new, emerging location technologies, the creation of the National Emergency
99 Address Database (NEAD) for storing Wi-Fi access points and Bluetooth® beacons for determination of
100 dispatchable location, and the establishment of a z-axis metric through the Test Bed process."

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[1] Hold call until Phase 2 available options.

[2] *Wireless E911 Location Accuracy Requirements*, 30 FCC Rcd 1259 at paras. 121-132 (2015) ("Fourth Report & Order").

101 The recommendations of the CSRIC V LBR Report are summarized below:

102 • "It is not recommended to delay the call delivery to the 9-1-1 system and associated PSAPs for
103   timeframes related to the current availability of Phase 2 location.

104 • "It is recommended that Interim or Quick Fix be used where its implementation is expected to derive
105   sufficient benefit to justify investment. This methodology may have some benefits, but there are some
106   factors that may limit its usefulness and return on investment depending on how implemented.

107 • "It is recommended that the FCC work with device manufacturers and WSPs to assess the feasibility of
108   enabling all devices used for static and nomadic purposes with the ability to validate if it has been moved
109   and alert the network of its status.

110 • "It is recommended to further study the suitability of device-based hybrid for use in E9-1-1 call
111   routing. To-date, no location method, other than Cell ID, has proven reliable enough and quick enough to
112   be relied upon for routing 9-1-1 calls to the appropriate PSAP. While DBH methods are already moving
113   the performance needle to locate wireless callers in challenging indoor environments, it remains to be
114   seen whether this method will prove useful in improving 9-1-1 call routing.

115 • "It is recommended that the FCC reach out to the Smartphone operating system and device providers
116   such as Apple, Google, LG, Nokia, etc. to invite them to participate in 9-1-1 industry forums and
117   standards activities as 9-1-1 location providers and advise on what action(s) by the FCC would be
118   required to provide WSPs with the assurances and protections needed in order for them to implement
119   proprietary 3rd party location solutions.

120 • "It is recommended that WSPs should investigate updating device and location server capabilities to
121   choose for use with 9-1-1 location-based call routing, between obtaining an interim Assisted-GPS (A-
122   GPS) location fix or utilizing a current location stored on the device from a commercial location application
123   running on the phone, that has been sanity checked for validity.

124 • "It is recommended that the standard bodies Telecommunications Industry Association (TIA) TR-45.8 and
125   Alliance for Telecommunication Industry Solutions (ATIS) Wireless Technologies and Systems Committee
126   (WTSC) need to review J-STD-036 to determine if any interface, signaling and parameter changes are
127   required in order to support the utilization of a device's commercial location as an interim location method
128   for delivery and use with wireless 9-1-1 call routing.

129 • "It is recommended that the FCC should continue to support the independent testing and analysis of new
130   location technologies that promise significantly increased accuracy and quicker time to first fixes that
131   would allow for their use in routing 9-1-1 calls to the jurisdictionally appropriate PSAP.

132 • "It is recommended that the FCC should encourage the use of additional A-GPS/A-GNSS satellite
133   constellations by WSPs as one input, among many inputs, into the 9-1-1 location algorithm as it is
134   currently in use for device-based hybrid commercial locations.

135 • "It is recommended that the FCC should seek assurance from providers of location fixes calculated from
136   proprietary databases sought to be used for routing 9-1-1 calls, that their databases and algorithms are
137   maintained in a manner that assures consistent and accurate locations required for emergency services.
138   Furthermore, the FCC should require these databases to be standards compliant and allow for periodic,
139   standardized accuracy testing conducted by users and recipients of DBH locations, without sending the
140   voice call to PSAP.

141 • "It is recommended that the FCC should require providers of location fixes calculated from proprietary
142   databases sought to be used for routing 9-1-1 calls, to provide metrics and other performance verification
143   tools to WSPs to ensure that the location fixes meet accuracy and quality requirements.

144 • "It is recommended that the WSPs who deliver 9-1-1 calls and are held responsible for the calculation of
145   the locations fixes passed to public safety, must have metrics and procedures in place to ensure that
146   internal positioning methodologies used are reliable, consistent and performing at expected accuracy and
147   quality requirements."

148 # 5 Assumptions

149 The following are assumptions regarding Location-Based Routing that are used in the analysis contained within this
150 Technical Report.

151

1. Location-Based Routing is only supported on originating networks supporting 4G Long-Term Evolution (LTE) and beyond.
2. Any location technologies that deliver enhanced location directly to the PSAP are out of scope.
3. The User Equipment (UE) must be registered with the network [i.e., LBR is not supported on Non-Service Initialized (NSI) handsets].
4. The UE may be mobile, static (fixed) or nomadic.
5. LBR is only supported when the location source can send the UE's location to the network within the time required to perform routing for an emergency call.
6. Per the FCC CSRIC V report recommendations, a "routable location" should be available within 5 seconds[3] of the initiation of a 9-1-1 call.
7. When location determination is done outside the originating network via proprietary methods, the interface for location conveyance to the originating network needs to be standardized.
8. There may be one or more location determination methodologies capable of generating a location for use with LBR.
9. It is the responsibility of the originating network to select the available location estimate most likely to be representative of the UE's actual location for use in routing the call.
10. The location used for LBR may be either civic or geodetic.
11. The fallback for Location-Based Routing is cell site/sector routing if no lower-uncertainty location estimate is available.
12. Originating network LBR requires no changes in the emergency service network or the PSAP.
13. The preference for CMRS call routing is using LBR techniques. However, cells entirely inside a single PSAP coverage area may be flagged to have cell-based routing to restrict the additional delay of LBR for cells at, or near, the boundary of a PSAP coverage area.

6 Standards Associated with Location-based Routing

6.1 ATIS-0700015

ATIS developed ATIS-0700015, *ATIS Standard for Implementation of 3GPP Common IMS Emergency Procedures for IMS Origination and ESInet/Legacy Selective Router Termination* to define and adapt as necessary 3GPP common IP Multimedia Subsystem (IMS) emergency procedures for applicability in North America. This standard supports emergency communications originating from an IMS subscriber (fixed, nomadic, or mobile) and delivered to an Emergency Services IP network (ESInet) or to a legacy Selective Router. As it relates to the FCC Notice of Inquiry (NOI), the standard defined procedures for an IMS Originating Service Provider network to acquire location and route an emergency call to the appropriate Emergency Services Network. The standard is intended to complement the National Emergency Number Association (NENA) i3 standard.

In brief, two functional elements are defined to specify how location is acquired and routed to the appropriate Emergency Services Network.

- The Location Server (LS) is a functional element that contains or acquires location. ATIS-0700015 did not identify specific location acquisition procedures for the LS, and there may be various implementations of a LS. Examples of a LS may be a Gateway Mobile Location Center (GMLC), a Secure User Plane Location (SUPL) Platform (SLP), an MPC, Evolved Serving Mobile Location Center (E-SMLC) or a Fixed Location Server.
- The Location Retrieval Function (LRF) retrieves location information for a UE, if necessary, from the LS, and obtains routing information for an emergency session from the Routing Determination Function (RDF).

In the near term where the caller's location cannot be obtained in time to route the call, ATIS-0700015 defines procedures for the LRF to route emergency calls based upon cell site information. Specifically, if an emergency call is to be routed to a legacy Emergency Services Network, the LRF will allocate a Reference Identifier [e.g., an Emergency Services Routing Key (ESRK)] in a similar manner as is done for legacy CMRS networks. If a call is to be routed to a NG9-1-1 Emergency Services Network the LRF will allocate a Reference Identifier associated with an Associated Location. An Associated Location is a location within the designated PSAP jurisdiction that may be used in wireless call scenarios to route the call toward the designated PSAP. It may either be in geodetic format

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[3] More recent technological developments have suggested that shorter timeframes are possible and preferable.

202 (e.g., lat: 41.809882, long: -88.112388) or civic format (e.g., 3030 Warrenville Rd Lisle IL). The LRF will allocate a
203 Reference Identifier [referred to by NENA i3 as Location by Reference (LbyR)] that may be used by the NG9-1-1
204 Emergency Services Network to acquire the Associated Location and route the call to the PSAP. While the
205 Associated Location is used for routing in the NG9-1-1 Emergency Services Network it is never presented to the
206 PSAP.

207 In addition, ATIS-0700015 defines procedures to route emergency calls based upon the caller's location if that
208 location can be obtained within a reasonable window for call routing. Specifically, if a call is to be routed to a legacy
209 Emergency Services Network, the LRF will allocate an ESRK based upon the caller's location. If a call is to be
210 routed to a NG9-1-1 Emergency Services Network the LRF will allocate a Reference Identifier [referred to by NENA
211 i3 as Location by Reference (LbyR)] that may be used by the NG9-1-1 Emergency Services Network to acquire the
212 caller's location. The caller's location will then be used to route the call to the PSAP.

213 While ATIS-0700015 does not specify location technologies that may be used to acquire the caller's location in time
214 to be used for routing, it does provide the mechanism to use that location for routing if it is available. Further
215 discussion regarding ATIS-0700015 may be found in Annex A.

6.2 3GPP 23.271 Technical Specification Group Services and System Aspects; Functional stage 2 description of Location Services (LCS)

218 This standard specifies the stage 2 procedures for the LoCation Services (LCS) feature in Universal Mobile
219 Telecommunications Service (UMTS), GSM and EPS [for Evolved UMTS Terrestrial Radio Access Network (E-
220 UTRAN)], which provides the mechanisms to support mobile location services for operators, subscribers and third
221 party service providers.

222 Location Services may be considered a network-provided enabling technology consisting of standardized service
223 capabilities, which enable the provision of location applications. The application(s) may be service provider specific.
224 The description of the numerous and varied possible location applications which are enabled by this technology are
225 outside the scope of this Technical Report. However, clarifying examples of how the functionality being described
226 may be used to provide specific location services may be included.

227 This stage 2 service description covers the LCS system functional model for the whole system, the LCS system
228 architecture, state descriptions, message flows, etc.

229

6.3 3GPP TS 36.355 Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)

233 LTE Positioning Protocol (LPP) is a point-to-point protocol between a location server (E-SMLC or SLP) and a target
234 device (User Equipment [UE]) in order to position the target device using position-related measurements obtained
235 by one or more reference sources. An LPP session is used between a Location Server and the target device in
236 order to obtain location related measurements or a location estimate or to transfer assistance data.

237 Starting in 3GPP Release 12, LPP supports an early location fix capability, whereby a location server (e.g., an E-
238 SMLC) can request an early location fix followed by a final more accurate location fix. The location server indicates
239 this request to the UE by providing two response times: a "responseTimeEarlyFix" for the early location and a final
240 response time for the final location, with both response times lying between 1 and 128 seconds. The early and final
241 location fix can each be a location estimate or a set of measurements [e.g., measurements for A-GPS, A-GNSS,
242 Enhanced Cell Identification (ECID), Observed Time Difference Of Arrival (OTDOA) or Wireless Local Area Network
243 (WLAN)]. A benefit of this procedure compared to using two separate LPP requests (one with a low response time
244 and another with a higher response time) is that the UE will not discard the measurements used for the early location
245 fix but will instead apply them to the final location fix, which can increase the accuracy and/or reduce the response
246 time for the final location fix.

6.4 OMA LPP Extensions (LPPe)

248 LTE Positioning Protocol LPP [3GPP-LPP] is a positioning protocol for E-UTRAN control plane. However, LPP has
249 been designed in such a way that it can also be utilized outside the control plane domain such as in the user plane
250 in the context of SUPL. LPP elementary messages (Request and Provision of Capabilities and Location Information
251 and Assistance Data) each include a container, an External Protocol Data Unit (EPDU), which can be used by

252 standardization fora outside 3GPP to define their own extensions to LPP messages. Open Mobile Alliance (OMA)
253 LPP Extensions take advantage of this option.

6.5 ATIS-0700028 - Location Accuracy Improvements for Emergency Calls

255 ATIS-0700028[4] specifies the requirements, architecture, and interfaces required to support improved location
256 accuracy as set forth in the FCC's Fourth R&O on location accuracy[5]. Access Point and/or Bluetooth beacon public
257 civic address information from External Data Sources is sent to the National Emergency Address Manager (NEAM).
258 The NEAM validates and geocodes this civic address information and pushes the location information to the NEAD.
259 In real time, the caller initiates a 9-1-1 call and Access Point and/or Bluetooth beacon identifiers (e.g., MAC
260 addresses) visible to the UE may be obtained by the Serving Core Network. In today's environment the Serving
261 Core Network uses the cell ID information to route the call toward the PSAP. In parallel, the Serving Core Network
262 queries the NEAD with these Reference Point identifiers and initiates the acquisition of the geodetic location using
263 Phase II processing methods. The NEAD returns the civic addresses and associated geocoded locations of the
264 Access Points or Bluetooth beacons. The Serving Core Network may choose the most appropriate location returned
265 from the NEAD and caches that, along with the geodetic location it acquired, in anticipation of a location query from
266 the Legacy Emergency Services Network or anNG9-1-1 Emergency Services Network.

7   Supplemental Location Acquisition Technology/Offerings

268 In addition to the methods discussed in this Technical Report. there are products and services that have the potential
269 to provide emergency caller location to the PSAP. None of those solutions currently offer location-based routing
270 capabilities..

271 **RapidSOS**

272 RapidSOS provides a Clearinghouse for supplemental location and its website states the following, "[t]he NG9-1-1
273 Clearinghouse is a nationwide Location Information Server (LIS) for faster, more accurate device location from
274 smartphones." When a mobile 9-1-1 call origination is detected on supported devices, handset location is pushed
275 to the RapidSOS LIS. RapidSOS partners with Google, Apple, and other technology companies to make their
276 location data available to PSAPs as supplemental location information. When a mobile 9-1-1 call is received at the
277 PSAP, the PSAP queries, potentially through an ESInet, the RapidSOS LIS to obtain the mobile device location.
278 The PSAP may compare the location information provided by RapidSOS with the location information it received
279 using the normal Wireless Phase II delivery methods.

280 **Android Emergency Location Services (ELS) from Google**

281 ELS is a *supplemental* service that makes handset location from Android phones available to emergency services
282 during a 9-1-1 emergency call. ELS works on more than 99% of current Android devices with Google Play Services.
283 Location is computed on the handset and sent toward the PSAP/emergency services network via a destination
284 Endpoint maintained by the ELS partner. The location is not received or used by Google.

285 When configured, ELS will be activated when the Android user calls or texts a configured emergency number.
286 Location services will be automatically enabled in high accuracy mode and a high power location request is
287 registered with the Android Fused Location Provider (FLP). FLP analyzes A-GPS, cell tower trilateration, Wi-Fi
288 hotspot proximity, Bluetooth, and a variety of sensor data in the phone to derive accurate location indoors and
289 outdoors (latitude, longitude, altitude) as quickly as possible. Once the emergency call is completed, the user's
290 previous location and data settings are restored.

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[4] ATIS-0700028, Location Accuracy Improvements for Emergency Calls

[5] FCC 07-114, *Federal Communications Commission Fourth Report and Order in the Matter of Wireless E911 Location Accuracy Requirements*; February 3, 2015
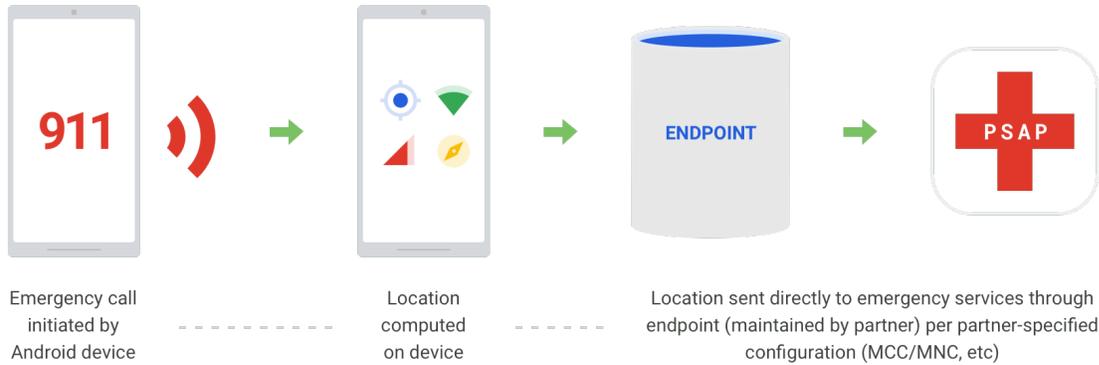
Emergency call initiated by Android device ⟶ Location computed on device ⟶ Location sent directly to emergency services through endpoint (maintained by partner) per partner-specified configuration (MCC/MNC, etc)

291

292 **Figure 1 – Android Emergency Location Services (ELS)**

293 ELS requires at least one "endpoint" [e.g., Short Message Service Center (SMS-C) or Hyper Text Transfer Protocol
294 Secure (HTTPS) server] to receive location information. This means that if it were implemented in the U. S., the
295 ELS solution could be incorporated into the carrier Short Message Service (SMS) service or the device would need
296 to have Internet connectivity to access an HTTPS server.

297 **Apple Hybrid Emergency Location (HELO)**

298 When a user initiates an emergency call, supported Apple devices can obtain location information from various
299 sources, such as Global Navigation Satellite Systems (GNSSs) and Wi-Fi. Apple calls this capability "Hybridized
300 Emergency Location" or "HELO". HELO is available during an emergency call on iPhone 5s or later running iOS 9.0
301 or later, and on Apple Watch, via the Network Initiated Location Request (NILR) path. HELO may not be supported
302 by all legacy radio access technologies and must be elected by each carrier. In testing with the NILR process, the
303 HELO process, as integrated into NILR, typically requires 8 – 22 seconds to acquire a high-integrity, low-uncertainty
304 fix.

305 Enhanced Emergency Data (EED) is a supplemental conveyance capability to provide HELO data to PSAPs via an
306 alternate data path. Support for HELO plus EED functionality is available on iPhones running iOS 12 and Apple
307 Watch running watchOS 5.

308 When a user makes a 9-1-1 call from an EED enabled device, the device will use HELO to estimate the user's
309 location. Apple will forward the HELO estimate to a LIS. After the first EED message, subsequent messages are
310 automatically sent to the LIS at regular intervals. When a call arrives at a local 9-1-1 center, it may query the LIS
311 using the caller's mobile telephone number.

312 **Samsung/Laaser**

313 The LaaSer platform has the ability to provide location data for public safety through various methods. Within the
314 U.S., LaaSer has taken a carrier-centric approach which entails integrating device location into existing carrier
315 mechanisms and functions. As such, in the U.S., LaaSer is not technically a supplemental location provider as it is
316 intended to be integrated into the IMS/LTE network architecture call flow.

317 LaaSer provides a caller location and supplemental data platform that receives data from mobile devices and other
318 sources. The LaaSer platform can receive data from participating Original Equipment Manufacturer
319 (OEM)/Operating System (OS) emergency location and supplemental data systems that support a specification that
320 LaaSer has defined. According to LaaSer, multiple OEMs are in various stages of implementing to their
321 specification. In this manner LaaSer can receive device-determined location data and/or raw telemetry information
322 (e.g., beacon-based location) to perform additional location determination and validation. LaaSer's location platform
323 uses that telemetry data, wireless carrier network location data, and other inferential and exogenous data to
324 determine and validate the device location with an accompanying normalized uncertainty and confidence.

325 One example of an OEM implementation that supports LaaSer's specification is Samsung's Advanced911 function,
326 via which LaaSer's location platform can be used to facilitate both caller location delivery and location-based routing.
327 LaaSer-enabled Samsung devices send telemetry data during key events in the 9-1-1 dialing process. The process
328 flow of data transmission is configurable per wireless carrier, public safety entity, and/or jurisdictional preferences
329 to ensure compliance with all applicable standards and requirements. This approach is designed to deliver fast and
330 credible location determination.

331 Extensive testing, trials, and pilots conducted in partnership with OEMs, wireless carriers, and public safety entities
332 have shown that routable locations from enabled devices are available within two (2) seconds from the caller
333 pressing "dial" or "send" on a high percentage of 9-1-1 emergency calls. The determination of what it means to be
334 "routable" is configurable per carrier and jurisdictional preferences and can vary relative to call characteristics (i.e.,
335 taking into account the size or type of serving cell sector). The device-based routing capability is intended to
336 augment existing wireless carrier network routing mechanisms and is an "improvement only" system, meaning that
337 it will not hinder or slow down existing wireless carrier network routing mechanisms. If the device location is not
338 determined at a sufficient uncertainty in time to be used for emergency call routing, the existing wireless carrier
339 routing mechanism will proceed as normal.

7.1 Applicability to the CSRIC V LBR Categories

341 The CSRIC V report identified 5 alternatives to support location-based routing. In general, the supplemental location
342 acquisition technology methods would have to be integrated into the IMS/LTE call flow in order to facilitate improved
343 location-based routing. The following paragraphs illustrate the applicability of the location technologies described
344 in Clause 7 to the 5 CSRIC V alternatives.

345 **1.   Hold Call until Phase 2 Available**

346 Since this alternative suggests delaying call routing until the Phase II location is obtained, none of the location
347 acquisition technology methods described in Clause 7 would apply.

348 **2.   Interim or Quick Fix**

349 This alternative suggests delaying the call routing until a location suitable for routing (but not necessarily for
350 dispatch) is acquired by the mobile network.

351 *RapidSOS*

352 Since RapidSOS provides a NG9-1-1 Clearing House (a LIS), it would not be involved in an IMS/LTE call flow
353 and would not apply to this alternative.

354 *Google ELS*

355 In current implementations the Google "endpoint" is outside the domain of the IMS/LTE call flow infrastructure.
356 Google's "endpoint", which receives the mobile device location, would have to be integrated into a "gateway" o
357 providing access to the IMS/LTE network location acquisition technologies. Another method would be for the
358 Android mobile sets to incorporate the location in the call request with the 9-1-1 call. Therefore, the Google ELS
359 solution may be suitable for this alternative, provided that location is available within the same time frame as
360 the interim or quick fix location would be available.

361 *Apple HELO*

362 In current implementations the IMS/LTE call routing infrastructure may not be configured to use Apple's HELO.
363 In addition to the NILR path, the Apple HELO-provided location could conceivably be integrated into a "gateway"
364 or location clearinghouse providing access to the IMS/LTE network location routing technologies.

365 Another method could be for Apple iPhones mobile sets to incorporate the location in the call request with the
366 9-1-1 call. Therefore, the Apple HELO solution may be suitable for this alternative, provided location is available
367 within the same time frame as the interim or quick fix location would be available.

368 *LaaSer*

369 In current implementations the LaaSer location delivery application is outside the domain of the IMS/LTE call
370 routing infrastructure. However, the LaaSer location delivery application is intended to be integrated into the
371 IMS/LTE network location routing technologies. Another method could be for LaaSer-enabled handsets to
372 incorporate the location in the call request with the 9-1-1 call. Therefore, the LaaSer solution may be suitable
373 for this alternative, provided location is available within the same time frame as the interim or quick fix location
374 would be available.

375 *National Emergency Address Database (NEAD)*

376 As mentioned above the NEAD returns civic addresses and geocoded locations of Access Points and Bluetooth
377 beacons, if available, when queried by the Serving Core Network. In normal operation the Serving Core Network
378 would choose the most appropriate civic address and hold that civic address while it acquires a geodetic
379 location. The geodetic and NEAD-provided civic address would be returned when the Serving Core Network

380 was queried by an ALI system in a Legacy Emergency Services Network or a PSAP served by an NG
381 Emergency Services Network.

382 If the NEAD location information were to be considered for Interim or Quick Fix location-based routing,
383 conceptually the Serving Core Network could use the most appropriate civic address received from the NEAD
384 for routing

385

386 **3. Geo-code Registered/Provisioned Civic Address**

387 Since this alternative suggests geocoding a registered location, none of the location acquisition technology
388 methods described in Clause 7 would apply.

389

390 **4. Device-Based Hybrid Location**

391 This alternative assumes some interaction between the handset and the mobile network in order to acquire
392 location.

393 *RapidSOS*

394 Since RapidSOS provides a NG9-1-1 Clearing House (a LIS), it would not be involved in an IMS/LTE call flow
395 and would not apply to this alternative.

396 *Google ELS*

397 In current implementations the Google "endpoint" is outside the domain of the IMS/LTE call flow infrastructure.
398 Google's "endpoint", which receives the mobile device location, would have to be integrated into a "gateway"
399 providing access to the IMS/LTE network location acquisition technologies. Therefore, the gateway and the
400 mobile handset would interact to acquire the caller location. The Google solution may be suitable for this
401 alternative, provided that location is available within the required time frame.

402 *Apple HELO*

403 In current implementations the IMS/LTE call routing infrastructure may not be configured to use Apple's HELO.
404 In addition to the NILR path, the Apple HELO-provided location could conceivably be integrated into a "gateway"
405 or location clearinghouse providing access to the IMS/LTE network location routing technologies. Another
406 method could be for Apple iPhones mobile sets to incorporate the location in the call request with the 9-1-1 call.
407 Therefore, the Apple HELO solution may be suitable for this alternative, provided location is available within the
408 required time frame.

409 *LaaSer*

410 In current implementation the LaaSer location delivery application is outside the domain of the IMS/LTE call
411 routing infrastructure. However, the LaaSer location delivery application is intended to be integrated into the
412 IMS/LTE network location routing technologies. Another method could be for LaaSer-enabled handsets to
413 incorporate the location in the call request with the 9-1-1 call. Therefore, the LaaSer solution may be suitable
414 for this alternative, provided location is available within the required time frame.

415 **5. Wireless 9-1-1 Location Accuracy Emerging Technologies**

416 This alternative relies upon compliance to the FCC 4th Report and Order on 9-1-1 Location Accuracy to identify
417 methods to improve location-based routing. However, the FCC 4th Report and Order focuses only on improved
418 location to the PSAP (i.e., Dispatchable Location) and not on improving emergency call routing.

419

8 Analysis of Location-Based Routing Methods

421 Previous clauses of this document have discussed standards and vendor offerings that relate to routing emergency
422 calls and providing location to the PSAP. None of them, as of the publication of this document, directly supports
423 location-based routing. This clause provides a high-level architectural diagram that may be used in the analysis of
424 the location technologies described in Clause 7, sets out criteria for assessing the feasibility of location-based
425 routing options and provides extensions that may be needed to support location-based routing.

426   This clause discusses extension to current methods that may lead to the implementation of location-based routing
427   (vs. cell-based routing) of emergency calls. In order to route on location, the "routable" location must be available
428   in sufficient time so as not to delay call processing beyond acceptable limits. The discussion in this clause assumes
429   that is true.

430

8.1   *Conceptual Architecture*

432   To incorporate location-based routing into the CMRS network would require logical extensions to the routing
433   process defined in ATIS-0700015. This is similar to the concepts that were defined ATIS-0700028, *Location*
434   *Accuracy Improvements for Emergency Calls* where the CMRS network queried a NEAD to obtain locations
435   associated with Access Points or Bluetooth beacons[6]. In the case of location-based routing, the CMRS network
436   would use the location determination processes as normal and then, in parallel, determine if an enhanced location
437   may be available to route the call.

438   In the normal processing defined in ATIS-0700015 there are three functions that are involved in acquiring the
439   location and determining how to route the call. The LS is defined as the functional element that acquires the geodetic
440   location. In practice this maybe an E-SMLC or a GMLC. The LRF determines call routing information by
441   interrogating an RDF, and generates a Reference Identifier (e.g., ESRK or location reference URI.

442   In order to extend the architecture and procedures specified in ATIS-0700015, there must be a standard way that
443   the CMRS network acquires the enhanced location. There is the potential to have multiple enhanced location
444   service providers that provide location using proprietary location protocols. Figure 2 illustrates a Location
445   Interworking Function (LOCIWF). Shown on the left side of the Location Interworking Function icon are various
446   Location Services, which provides a location in a manner that may be outside the concepts of the 3GPP standards.
447   It would be the responsibility of the Location Interworking Function to interwork those proprietary location protocol
448   methods to a standard protocol [illustrated by the use of Common Location Interworking Protocol (CLIP)]. Note that
449   CLIP may be a pull (query/response) protocol where the CMRS network queries the Location Interworking Function
450   and/or it may be a push protocol where the Location Interworking Function pushes a location to the CMRS network
451   once the Location Interworking Function has obtained it. The Location Interworking Function does not attempt to
452   normalize between location services. Again, these are just conceptual ideas.

453
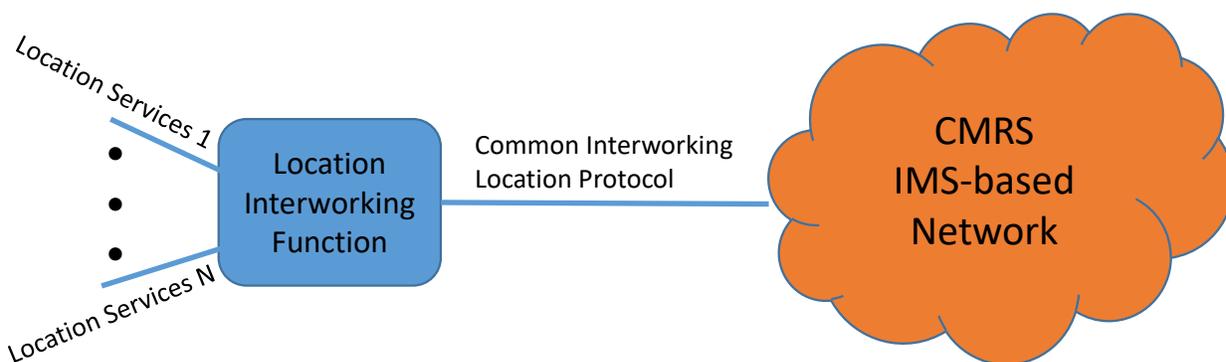
454
455   **Figure 2 – Conceptual Location Interworking Function**
456

8.1.1   LS interacting with the LOCIWF

458   Figure 3 shows as an architecture diagram for location-based emergency call routing that uses an external Location
459   Interworking Function to acquire the UE location. In this approach, the LS interacts with the Location Interworking
460   Function over a new interface (shown as Interface 16 in Figure 3) to acquire the location information. The Location
461   Interworking Function acquires the UE location over the new interface (shown as Interface 17 in Figure 3). The

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[6] ATIS-0700028 did not address location-based routing but provided additional civic addresses in addition to the geodetic location acquired by the location determination equipment.

462 Location Interworking Function may have methods to detect the initiation of an emergency call by the UE and then
463 acquire the UE location automatically and push that location to the LS before it receives a request from the LS.

464 In parallel to the use of Location Interworking Function, the LS may request UE location from the E-SMLC over
465 interface 4. The E-SMLC may acquire the UE location over interface 5 using the current method. The E-SMLC
466 may also acquire the UE location when the emergency bearer is setup and push that location to the LS before it
467 receives a request from the LS.
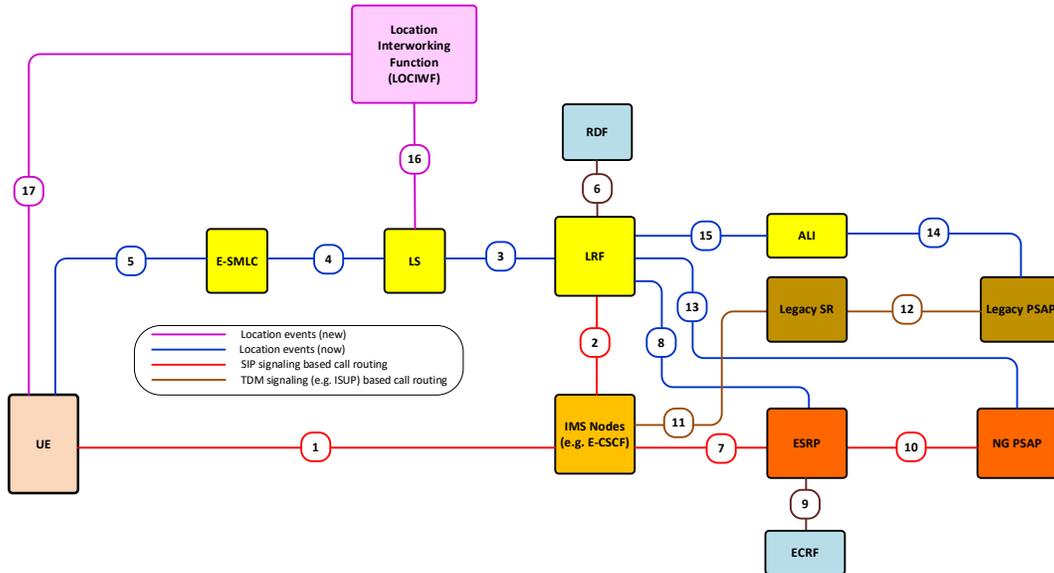
468

469 **Figure 3 – Architecture diagram with LS to Location Interworking Function interface**

470 **Table 1 – Definitions for Figure 3 & Figure 4**

Term	Definition
ALI	Automatic Location Identification – Accepts query from Legacy PSAP and queries LRF for location
E-SMLC	Evolved Serving Mobile Location Center – responsible for acquiring UE location, possibly by interacting with a UE or Location Interworking Function (as shown in Figure 4)
ECRF	Emergency Call Routing Function – provides routing information for an emergency session based upon the location provided by the Emergency Service Routing Proxy (ESRP)
ESRP	Emergency Service Routing Proxy – routing proxy that delivers the emergency session to the NG PSAP or downstream ESRP
IMS Nodes	IP Multimedia Subsystem – core IMS functional elements involved in routing the emergency call
LOCIWF	Location Interworking Function – interworks location provided by location services providers to a common location format that may be consumed by CMRS network elements (e.g., E-SMLC or LS)
Legacy PSAP	Legacy Public Safety Answering Point
Legacy SR	Legacy Selective Router – routes calls to the PSAP based upon a Reference identifier such as an ESRK.
LRF	Location Routing Function – retrieves location information for a UE and obtains routing information for an emergency session from the RDF
LS	Location Server – General term for the entity responsible for obtaining the location of the UE (e.g., GMLC)
NG PSAP	Next Generation 9-1-1 Public Safety Answering Point
RDF	Routing Determination Function – provides routing information for an emergency session based upon the location provided by the LRF

Term	Definition
UE	User Equipment – initiates the emergency session establishment request

471

472 **Table 2 – Interface Definitions for Figure 3**

Interface	Description
1	Signaling path for initiating the emergency session
2	Interface to acquire routing instructions
3	Location acquisition interface between the LRF and the LS (e.g., GMLC)
4	Location acquisition interface between the LS (e.g., GMLC) and the E-SMLC
5	Control plane location acquisition interface between the UE and the E-SMLC
6	Routing determination interface between the LRF and the RDF
7	Signaling path to route emergency request to ESRP
8	Location dereference interface for route determination between the LRF and ESRP
9	Routing determination interface between the ESRP and the ECRF
10	Signaling path to deliver the emergency call to a NG PSAP
11	Signaling path to route the emergency call to Legacy Selective Router
12	Signaling path to deliver the emergency call to a Legacy PSAP
13	Location dereference interface between the NG PSAP and the LRF
14	Location acquisition interface between the Legacy PSAP and the ALI
15	Location acquisition interface between the LRF and the ALI
16	Location acquisition interface that provides a common location protocol between the Location Interworking Function and the LS (e.g., GMLC)
17	Logical interface (out of scope) between the UE and Location Services hosted on or associated with the Location Interworking Function

473

8.1.2 E-SMLC interacting with the LOCIWF

475 Figure 4 shows as an architecture diagram for location-based emergency call routing that uses an external Location
476 Interworking Function to acquire the UE location. In this approach, the E-SMLC interacts with the Location
477 Interworking Function over a new interface (shown as Interface 16 in Figure 4) to acquire the location information.
478 The Location Interworking Function acquires the UE location over the new interface (shown as Interface 17 in Figure
479 4). The Location Interworking Function may have methods to detect the initiation of an emergency call by the UE
480 and then acquire the UE location automatically and push that location to the E-SMLC before it receives a request
481 from the E-SMLC. The E-SMLC may push any such received location information to the LS.

482 In parallel to interacting with the Location Interworking Function, the E-SMLC may acquire the UE location over
483 interface 5 using the current method. The E-SMLC may also acquire the UE location when the emergency bearer
484 is setup and push that location to the LS before it receives a request from the LS.

14

485
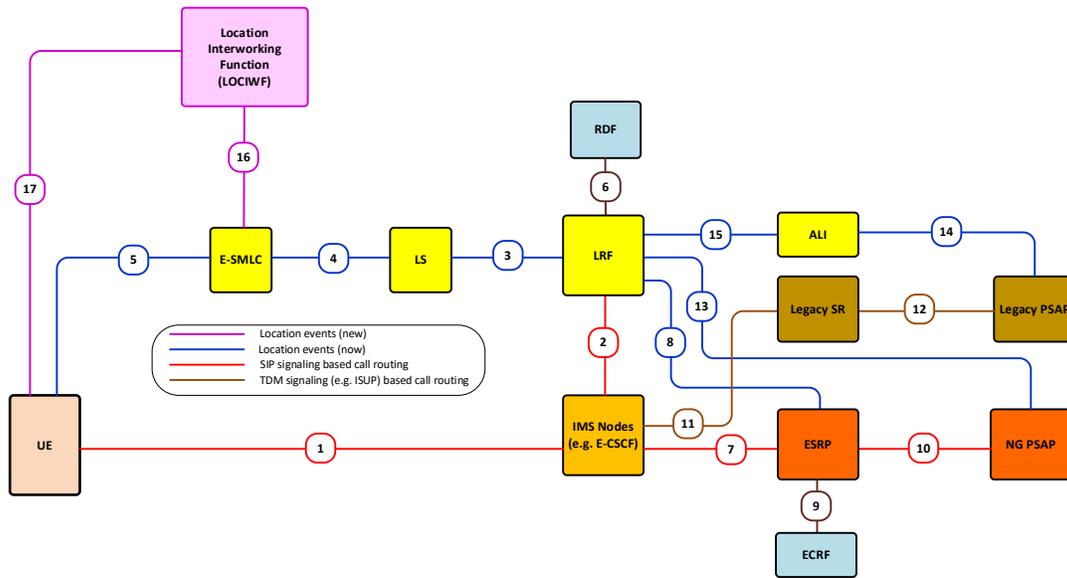
Figure 4 – Architecture diagram with E-SMLC to Location Interworking Function interface

Table 3 – Interface Definitions for Figure 4

Interface	Description
1-15	Same as described in Table 2
16	Location acquisition interface that provides a common location protocol between the Location Interworking Function and the E-SMLC
17	Logical interface (out of scope) between the UE and Location Services hosted on or associated with the Location Interworking Function

488

## 8.1.3 LRF interacting with the LOCIWF

Figure 5 shows as an architecture diagram for location-based emergency call routing that uses an external Location Interworking Function to acquire the UE location. In this approach, the LRF interacts with the Location Interworking Function over a new interface (shown as Interface 16 in Figure 5) to acquire the location information. The Location Interworking Function acquires the UE location over the new interface (shown as Interface 17 in Figure 5). The Location Interworking Function may have methods to detect the initiation of an emergency call by the UE and then acquire the UE location automatically and push that location to the LS before it receives a request from the LS.

In parallel to interacting with the Location Interworking Function, the LRF may request UE location from the LS over interface 3. The LS may interact with the E-SMLC to acquire the UE location over the interface 4 using the current method. The E-SMLC may acquire the UE location over interface 5 using the current method. The E-SMLC may also acquire the UE location when the emergency bearer is setup and push that location to the LS before it receives a request from the LS.

501
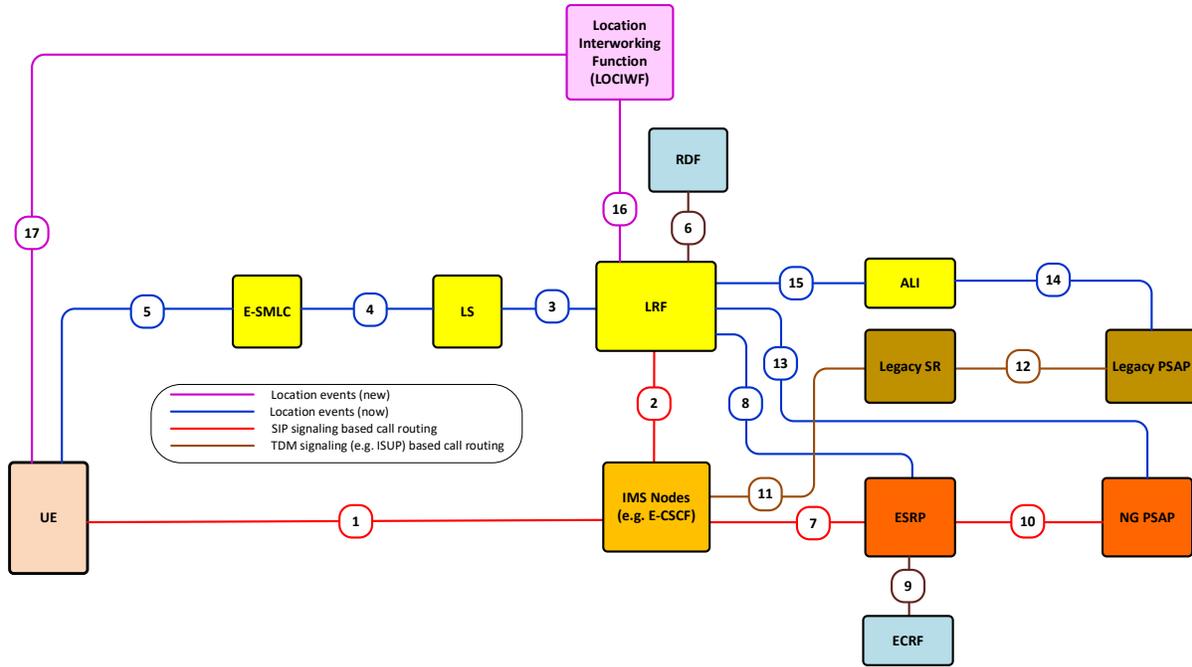
502   **Figure 5 – Architecture diagram with LRF to Location Interworking Function interface**

503   **Table 4 – Interface Definitions for Figure 5**

Interface	Description
1-15	Same as described in Table 2
16	Location acquisition interface that provides a common location protocol between the Location Interworking Function and the LRF
17	Logical interface (out of scope) between the UE and Location Services hosted on or associated with the Location Interworking Function

504

8.2 Assessment Criteria

505
506   The following is a list of criteria to assess alternative location-based routing methods:

507   • Availability of location suitable for routing

508   Any solution needs to provide the location of the calling UE prior to some maximum amount of time (e.g., 2 to 5
509   seconds) in order for the call to be routed based on location.

510   • Must be extensible from existing routing methods

511   ATIS-0700015 defines the methodology to route emergency services calls to either a legacy emergency services
512   network or a NENA i3 ESInet. Currently the standard identifies cell routing (using Associated Location) as the
513   technique to route wireless emergency calls. Any solution would have to be able to gracefully extend the ATIS-
514   0700015 architecture to enable location-based routing. If location-based routing cannot be performed, the fall back
515   is cell-based routing.

516   • Must be transparent to the emergency services network and PSAP

517   Any method that provides location-based routing must be transparent to the emergency services network and the
518   PSAP. That is, the CMRS network may acquire a routable location and use it to route to the appropriate emergency
519   services network. A NENA i3 ESRP may query for routing location and that routing location may be returned.
520   However, when the PSAP queries for location to support dispatch (i.e., emergencyDispatch) it should receive the
521   estimated location of the caller.

8.3 Conceptual Call Flow Extensions to Support LBR

Currently ATIS-0700015 supports location-based routing based on UE provided location as described in Clauses 8.7.4 (Routing a UE Provided Location to the Legacy Emergency Services Network) and 8.7.5 (Routing a UE Provided Location to the ESInet).

If a DBH implementation using the control plane is capable of delivering a location that may be used for routing, Figure 6 illustrates that call flow.

In the normal flow illustrated in Figure C.1 of ATIS-0700015 (also shown in Annex A of this document) there is an emergency attach (1). The Mobility Management Entity (MME) requests location from the E-SMLC (2). Depending upon implementation there are positioning method messages that may flow between the E-SMLC and the UE (3). Once the position has been acquired the E-SMLC responds back to the MME with the location (4). Then the MME pushes the location to the GMLC (5) and the GMLC acknowledges receipt of that location (6). In the current environment the GMLC caches the location in anticipation of a query from an LRF.

Figure 6 extends ATIS-0700015 Figure C.1 to support location-based routing using DBH. In Step a the UE detects the emergency call. Steps 1, 2, and 3 occur as discussed above. In parallel, the LRF receives an INVITE from the E-CSCF as shown in Step i and queries the GMLC as shown in Step ii; it does not determine an Associated Location. Steps 3 through 6 continue as discussed above. The GMLC responds to the LRF providing it with location information (Step iii). If the location is returned within an appropriate timeframe, the LRF could use that location to query the RDF (not shown) and choose a route URI that will be returned to the E-CSCF (Step iv). Then normal processing forwards the emergency call toward the PSAP.

There may be a Route timer associated with the LRF. If the LRF does not get a location response from the GMLC (Step iii) before the timer expires, then the LRF can fall back to cell-based routing using the Associated Location.
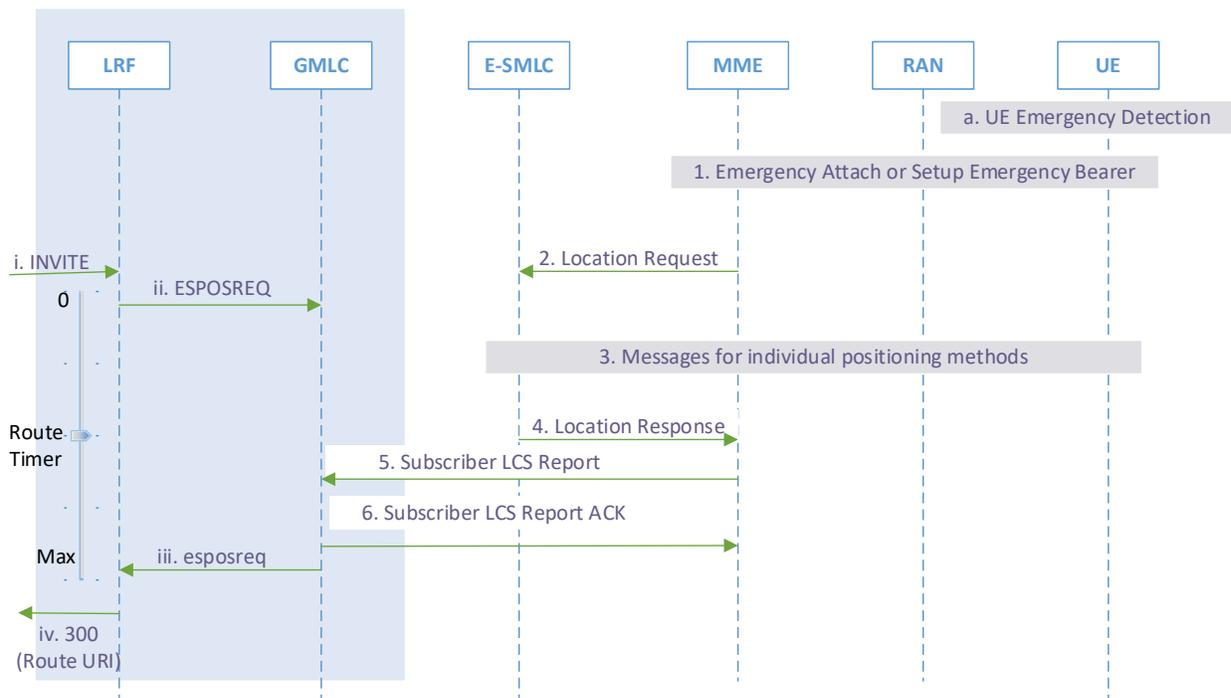
Figure 6 – Device-Based Hybrid Using the Control Plane Flow Providing Location-based Routing

There are multiple places in the CMRS network where the interactions with the Location Interworking Function could be placed. One is associated with the E-SMLC, a second is associated with the GMLC[7] and a third is associated with an LRF that is separate from a GMLC. The figures below conceptually extend Figure C.1 of ATIS-0700015 to

---

[7] In some implementations the LRF and GMLC may be one element as shown in the blue shading in the figures. In other implementations they may be separate platforms.

549 illustrate how enhanced location could be acquired by the CMRS network and used for location-based routing (with
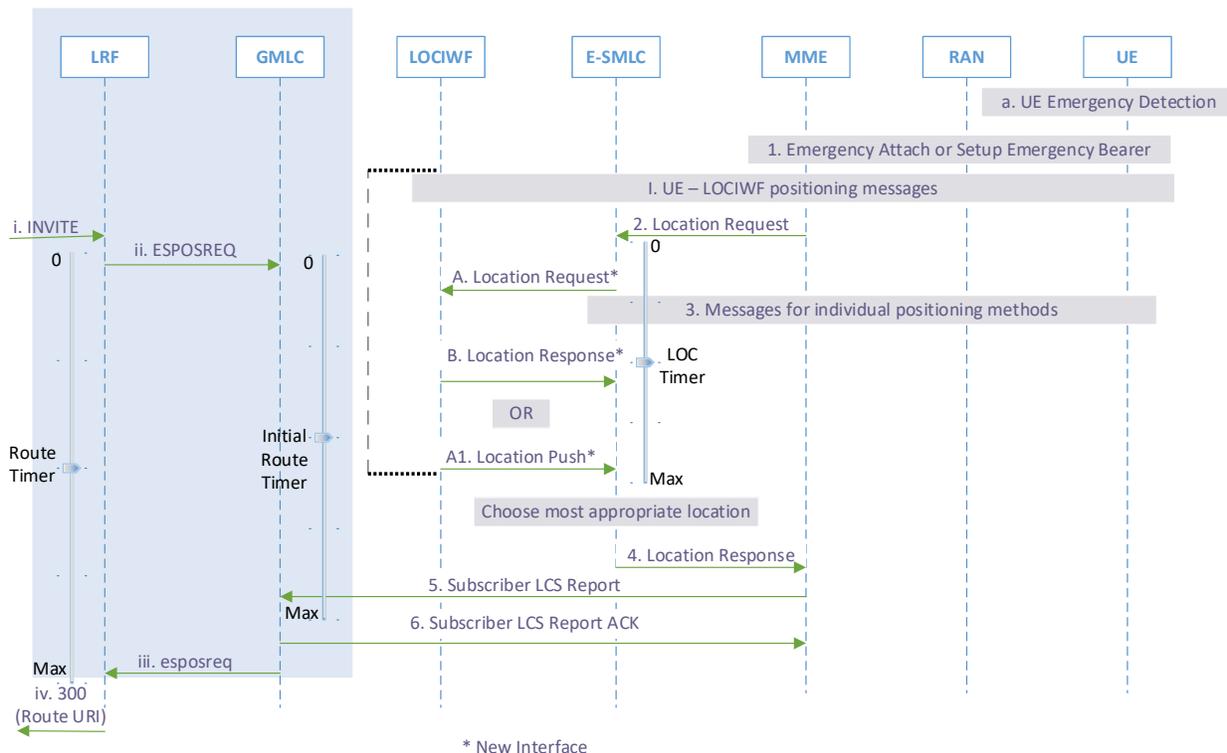550 the assumption that the location is acquired in time).

551 Figure 7 illustrates a conceptual flow where the E-SMLC interacts with the LOCIWF. ATIS-0700015 Figure C.1 is
552 extended to support location-based routing by including steps where the E-SMLC could interact with the LOCIWF
553 to obtain enhanced location (as shown in Steps A and B, or A1). In Step a, the UE detects the emergency call. In
554 Step I, there are location acquisition messages that flow between the UE and the LOCIWF. These are proprietary
555 and outside the scope of this document. In Step i, the LRF receives an INVITE from the E-CSCF and queries the
556 GMLC as shown in Step ii. The LRF does not determine an Associated Location. Steps 1 through 3 would be
557 executed as discussed above. In parallel the E-SMLC could interact with the LOCIWF to obtain an enhanced
558 location. As shown in the figure there may be two approaches. The E-SMLC queries the LOCIWF (Step A) and it
559 responds with location (Step B). Or potentially, since the enhanced location service is autonomously acquiring the
560 location, the LOCIWF could push the location to the E-SMLC (Step A1). Note that how the LOCIWF determines the
561 address of the E-SMLC is for future study. If the E-SMLC receives the enhanced location and the location
562 determined by the location determination technology, it could make a decision as to the most appropriate location
563 to pass forward. It could then return that location to the MME (Step 4). The MME would push the location to the
564 GMLC (Step 5) and the GMLC would acknowledge (Step 6). The GMLC would respond to the LRF with location
565 (Step iii). If the location is returned within an appropriate timeframe, the LRF could use that location to query the
566 RDF (not shown) and choose a route URI that could be returned to the E-CSCF (Step iv). Then normal processing
567 would forward the emergency call toward the PSAP. When the E-SMLC receives one location (either the enhanced
568 location or the location determined by the location determination technology) it may do a quality analysis of that
569 location and if suitable for routing, return it in Step 4 without waiting for the other location.

570 As shown in Figure 7 there are three potential timers that support this flow. Conceptually the LOC timer could be
571 used by the E-SMLC to determine how long it waits for a routable location (either the first one that has sufficient
572 quality to route the call or by comparing the locations received). If it doesn't receive either location before the timer
573 expires, it will wait for one of the locations and return it. In that case the location is most likely not a routable location.

574 Also shown is an Initial Route timer in the GMLC. If the timer expires before it receives a location (Step 5) it is not
575 likely that a location can be returned to the LRF that may be used for routing.

576 There will be a Route timer associated with the LRF. If the LRF does not get a location response from the GMLC
577 (Step iii) before the timer expires then the LRF will fall back to cell-based routing.

578

579

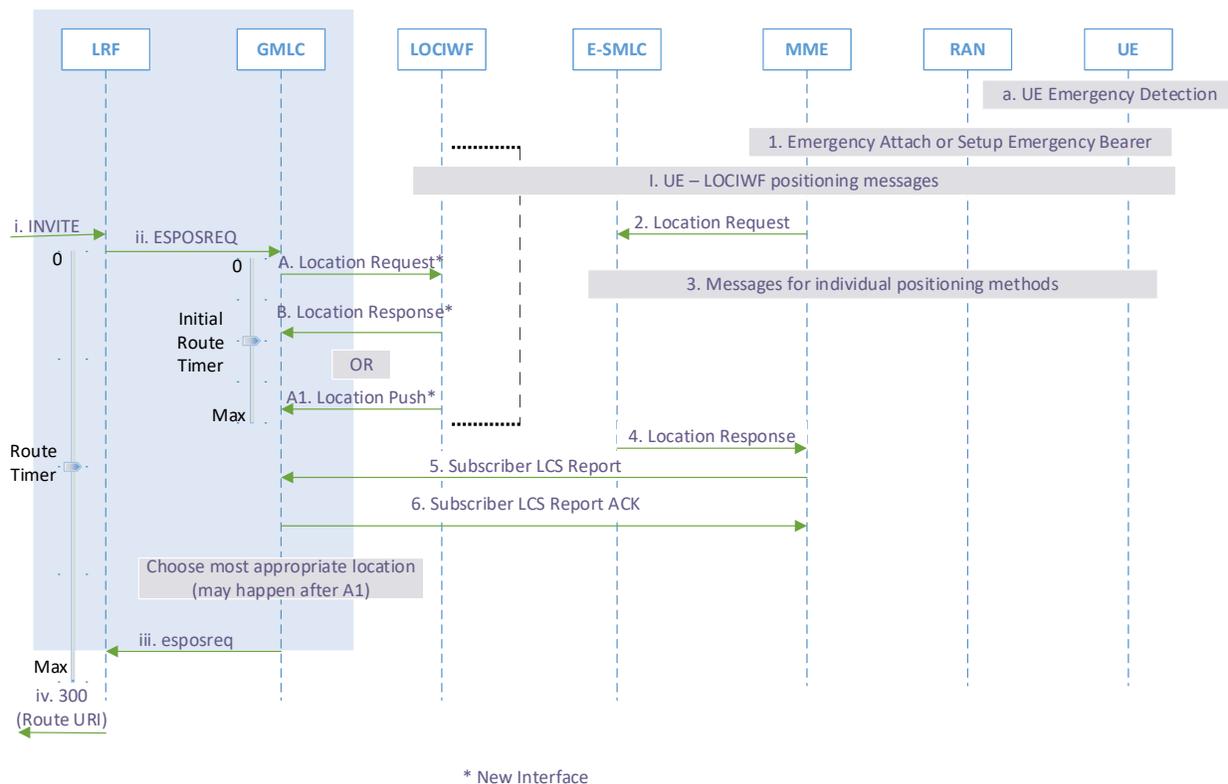580   **Figure 7 Conceptual Flow Using E-SMLC Logic**

581

582   Figure 8 illustrates a conceptual flow where the GMLC interacts with the LOCIWF. In the scenario depicted in Figure
583   8, the procedures at the E-SMLC are not changed and the E-SMLC will return the location when it obtains it (Step
584   4).

585   ATIS-0700015 Figure C.1 is extended to support location-based routing by including steps where the GMLC could
586   interact with the Location Interworking Function to obtain enhanced location (as shown in Steps A and B, or A1).

587   In Step a, the UE detects the emergency call. In Step I there are location acquisition messages that flow between
588   the UE and the LOCIWF. These are proprietary and outside the scope of this document. Steps 1, 2, and 3 are
589   processed in parallel as discussed above. When the LRF receives the INVITE (Step i) it queries the GMLC (Step
590   ii). The GMLC then interacts with the LOCIWF. As shown in the figure there may be two approaches. The GMLC
591   queries the LOCIWF (Step A) and it responds with location (Step B). Or potentially since the enhanced location
592   service is autonomously acquiring the location, the LOCIWF could push the location to the GMLC (A1). Note that
593   how the LOCIWF determines the address of the GMLC is for future study. When the GMLC receives one location
594   (either the enhanced location or the location determined by the location determination technology) it may do a
595   quality analysis of that location and if suitable for routing, return it in Step iii without waiting for the other location. If
596   the location is returned within an appropriate timeframe, the LRF could use that location to query the RDF (not
597   shown) and choose a route URI that could be returned to the E-CSCF (Step iv). Then normal processing forwards
598   the emergency call toward the PSAP.

599   This scenario would not require a LOC timer as discussed above since there are no changes to the E-SMLC. The
600   Initial Route timer in the GMLC could be used as discussed above. The Route timer in the LRF could be used to
601   determine if the call is routed based on the location provided by the GMLC or the LRF falls back to cell-based
602   routing.

603

604   **Figure 8 – Conceptual Flow Using GMLC Logic**
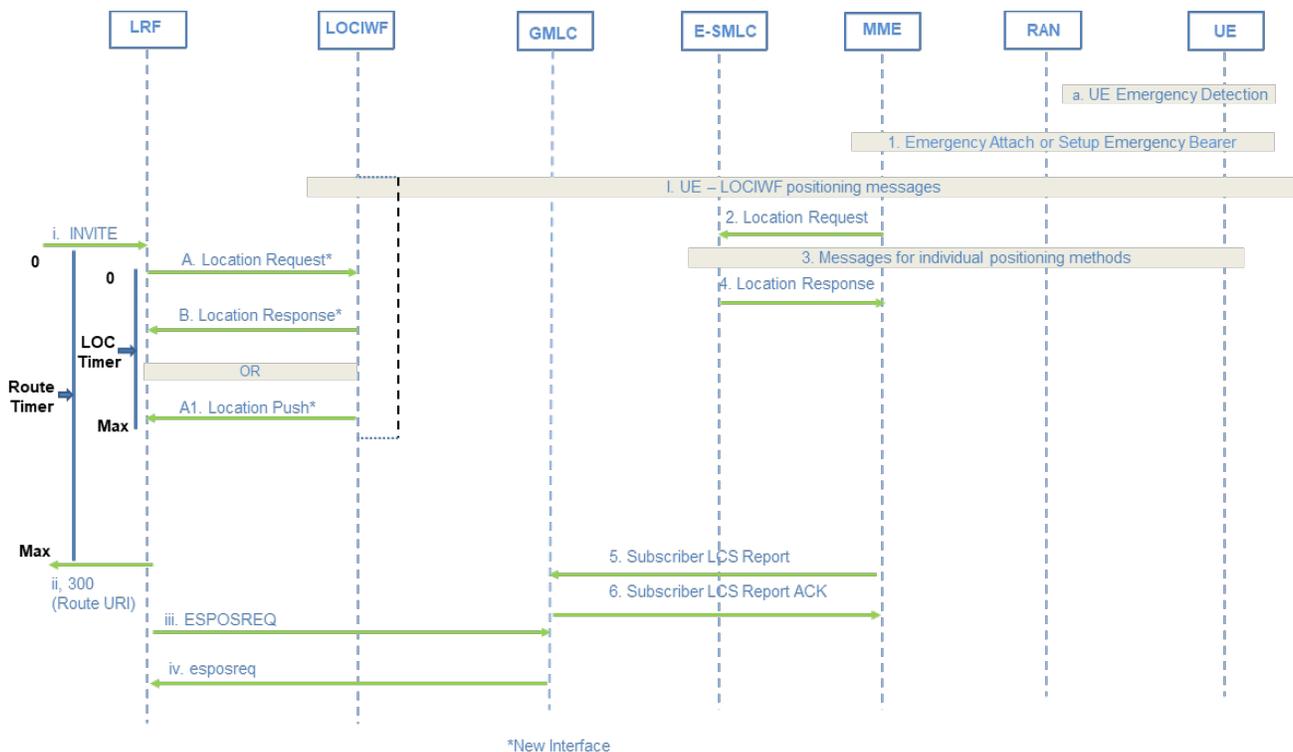
605   Figure 9 illustrates a conceptual flow where an LRF (that is implemented separately from a GMLC) interacts with
606   the LOCIWF. In this scenario, the processes performed by the E-SMLC and GMLC are not changed and the E-
607   SMLC will return the location determined by the location determination technology to the GMLC via the MME when
608   it obtains it (Steps 1 through 6).

609 Figure 9 extends ATIS-0700015 Figure C.1 to support location-based routing by including steps where the LRF
610 interacts with the Location Interworking Function to obtain enhanced location (as shown in Steps A and B, or Step
611 A1).

612 In Step a, the UE detects the emergency call. In Step I, there are location acquisition messages that flow between
613 the UE and the LOCIWF. These are proprietary and outside the scope of this document. Steps 1 through 6 are
614 processed in parallel with the acquisition of routing location by the LRF and the routing of the emergency call. When
615 the LRF receives the INVITE (Step i) it interacts with the LOCIWF. As shown in the figure, this interaction may take
616 one of two forms. The LRF queries the LOCIWF (Step A) and it responds with location (Step B), or alternatively,
617 the LOCIWF could push the location obtained via interactions with the UE to the LRF (Step A1). Note that the means
618 by which the LOCIWF determines the address of the LRF is for future study. The LRF will set a timer (i.e., LOC
619 Timer) which will specify how long the LRF is willing to wait to receive UE location from the LOCIWF. If the LRF
620 receives location information from the LOCIWF before the LOC Timer expires, it may do a quality analysis of that
621 location (e.g., by comparing it to the Associated Location provisioned at the LRF) and if suitable for routing, the LRF
622 will use that location to query the RDF (not shown). The RDF will use that location to identify a Route URI for the
623 call and will return the Route URI to the LRF (not shown). The LRF will use the procedures specified in ATIS-
624 0700015 to return the Route URI and other information to the E-CSCF (Step ii). The E-CSCF will then apply normal
625 processing, as specified in ATIS-0700015, to forward the emergency call to the appropriate Emergency Services
626 Network.

627 If a routing location is not provided by the LOCIWF to the LRF within the pre-determined timeframe, or is not
628 determined to be of sufficient quality, the LRF will use the mechanisms currently specified in ATIS-0700015 for
629 determining a routing location for the call (i.e., it will use the Associated Location to query the RDF). Note that in
630 this call flow, the location acquired by the E-SMLC and pushed to the GMLC via the MME will not play a role in
631 emergency call routing but could still impact the caller location returned by the LRF in response to queries from
632 PSAPs/Automatic Location Identification (ALI) systems/Legacy PSAP Gateways (LPGs). As such, the LRF may
633 interact with the GMLC in parallel with the emergency call routing procedures described above to obtain network-
634 based caller location for possible delivery to PSAPs. Further study is needed to describe potential interactions
635 between the location provided by the LOCIWF and network-provided location in identifying the caller location that
636 should be returned in response to PSAP/ALI/LPG queries.

637

639 **Figure 9 – Conceptual Flow Using LRF Logic**

640

641 Figure 10 illustrates a conceptual flow using the early location fix capability of LPP described in Clause 6.3. Figure
642 10 does not require an architectural change and requires only small changes to existing signaling procedures. In
643 Step a, the UE detects the emergency call. In Step 1, the UE may start obtaining location measurements in
644 anticipation of the location request at Step 4. At Step 3, after the MME becomes aware of the emergency call from
645 the emergency attach or setup of an emergency bearer at Step 2, the MME requests location from the E-SMLC and
646 includes a request for an early location fix. The E-SMLC then requests an early and a final location fix from the UE
647 at Step 4. For example, the response time for the early location fix can be set to a few seconds, while the response
648 time for the final location fix can be set to 20-30 seconds. After the UE returns the early location fix at Step 5, the
649 E-SMLC determines or verifies a location estimate for the UE and returns this to the MME at Step 6 in a normal
650 location response. The MME provides this to the GMLC at Step 7 and includes an indication that this is an early
651 location fix. The GMLC then provides the early location fix to the LRF at Step iii following a request at Step ii. The
652 LRF uses the early location fix for LBR at Step iv. At some later time, the UE returns a final location fix to the E-
653 SMLC at Step 9. The E-SMLC determines or verifies a location estimate for the UE and returns this to the MME at
654 Step 10. The MME provides this to the GMLC at Step 11 and indicates this is a final location fix. The GMLC may
655 then provide the final location fix to the LRF at Step vi following a second location request at Step v. Signaling for
656 Steps 10-12 can be the same as for Steps 6-8 with the difference that Steps 6 and 7 indicate an early location fix
657 whereas Steps 10 and 11 indicate a final location fix. The location request/response transaction between the MME
658 and E-SMLC, which is started at Step 3, terminates after the response for the final location fix at Step 10.

659
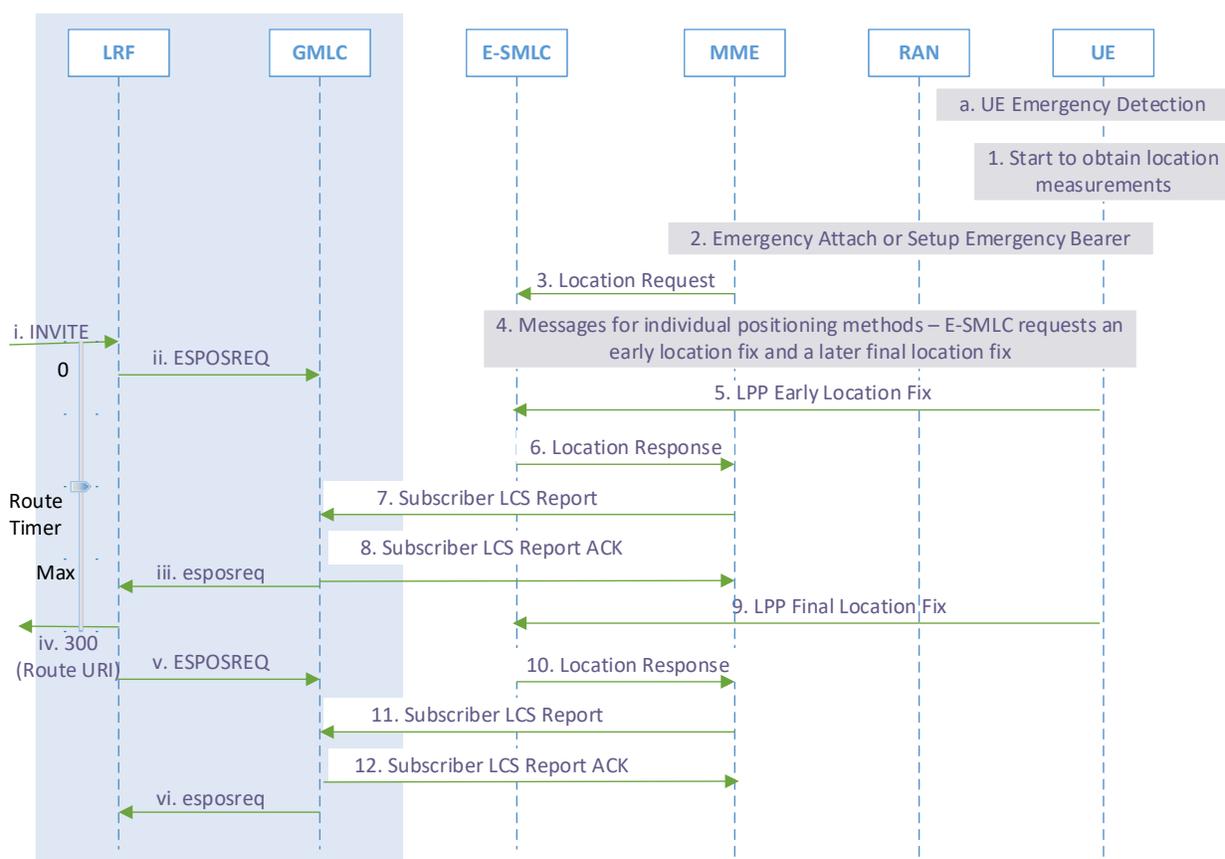
Figure 10 – Conceptual Flow Using an LPP Early Location Fix

9 Potential Standards Gaps Associated with Location-based Routing Methods

665 ATIS-0700015 is the defining standard as to how IMS-based networks route emergency calls to legacy emergency
666 services networks, and to NENA i3 ESInets natively using the Session Initiation Protocol (SIP) and passing the UE
667 location either by value or by reference. As noted in Annex A, Figure 8.2 illustrates a call flow where the emergency

668 call is routed based upon the acquired UE location. However, other clauses of ATIS-0700015 imply that wireless
669 calls are only routed based upon cell information by using an Associated Location.

670 How location is acquired is beyond the scope of the current version of ATIS-0700015. However, as shown in Figure
671 C.1 it is implied that location is acquired via control plane or user plane methods. There is no current support in
672 ATIS-0700015 for acquiring UE location from an enhanced location service provider as discussed in Clause 8.

673

674 10 Conclusion

675 In the analysis performed by ATIS it has been determined that location-based routing is technically feasible within
676 the timing considerations recommended by CSRIC V.

677

678 11 Recommendations

679 This document recommends that ATIS-0700015 be augmented to consistently illustrate how emergency calls can
680 be routed based upon UE location, assuming that location can be acquired in sufficient time so as not do unduly
681 delay call processing. ATIS-0700015 should be extended to define the concepts discussed in Clause 8 of this
682 document where the CMRS network may have access to a location provided by an enhanced location service
683 provider and be able to make routing decision based upon that location, potentially by comparing it to a location
684 acquired via control plane or user plane methods. The extensions to ATIS-0700015 would address technical,
685 operational and protocol considerations to incorporate these location technologies.

686 ATIS committees should continue to engage with industry players that are defining new methods to acquire UE
687 location and identify whether additional standards work may be necessary to facilitate these new methods.

688

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A ATIS-0700015 Constructs Supporting Location-based Routing

695 This Annex extracts clauses from ATIS-0700015 that relate to Location-based Routing. In some instances, the text
696 or figures apply directly. In some cases, modifications would be required to clarify support for LBR.

697 Figure 8.2 in ATIS-0700015 illustrates a call flow where the emergency call is routed based upon the acquired UE
698 location. This could be used as the reference flow for LBR call flows where the LRF is able to acquire the UE
699 location in time to use it to query the RDF (Steps 5 and 6). Then the RDF would return a Route URI (Step 7) that
700 would allow the emergency call to be routed toward the PSAP. This flow would need to be harmonized with Figure
701 8.3 which illustrates routing the call using the Associate Location based upon the cell ID. The LRF would have to
702 incorporate procedures to determine which method to use.

703
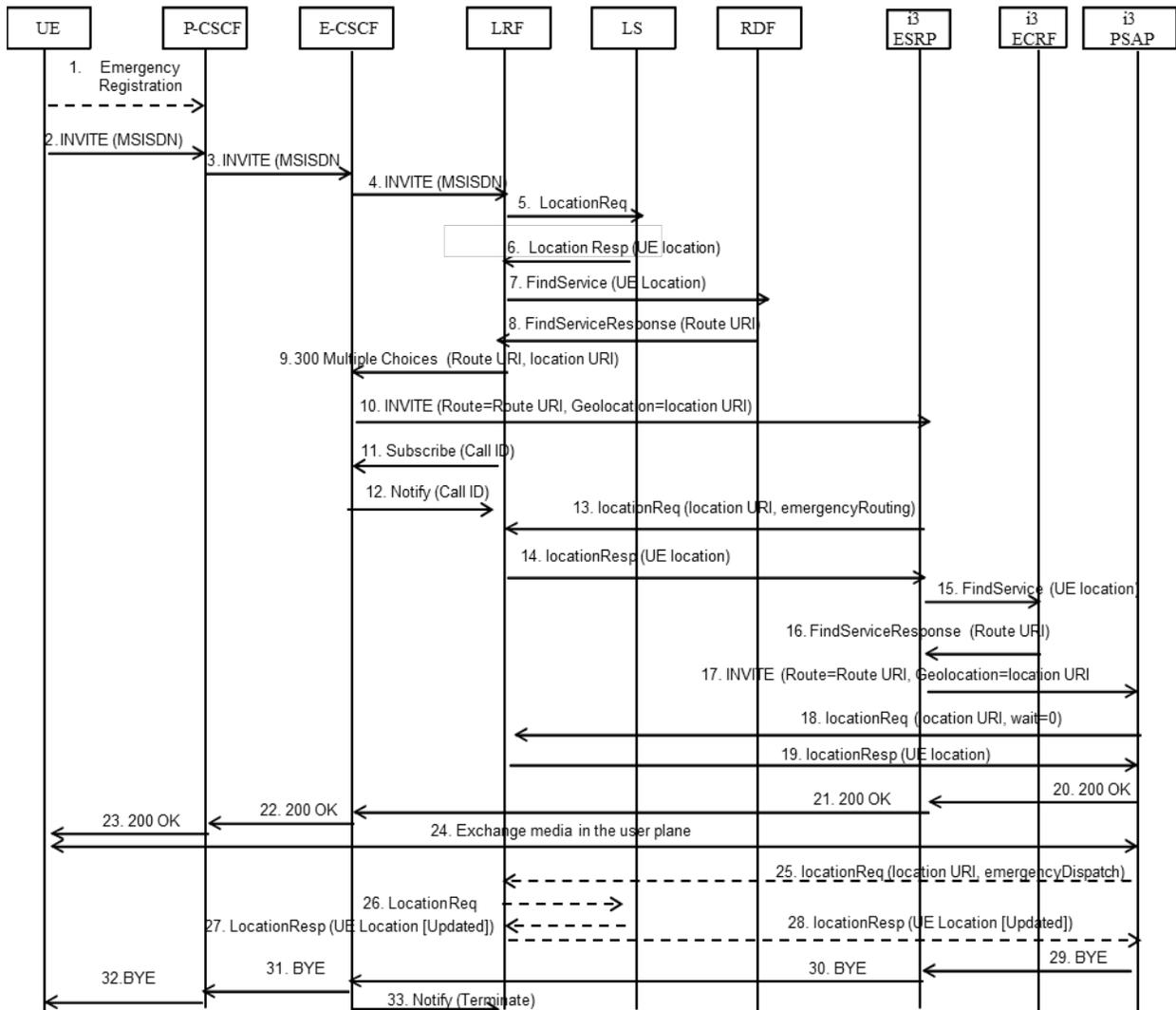
704

705 **ATIS-0700015 – Figure 8.2 – UE Location-Routed Call Delivery to NENA i3 ESInet – Location-by-Reference**

706

707 **Step 1.** (Conditional) Emergency registration occurs (if not already emergency registered and has
708 credentials).

23

| 709 710	**Step 2.**	The UE sends a SIP INVITE to the P-CSCF that contains a Mobile Station International Subscriber Directory Number (MSISDN) and no location information.
711	**Step 3.**	The P-CSCF, detecting an emergency call, forwards the SIP INVITE to the E-CSCF.
712	**Step 4.**	The E-CSCF queries LRF for location and/or route, by forwarding the SIP INVITE.
713 714	**Step 5.**	The LRF may select a technique for acquiring location information based upon the call type. The LRF interacts with the LS to acquire location/initiate position determination process.
715	**Step 6.**	The LS responds with UE location value.
716	**Step 7.**	The LRF queries the RDF for routing information.
717	**Step 8.**	The RDF responds by providing a Route URI.
718 719 720	**Step 9.**	The LRF redirects the call back to the E-CSCF with location information (in this example, location information is LbyR; therefore, the LRF constructs a Reference Identifier with the location URI) and a Route URI that will direct the call toward the ESInet.
721 722	**Step 10.**	The E-CSCF forwards the SIP INVITE (with any location information received from the LRF; in this example, a Reference Identifier with the location URI) to the ESRP via an IBCF.
723 724 725	**Step 11.**	The LRF sends a SIP SUBSCRIBE to the E-CSCF to be informed of call state. (Alternatively, the Subscription may be done at the system start-up and be applicable to all calls [not shown]).
726	**Step 12.**	The E-CSCF sends an initial state NOTIFY to the LRF.
727 728 729 730	**Step 13.**	In this example, the SIP INVITE contains a location URI, so the ESRP queries the LRF (as identified in the location URI) for location value. This call flow illustrates the use of HELD as a de-reference protocol. The value of the responseTime parameter in the HELD locationRequest sent by the ESRP is set to "emergencyRouting".
731	**Step 14.**	The LRF supplies the UE location obtained in Step 6 to the ESRP.
732 733	**Step 15.**	(Informative) Within the ESInet, the ESRP queries the ECRF for routing information using the Location-to-Service Translation (LoST) protocol.
734	**Step 16.**	(Informative) The ECRF replies to the ESRP with a PSAP URI.
735	**Step 17.**	The ESRP forwards the SIP INVITE to the NENA i3 PSAP.
736 737 738	**Step 18.**	In this example, the SIP INVITE contains a location URI, so the PSAP queries the LRF (as identified in the location URI) for initial location (i.e., responseTime contains a wait timer value of "0").
739	**Step 19.**	The LRF returns the UE location obtained in Step 6.
740 741	**Step 20.**	The PSAP indicates the call has been answered by returning a SIP 200 OK to the ESRP. This Step may occur before Step 18.
742	**Step 21.**	The ESRP forwards a SIP 200 OK to the E-CSCF.
743	**Step 22.**	The E-CSCF forwards a SIP 200 OK to the P-CSCF.
744		NOTE: The E-CSCF sends a NOTIFY to the LRF based on Step 11 (not shown).
745	**Step 23.**	The P-CSCF forwards a SIP 200 OK to the UE.
746	**Step 24.**	Media is exchanged in the user plane.
747 748	**Step 25.**	(Optional) The PSAP queries the LRF (as identified in the location URI) for updated location information (responseTime parameter="emergencyDispatch" in this example).
749 750 751	**Step 26.**	(Conditional on Step 25) The LRF queries the LS for updated location information. (Note that the value of the responseTime parameter [emergencyDispatch or a specific time value] will be used by the LRF to determine whether to query the LS).
752	**Step 27.**	(Conditional on Step 26) The LS returns updated UE location information to the LRF.
753	**Step 28.**	(Conditional on Step 25) The LRF supplies update UE location to the PSAP.
754	**Step 29.**	The PSAP sends a SIP BYE to the ESRP. Note that this may be sent by the UE as well.
755	**Step 30.**	The ESRP forwards a SIP BYE to the E-CSCF through the BCF/IBCF.
756	**Step 31.**	The E-CSCF forwards a SIP BYE to the P-CSCF.
757	**Step 32.**	The P-CSCF forwards a SIP BYE to the UE.

758   **Step 33.** The E-CSCF sends a termination SIP NOTIFY to the LRF in order to release resources. This
759   may occur any time after step 30.

760

761 Appendix C of ATIS-0700015 describes procedures applicable to location acquisition and conveyance to assist call
762 routing and to provide location to the PSAP. These procedures correspond to procedures defined in 3GPP TS
763 23.271 and OMA SUPL. Figure C.1 is copied as an example of a flow to support LBR, and the UE location may be
764 acquired in time to use it to route the emergency call. Figure C.1 shows the procedure to support location when an
765 IMS emergency call is originated using an LTE access.

766
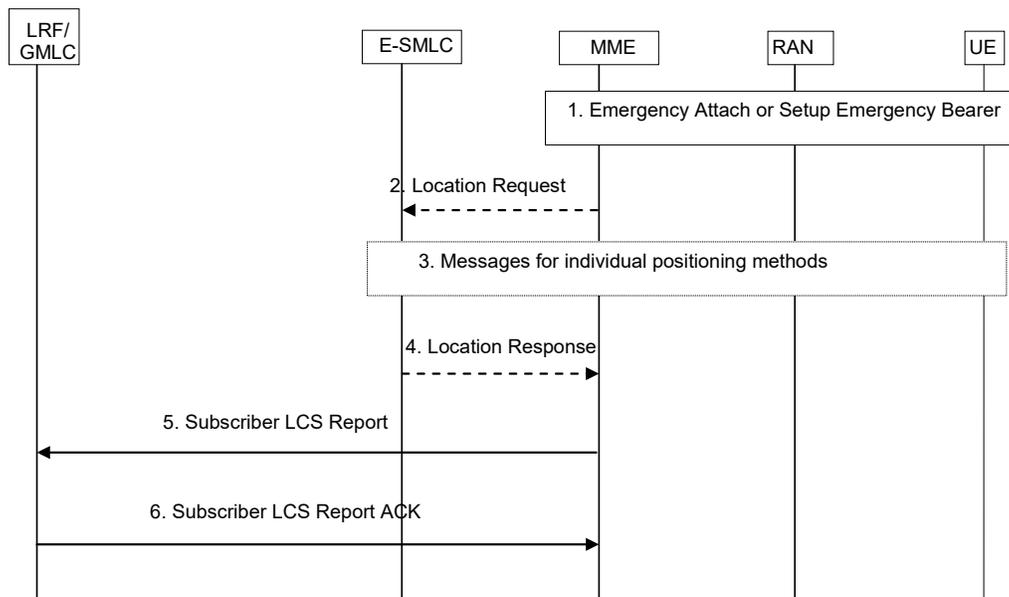
767

768 **ATIS-0700015 Figure C.1 – Control Plane Location for IMS Emergency Call Origination for LTE Access**

769

770   **Step 1.** The user initiates an emergency call. The UE either performs an emergency attach if in
771   limited service state or requests an emergency PDN connection if in normal service state
772   and after performing a normal attach. Details of an emergency attach and normal attach for
773   LTE can be found in 3GPP TS 23.401..

774   **Step 2.** Steps 2 to 4 may be skipped if the MME only needs to send its identity or serving Cell ID to
775   the LRF and not the location of the UE. Otherwise, the MME selects an E-SMLC and sends
776   a Location Request message to the selected E-SMLC. The Location Request includes the
777   type of location information requested, the requested QoS, identity of serving cell, and UE
778   capability to support LPP. The requested QoS corresponds to that needed to obtain a
779   location estimate sufficient to select a destination PSAP.

780   NOTE: If the UE was in connected mode prior to Step 1, the MME may not have the most
781   current serving cell identity if there was an intra-eNodeB handover.

782   **Step 3.** If the requested location information and the location accuracy within the QoS can be
783   satisfied based on parameters received from the MME (e.g., cell identity), the E-SMLC may
784   send a Location Response immediately. Otherwise, the E-SMLC determines the positioning
785   method and instigates the particular message sequence for this method as described in
786   3GPP TS 36.305. The positioning method may be either network centric or UE centric. If
787   the position method or methods fail, the E-SMLC may use the current cell identity to derive
788   an approximate location estimate.

789   **Step 4.** When a location estimate best satisfying the requested QoS has been obtained, the E-
790   SMLC returns a Location Response to the MME with an indication whether the obtained
791   location estimate satisfies the requested accuracy or not. This message carries the location

792   estimate that was obtained. If a location estimate was not successfully obtained, a failure
793   cause is included in the Location Response.

794   **Step 5.**   The MME determines a GMLC using either the serving cell identity or some fixed
795   association for the MME. The MME sends a Subscriber Location Report to the GMLC
796   carrying the IMEI and if available the IMSI and MSISDN of the UE, the event causing the
797   message (EPC NI-LR), and, if obtained in Steps 2 to 4, the location estimate. The serving
798   cell identity of the UE needs to also be sent if available. The MME includes its own address.

799   **Step 6.**   The GMLC returns an acknowledgment to the MME. The GMLC provides the received
800   information to an associated LRF, which stores the information for future use. The LRF will
801   use the information when later queried by an E-CSCF for routing information for the IMS
802   emergency call which the UE will originate following Step 1. Since there is a possibility of
803   the E-CSCF query being received by the LRF before the information is provided by the
804   GMLC, the LRF may choose to wait a short period following the E-CSCF query for the
805   GMLC provided information to become available. This treatment depends on consistent use
806   by an operator of the control plane solution (e.g., use of the control plane solution for an
807   entire LTE network).

808

809 In Appendix D, ATIS-0700015 provides an informative flow chart to illustrate routing methodologies for the process
810 to acquire location, determine routing and route the call.

811 Bullet 2 states the following:

812   •   "If the session request received by the LRF contains MSISDN/ Mobile Directory Number (MDN) and cell
813   site information, the LRF will consult with an appropriate LS (e.g., a GMLC) to initiate location determination.
814   (Note that it is expected that cell-based location information will be used in the initial routing of the call.)"

815 This bullet would have to be changed to denote that the location information could, optionally, be acquired and then
816 that location could be used for routing.

817 The flow below at ① shows that the LRF uses the cell information (i.e., cell ID) to allocate an Associated Location.
818 The Associated Location represents a location within the PSAP jurisdiction that would allow the emergency call to

819 be routed to the appropriate PSAP. In parallel, at ② the LRF requests the Phase II location from the MPC/GMLC.

820 Note that the MPC/GMLC may be incorporated within the LRF. To support LBR, ① and ② would have to be
821 modified to allow the location to be acquired prior to routing the call.

822

The E-CSCF inserts PAI containing non-dialable callback number

P-CSCF detects an emergency call/session request and forwards it to the E-CSCF

Is a PAI present in the session request?

no

yes

E-CSCF forwards the emergency call/session request to LRF

LRF receives the emergency call/session request and initiates location retrieval and/or routing determination

Is a location value present in the session request?

yes

A

no

2

LRF interacts with an MPC/GMLC to obtain Phase II location; MPC/GMLC initiates location determination function[1]

yes

Is MSISDN + cell info present in the session request?

no

Is a TN (only) present in the session request ? (P-ANI indicates fixed caller)

yes

Is the LRF successful in obtaining a routing location?

yes

A

no

1

LRF maps cell information to routing (i.e., Associated) location

no

LRF interacts with a LS that contains pre-provisioned mappings of TN to fixed location

LRF de-references location reference URI to obtain initial (routing) location

yes

Is a location reference URI present in the session request?

no

B

Is the LRF successful in obtaining a location value?

no

B

yes

A

[1]The output of the location determination function is expected to be returned in response to subsequent de-reference requests (e.g., from PSAPs). It is not expected to be used by the LRF to interact with an RDF for initial routing of the call .

823

ATIS-0700015 Figure D.1 – Emergency Call is Detected by IMS Origination Network and Routing Location is Acquired/Derived

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825

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