Porting for Windows® on IA-64

Stan (Stawsh) Murawski
& Kyle Marsh
Developer Relations Group,
Shahrokh Mortazavi
Visual Languages & Tools,

Microsoft Corporation

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Agenda

- 64-bit Windows® Overview.
- 64-bit Windows® Applications.
- Win64 types and API.
  - Making Win32 code 64-bit ready.
- Development Demo.
- Tools Roadman for 64-bit Windows®
  - MS Windows Platform SDK & Visual Studio.
- Other Issues and Call to Action.

64-bit Windows®

- 64-bit Windows is Windows®, i.e.,
  - Feature set equivalent to Windows 2000.
- Win64™ API, “same as” Win32™ except ...
  - All pointers, passed and returned, are now 64-bit pointers.
- WOW64 runs Win32 Applications.
  - Win32 (IA-32) x86 application binaries run.
  - Win16 applications do not run.

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Features Equivalent to Windows 2000

64-Bit Windows Advantage

1. Larger virtual memory.
   - 4TB user and 4TB kernel.
2. Supports 64 bit integers.
   - Count more stuff in _int64 types.
   - Count faster with native 64 bit math, v.s. crt routines or user developed algorithms that us multiple “small” 32 bit registers.
   - Itanium(TM) Processor FPU counts faster too.
3. IA-64 code can reach performance potential of Itanium(TM) processors

64-bit Candidate Apps

1. Applications that use very large objects,
   - i.e., larger than 2 gigabyte objects.
   - e.g., Video editing.
2. Apps that use files that are larger than 2**32 bytes.
   - You can memory map *very* LARGE files!
   - e.g., databases.

64-Bit Candidate Apps (cont)

3. Apps that count > 2**32 “things”.
   - Statistical analysis applications.
   - _Int64 algorithms, e.g. 40 or 56 bit encryption “in a register”. (128 bit in 2 registers).
4. Apps HW Performance constrained.
   - Access to memory.
   - I/O and Bus speed.

MS 64-bit Windows® Candidate applications

- MS SQL Server™
  - Very large things
- MS Exchange™ Server
  - Very many things
- MS BackOffice™ Servers
  - Large virtual and physical memory
- But not all apps:
  - Microsoft Office™ will run as a Win32 (IA-32) application.

64 bit Windows types, type Rules and API

WORDs, INTs, Pointers 64

- Size Model is called LLP64.
  - Default `INT`s and `LONG`s are 32 bits.
  - Pointers are 64 bits.
  - For 64 bits integers use, e.g., `_int64`.
- LLP64 goodness for developers.
  - Maximum Windows ISV application compatibility. IA-64 benefits sooner.
  - Most compatible Win32-Win64 interop.
    - Least change to data structures.

LLP64 is least change to Win32 code

Win64 types

- New explicitly sized types.
  - `DWORD32`, `INT64`.
- New integral types that match the precision of a pointer.
  - `DWORD_PTR`.
- Some 32-bit Win32 data types 64 bits:
  - Pointers are 64 bits, plus `LPARAM`, `WPARAM`, `LRESULT`, `HMODULE`.

Most Win32 32-bit types remain 32 bit

Win64 Types from basetsd.h

TYPE NAME	WHAT IT IS
LONG32, INT32	32-Bit Signed
LONG64, INT64	64-Bit Signed
ULONG32, UINT32, DWORD32	32-Bit Unsigned
ULONG64, UINT64, DWORD64	64-Bit Unsigned

basetsd.h Types (continued)

TYPE NAME	WHAT IT IS
INT_PTR, LONG_PTR	Signed Int, Pointer precision
UINT_PTR, ULONG_PTR, DWORD_PTR	Unsigned Int, Pointer precision
SIZE_T	Unsigned count, Pointer precision
SSIZE_T	Signed count, Pointer precision

Win64 type “Rules”

- For integral pointer types:
  - use `UINT_PTR`, `INT_PTR`, `ULONG_PTR`, or `DWORD_PTR`.
  - Do not assume that `DWORD`, `LONG` or `ULONG` can hold a pointer.
- Use `SIZE_T` to specify byte counts that span the range of a pointer.
- Make no assumptions about the length of a pointer or `xxxx_PTR` or `xSIZE_T`.
  - Assume these are compatible precision.

The Win64™ API

- Simple pointer stretch of Win32® (and NT Native) API set.
- Win64™ data type definitions in `basetsd.h` define most of the change.
- Primary Issues are:
  - Polymorphic Data usage, e.g., use of (DWORD / PSTR).
  - Pointer/length combinations.
  - Miscellaneous cleanup, e.g, (0xFFFFFFFF for -1).
  - Cross 32/64 bit process communication.

Making code "64 bit ready"

Compile warning free!

Code Areas to Review (1 of 3)

- Code which uses the high address bit.
- Pointer truncations.
- Functions with pointers as out params.
  - `BOOL GetBuf( int fd, ULONG_PTR *buf);`
- Explicit and implicit unions with pointers.
- Data structures stored on disk or exchanged with 32 bit processes.
  - Structures that contain the types that change size, e.g., `LPARAM`, `WPARAM`, `LRESULT`, `HMODULE`.

Code Areas to Review (2 of 3)

Piecemeal size allocations:

```
struct foo {
   DWORD NumberOfPointers;
   PVOID Pointers[1];
} xx;
Wrong:
malloc(sizeof(DWORD)+100*sizeof(PVOID));
Correct:
malloc(offsetof(struct foo, Pointers)
   +100*sizeof(PVOID));
```

Code Areas to Review (3 of 3)

- Correct reference to polymorphic data.
- Ensure plug-in interfaces are RPC-able.
- Make COM objects able to run out of process.
- All assembly code.
  - It's not x86 (IA32) assembler.

Demos:

Win64 code and Win64 build

Demo:

Debugging Win64 code

Win64 Device Drivers

- Device Drivers are 64 bit code.
  - No support for 32 bit device drivers.
  - At IDF: “Win64 Device Driver Porting”.
- Code signing “safety rules” same as Win32.
- Drivers need to be PNP.
- Drivers need to consider *IF* they will be called from 32 and 64 bit mode code.
  - need to support 32 and 64 version of IOCTLs.
  - I/O request length is limited to 32 bits.

Drivers must be 64-bit, PNP & signed

Win64 Rapid migration

- Situation
  - You want to be IA-64.
  - 2 gig address space is AOK enough.
  - LOTs of Pointer truncation warnings.
  - Pointers and int/long are freely mixed.
  - Polymorphism via 32-bit types is used heavily.
- Alternative – Run in a 32-bit 64-bit address space “sandbox”.

Address Space “sandbox”

- IMAGE_FILE_LARGE_ADDRESS_AWARE
  - If SET, 64-bit address space available.
  - If CLEAR set, never/can’t see > 2GB.
    - Upper 33 address bits are 0.
    - Can truncate 64 bits, and extend 32 bits.
- Example OK Code:

```
DWORD dw;
PVOID dest, src = malloc(IO_BUFFER);

dw = (DWORD)src;
dest = (PVOID)dw;
ASSERT(((DWORD_PTR)src & 0xffffffff80000000) == 0);
ASSERT(src == dest);
```

Win32 on 64 bit Windows

- Address space is either 64 or 32.
  - Can not mix 32 and 64 in an address space
- 64-bit processes run Win64 APIs which call directly into the 64-bit kernel.
- 32-bit processes run Win32 APIs using 32-bit ntdll, kernel32, user32, etc.
  - 32/64 thunk made at System-Call interface between user-mode and kernel-mode.
    - Provides excellent compatibility due to small, validated, strictly defined API set.

No mixing 64/32 bit code in same process

64-bit Windows roadmap

SDK2.0 OS ships with Intel Cross Dev. SDK

BETA MS BETA of 64 bit Windows

RTM 64 bit Windows RTM

64-bit Windows roadmap

- Early HW developer bits.
- Joint Intel/MS SDK:
  - Cross-Dev SDK (Build#5), Jan'00
    - RTM Windows 2000 code base.
  - SDK2.0, Mar'00

NDA Req'd (HW dependent)

- MS 64-bit Windows BETA1
  - Spring/2Q '00.
  - Platform SDK (tools&OS) ships & supported by MS
- 64-bit Windows RTM (ship)
  - When computers with the Itanium(TM) Processor ship.

Tools Roadmap For 64-bit Windows

Shahrokh Mortazavi
Lead Program Manager
Visual Languages & Tools
Microsoft

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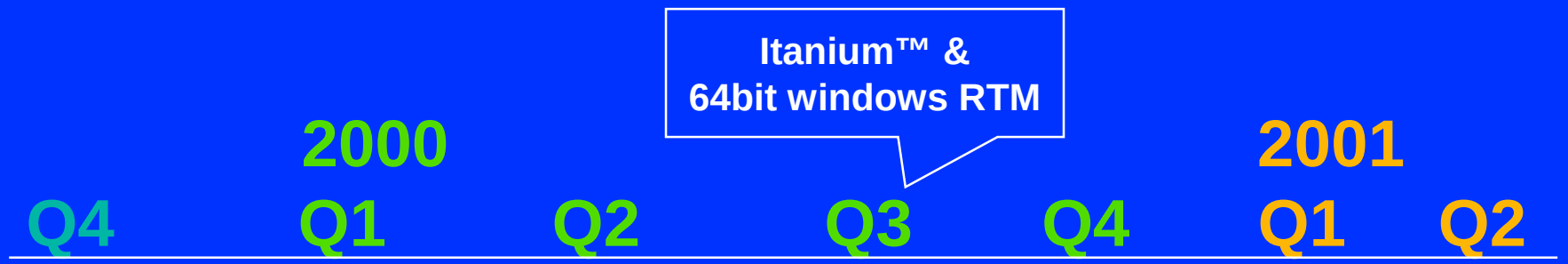
Agenda

- Visual Studio Roadmap
- SDK Tools Roadmap
- Tools status
- Optimization features
- Futures
- Call to Action

SDK Tools roadmap



SDK1 Simulator based, core tools only

SDK2.0 Targets real HW; debugger added

PSDK1 MS Platform SDK + tools

PSDK2 Release candidate

PSDK0 Sept '98

64-bit support in the MS Platform SDK for Windows 2000 (BETA).

SDK tools roadmap

- Joint Intel/MS
  - Cross Dev SDK (build#5), Jan'00
    - Compiler FrontEnd from next major release of VC
    - Backend/Optimizer
    - Linker, MFC, ATL
  - SDK 2.0, Mar'00
    - VC Debugger added; Improved code quality; bug fixes

NDA Req'd (HW dependent)

- Future PSDKs (DDK) directly from MS
  - Non-NDA, free

Today: SDKs, Soon: PSDKs

SDK Tools status

- Robustness/Correctness
  - Have been compiling NT since last year
  - Compiler bootstrap, SQL server, VC language tests
    - All with optimizations turned on
  - SDK user: “compiled/linked 10M LOC without problem”
- Code Quality
  - Parallel Itanium Dev team
  - All major optimization phases implemented
  - Currently focused on tuning

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SDK Tools are here & usable today!

Visual Studio Tools Roadmap

- Visual Studio next major release
  - 32-bit, focused on Enterprise/Web development
  - Various Intel specific features for KNI, WNI, 64-bit migration.
- 64-bit Visual Studio
  - Same as above, ported and tuned for Itanium™
    - Cross tools vs. Native tools
  - Mature optimization technology
  - Advanced debugging support: debug of optimized code!

Optimization specifics

- Partial list of optimizations:
  - Predication
  - Speculation
  - Local/global scheduling
  - Whole Program and Profile Guided Optimization
  - Software pipelining
  - All std opts: CSE, loop unrolling, branch opts, etc.
- Tuning focus
  - Respectable SPEC numbers: Not a “SPEC Warrior”
  - TPC benchmark
  - Integer, RWC performance is our primary focus

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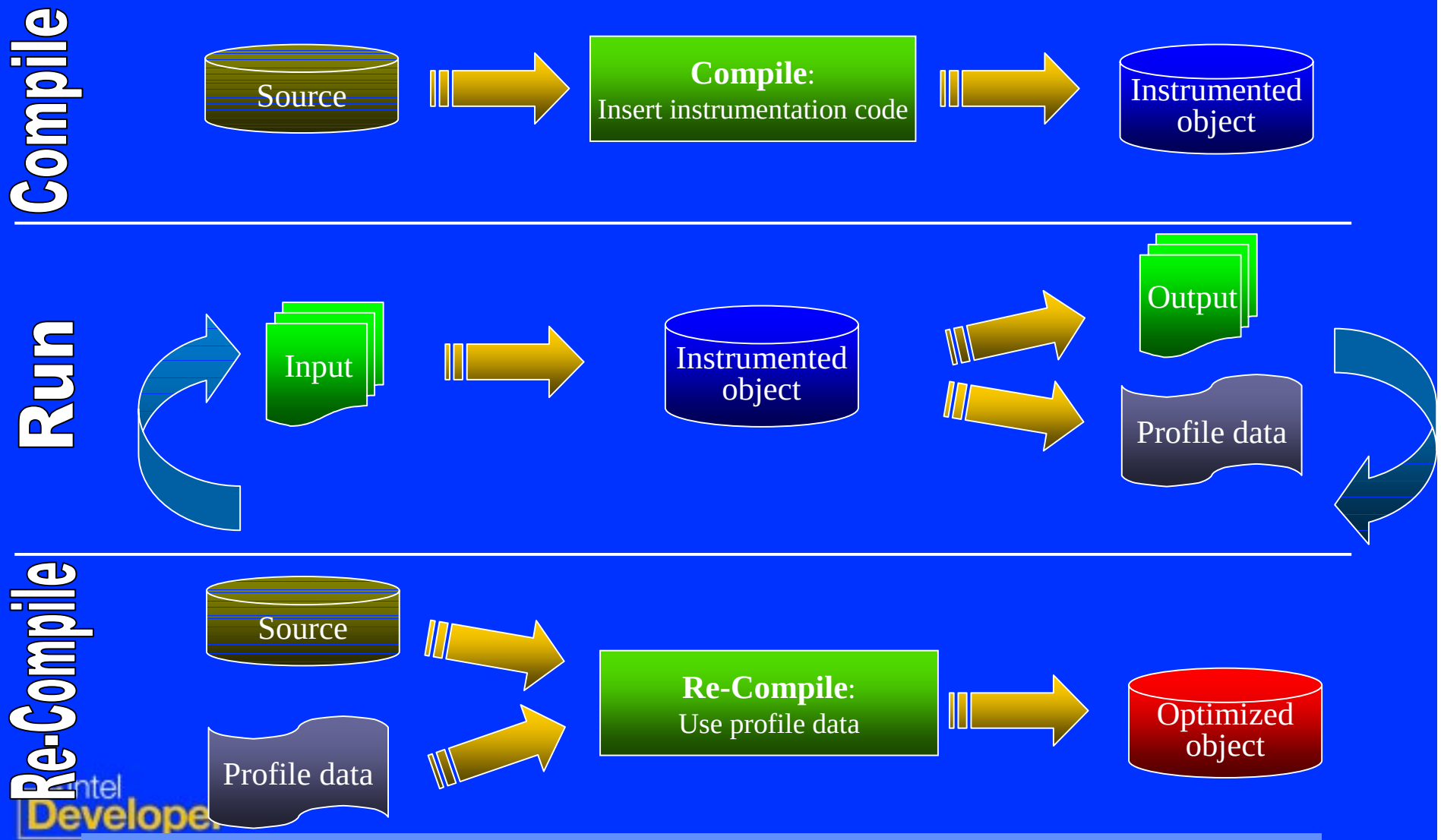
MS will deliver a world-class compiler

Profile-Guided Optimization



A Critical Optimization for best performance!

Tools Futures

- Improved debug of optimized code
- Improved optimizations
- Better FP code generation
- More analysis tools
- Improved compiler throughput
- Continued collaboration with MS-Research

Resources and Call to Action:

64-bit Windows Platform SDK

- Intel IA-64 SDK <= 1.7 included simulator.
  - Started work before IA-64 Hardware avail.
- MS Platform SDK for Windows 2000 has 64-bit doc. and tools. Online at <http://www.MSDN.Microsoft.com/>
- Intel "Cross-Dev" SDK avail Jan '00.
  - For developers with IA-64 early Hardware.
- DDK available for Driver Developers.

MS Developer Programs

- MSDN™ Developer Programs.
  - See “Partnering” at http://MSDN.Microsoft.com/.
- MS Developer Relations Initiatives: mailto:DrgWin64@Microsoft.com
  - Report 3rd party dependencies, both COM server Components and DLLs.
  - non-support 64 bit questions/comments.
- MS 64-bit Windows Tech-BETA.
  - Apply at BetaInfo@Microsoft.com.

Collateral and Feedback

- "Getting Ready for 64-bit Windows" on Platform SDK for Windows 2000.
  - Platform SDK CD (since Sept '98).
  - http://msdn.microsoft.com
    MSDN Online Library
    see "*Getting Ready for 64 bit Windows*"
- Beta site: betainfo@microsoft.com
- mailto:nt64feed@microsoft.com
  64 bit Windows feedback / questions.

Tell us about "other" code that your 64-bit code depends upon to build/run!

Call To Action - Readiness

- Start with good code for Windows 2000.
  - Follow the Design Guidelines.
- Install the Windows 2000 Platform SDK.
  - “Know“ what is in readme64.txt.
  - Use <basetsd.h> types and functions.
- Get 64 bit ready now.
  - Design “problem areas” out of your code.
    - No pointer truncation.
    - Correct polymorphism.
  - Clean build Win32™ code for Win64™.

No Source Fork
64-bit ready NOW!

Call To Action – Exploit 64

- New Function – new design options.
  - You can do stuff with Big INTs.
    - Count a lot of stuff, w/o FP.
  - You can do things with Large memory.
    - Memory mapping HUGE files.
    - HUGE arrays and structures.
- More Speed and Scale (even existing Apps)
  - Optimize for 64 bit “size” (see above)
  - Optimize for IA-64

Consider how you can use large address spaces!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