Make Your PL/I and C/C++ Code Fly With the Right Compiler Options

Peter Elderon
IBM

March, 2015

Insert Custom Session QR if Desired.

#SHAREorg

SHARE is an independent volunteer-run information technology association that provides **education**, professional **networking** and industry **influence**.

SHARE in Seattle 2015

WHAT …

- does good application performance mean to you?
  - Fast Execution Time
  - Short Compile Time

HOW …

- to achieve good application performance?
  - Install New Hardware
  - Utilize Compiler Options
  - Code for Performance

Install New Hardware

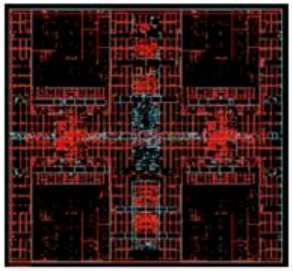
- Can make your code run faster

- Requires NO
  - Recompilation
  - Relinking
  - Migration to new release

- BUT, are you taking full advantage of all the new features from the new hardware?
  - i.e. the full ROI on the new piece of hardware

z Systems - Processor Roadmap

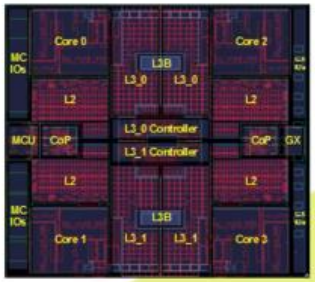
z10 2/2008



Workload Consolidation and Integration Engine for CPU Intensive Workloads

- Decimal FP
- Infiniband
- 64-CP Image
- Large Pages
- Shared Memory

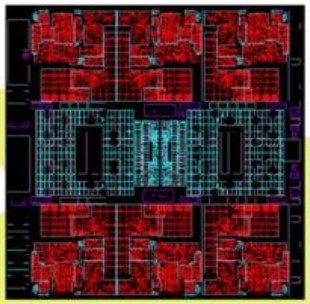
z196 9/2010



Top Tier Single Thread Performance,System Capacity

- Accelerator Integration
- Out of Order Execution
- Water Cooling
- PCIe I/O Fabric
- RAIM
- Enhanced Energy Management

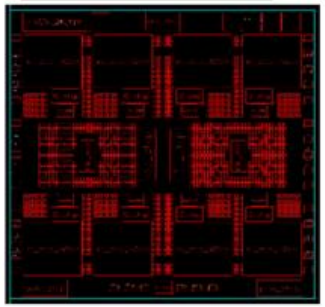
zEC12 8/2012



Leadership Single Thread, Enhanced Throughput

- Improved out-of-order
- Transactional Memory
- Dynamic Optimization
- 2 GB page support
- Step Function in System Capacity

z13 1/2015



Leadership System Capacity and Performance

- Modularity & Scalability
- Dynamic SMT
- Supports two instruction threads
- SIMD
- PCIe attached accelerators (XML)
- Business Analytics Optimized

Utilize Compiler Options

- Allows the compiler to exploit the hardware:
  - ARCH
  - HGPR
  - FLOAT(AFP)
- Balance between compile-time vs. execution-time:
  - OPT(2)
  - OPT(3)
  - HOT [C/C++]
  - IPA [C/C++]
    - PDF

Utilize Compiler Options (cont'd)

- Provide the details about the source or environment:
  - C/C++:
    - ANSIALIAS
    - IGNERRNO
    - LIBANSI
    - NOTHREADED
    - NOSTRICT
    - STRICT_INDUCTION
    - XPLINK
  - PL/I:
    - REDUCE
    - RESEXP
    - RULES(NOLAXCTL)
    - DEFAULT(CONNECTED REORDER NOOVERLAP)

Utilize Compiler Options (cont'd)

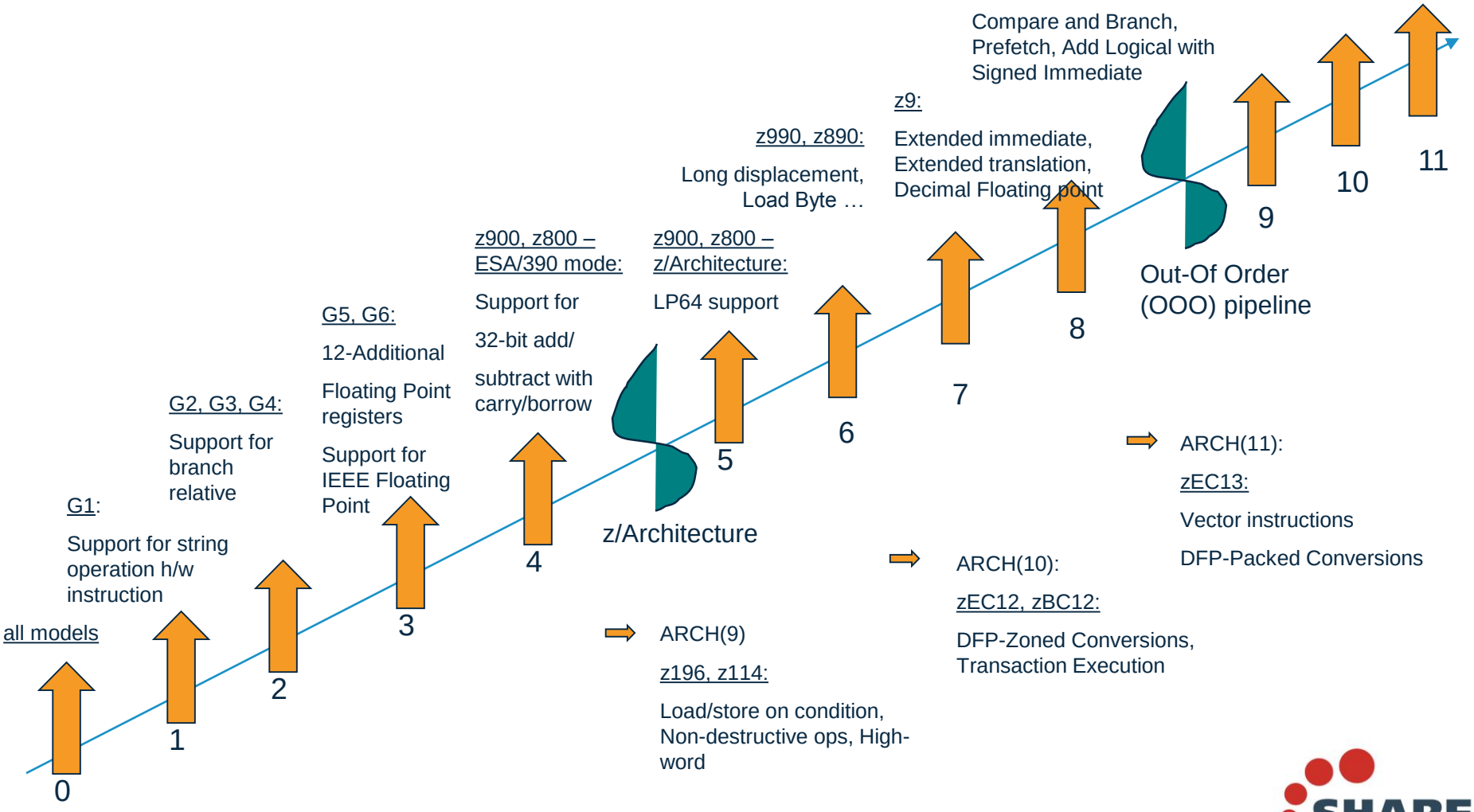
- Controls load module size:
  - COMPACT [C/C++]
  - INLINE [C/C++]
  - DEFAULT(INLINE) [PL/I]
  - UNROLL

ARCHitecture Option

- The ARCH option specifies the level of the hardware on which the generated code must run
  - C/C++ default is ARCH(7) for V2R1 and up
  - PL/I default is ARCH(7) for 4.5 and up
    - produces code that will run on z9 (or later) machines
  - LE 2.1 requires z9 (or later) machines

- **However:** you must set ARCH to the lowest level machine where your generated code will run
  - If you specify ARCH(n) and run the generated code on an ARCH(n-1) machine, you will most likely get an operation exception

ARCHitecture - Timeline



ARCH(9): Load/store on condition

consider this small program:

```
  2.0 |  test: proc returns( fixed bin(31) );
  3.0 |
  4.0 |    exec sql include sqlca;
  5.0 |
  6.0 |    dcl c fixed bin(31);
  7.0 |
  8.0 |    exec sql commit;
  9.0 |
 10.0 |    if sqlcode = 0 then
 11.0 |       c = 0;
 12.0 |    else
 13.0 |       c = -1;
 14.0 |
 15.0 |    return( c );
 16.0 | end;
```

ARCH(9): Load/store on condition

- Under OPT(3) ARCH(8), the instructions after the call are:

```
0000CA  0DEF            000008 |              BASR    r14,r15
0000CC  5800  D0F4      000010 |              L       r0,<a1:d244:l4>(,r13,244)
0000D0  A718  FFFF      000010 |              LHI     r1,H'-1'
0000D4  EC06  0005 007E 000010 |              CIJNE   r0,H'0',@1L8
0000DA  4110  0000      000010 |              LA      r1,0
0000DE                  000010 |       @1L8  DS      0H
0000DE  58E0  2000      000015 |              L       r14,_addrReturns_Value(,r2,0)
0000E2  5010  E000      000015 |              ST      r1,_shadow1(,r14,0)
```

ARCH(9): Load/store on condition

- under OPT(3) ARCH(9), the instructions after the call are:

```
0000CA  0DEF          000008 |        BASR    r14,r15
0000CC  A718  FFFF    000010 |        LHI     r1,H'-1'
0000D0  BF0F  D0F4    000010 |        ICM     r0,b'1111',<a1:d244:l4>(r13,244)
0000D4  58E0  2000    000015 |        L       r14,_addrReturns_Value(,r2,0)
0000D8  4100  0000    000010 |        LA      r0,0
0000DC  B9F2  8010    000010 |        LOCRE   r1,r0
0000E0  5010  E000    000015 |        ST      r1,_shadow1(,r14,0)
```

ARCH(9): Load/store on condition

- So, under ARCH(8), the code sequence was:
  - Load SQLCODE into r0
  - Load -1 into r1
  - Compare r0 (SQLCODE) with 0 and branch if NE to @1L8
  - Load 0 into r1
  - @1L8
  - Store r1 into the return value

- While under ARCH(9), the code sequence has no label and no branch:
  - Load -1 into r1
  - Load SQLCODE into r0 via ICM (so that CC is set)
  - Load 0 into r0
  - Load-on-condition r1 with r0 if the CC is zero (i.e. if SQLCODE = 0)
  - Store r1 into the return value

ARCH(10): DFP Zoned Conversion Facility

- This code converts a PICTURE array to FIXED BIN

```
pic2int: proc( ein, aus ) options(nodescriptor);

  dcl ein(0:100_000) pic'(9)9' connected;
  dcl aus(0:hbound(ein)) fixed bin(31) connected;
  dcl jx  fixed bin(31);

  do jx = lbound(ein) to hbound(ein);
    aus(jx) = ein(jx);
  end;
end;
```

ARCH(10): DFP Zoned Conversion Facility

- Under ARCH(9), the heart of the loop consists of these 8 instructions

```
0058   F248   D098   1000      PACK     #pd580_1(5,r13,152),_shadow2(9,r1,0)
005E   C020   0000   0021      LARL     r2,F'33'
0064   D204   D0A0   D098      MVC      #pd581_1(5,r13,160),#pd580_1(r13,152)
006A   4110   1009              LA       r1,#AMNESIA(,r1,9)
006E   D100   D0A4   200C      MVN      #pd581_1(1,r13,164),+CONSTANT_AREA(r2,12)
0074   F874   D0A8   D0A0      ZAP      #pd582_1(8,r13,168),#pd581_1(5,r13,160)
007A   4F20   D0A8              CVB      r2,#pd582_1(,r13,168)
007E   502E   F000              ST       r2,_shadow1(r14,r15,0)
```

ARCH(10): DFP Zoned Conversion Facility

- While under ARCH(10), it consists of 9 instructions and uses DFP in several of them – but since only the ST and the new CDZT refer to storage, the loop runs more than 66% faster

```
0060   EB2F   0003   00DF          SLLK     r2,r15,3
0066   B9FA   202F                 ALRK     r2,r15,r2
006A   A7FA   0001                 AHI      r15,H'1'
006E   B9FA   2023                 ALRK     r2,r3,r2
0072   ED08   2000   00AA          CDZT     f0,#AddressShadow(9,r2,0),b'0000'
0078   B914   0000                 LGFR     r0,r0
007C   B3F6   0000                 IEDTR    f0,f0,r0
0080   B941   9020                 CFDTR    r2,b'1001',f0
0084   5021   E000                 ST       r2,_shadow1(r1,r14,0)
```

ARCH(11): Vector Instruction Facility

- This simple code that tests if a UTF-16 string is numeric

```
wnumb: proc( s );
  dcl s   wchar(*) var;
  dcl n   wchar value( '0123456789' );
  dcl sx  fixed bin(31);

  sx = verify( s, n );
  if sx > 0 then ...
```

- Is done with an expensive library call with ARCH <= **10**

ARCH(11): Vector Instruction Facility

- With ARCH(11), the vector instruction facility is used to inline it as

```
E700   E000   0006                VL      v0,+CONSTANT_AREA(,r14,0)
E740   E010   0006                VL      v4,+CONSTANT_AREA(,r14,16)
                          @1L2    DS      0H
A74E   0010                       CHI     r4,H'16'
4150   0010                       LA      r5,16
B9F2   4054                       LOCRL   r5,r4
B9FA   F0E2                       ALRK    r14,r2,r15
E725   E000   0037                VLL     v2,r5,_shadow1(r14,0)
E722   0180   408A                VSTRC   v2,v2,v0,v4,b'0001',b'1000'
E7E2   0001   2021                VLGV    r14,v2,1,2
EC5E   000D   2076                CRJH    r5,r14,@1L3
A74A   FFF0                       AHI     r4,H'-16'
A7FA   0010                       AHI     r15,H'16'
EC4C   000E   007E                CIJNH   r4,H'0',@1L4
A7F4   FFE5                       J       @1L2
0700                              NOPR    0
                          @1L3    DS      0H
```

ARCHitecture Option

- The wonderful feature of the ARCH option is that no code changes are required by you

- In all of the above examples, the compiler
  - figured out where it could exploit the option
  - and then did all the work

HGPR Option

- Stands for High half of 64-bit General Purpose Register
- Permitted to exploit 64-bit GPRs in 32-bit programs
  - Compiler can now make use of
    - The 64-bit version of the z/Architecture instructions
    - The High-Word Facility [with ARCH(7) or above]
      - Can be viewed as having an additional 16 GPRs
- PRESERVE sub-option
  - Save/re-store in prolog/epilog the high halves of used GPRs
  - Only necessary if the caller is not known to be compiler-generated code
- Default is NOHGPR(NOPRESERVE)
  - Metal C defaults to HGPR(PRESERVE)

FLOAT(AFP) Option

- Additional Floating-Point (AFP) registers were added to ESA/390 models
- AFP sub-option enable use of the full set (16) of FPRs
- VOLATILE sub-option
  - FPR8 – FPR15 is considered volatile
    - i.e. compiler will not expect they're preserved by any called program
  - No longer required for CICS TS V4.1 or newer
- Default is AFP(NOVOLATILE)

OPTIMIZE Option

- The OPT option controls how much, or even if at all, the compiler tries to optimize your code
  - A trade-off between compile-time vs. execution-time

- NOOPT/OPT(0):
  - The compiler simply translates your code into machine code
  - Generated code could be large and slow
  - Good choice for:
    - Matching code generated with written source code
      - for the purpose of debugging a problem
    - Reducing compile time
  - Terrible choice if you care about run-time performance

OPTIMIZE Option (cont'd)

- When optimizing, the compiler will improve, often vastly, the code it generates by, for example
  - Keeping intermediate values in registers
  - Moving code out of loops
  - Merging statements
  - Reordering instructions to improve the instruction pipeline
  - Inlining functions

- Require more CPU and REGION during compilation

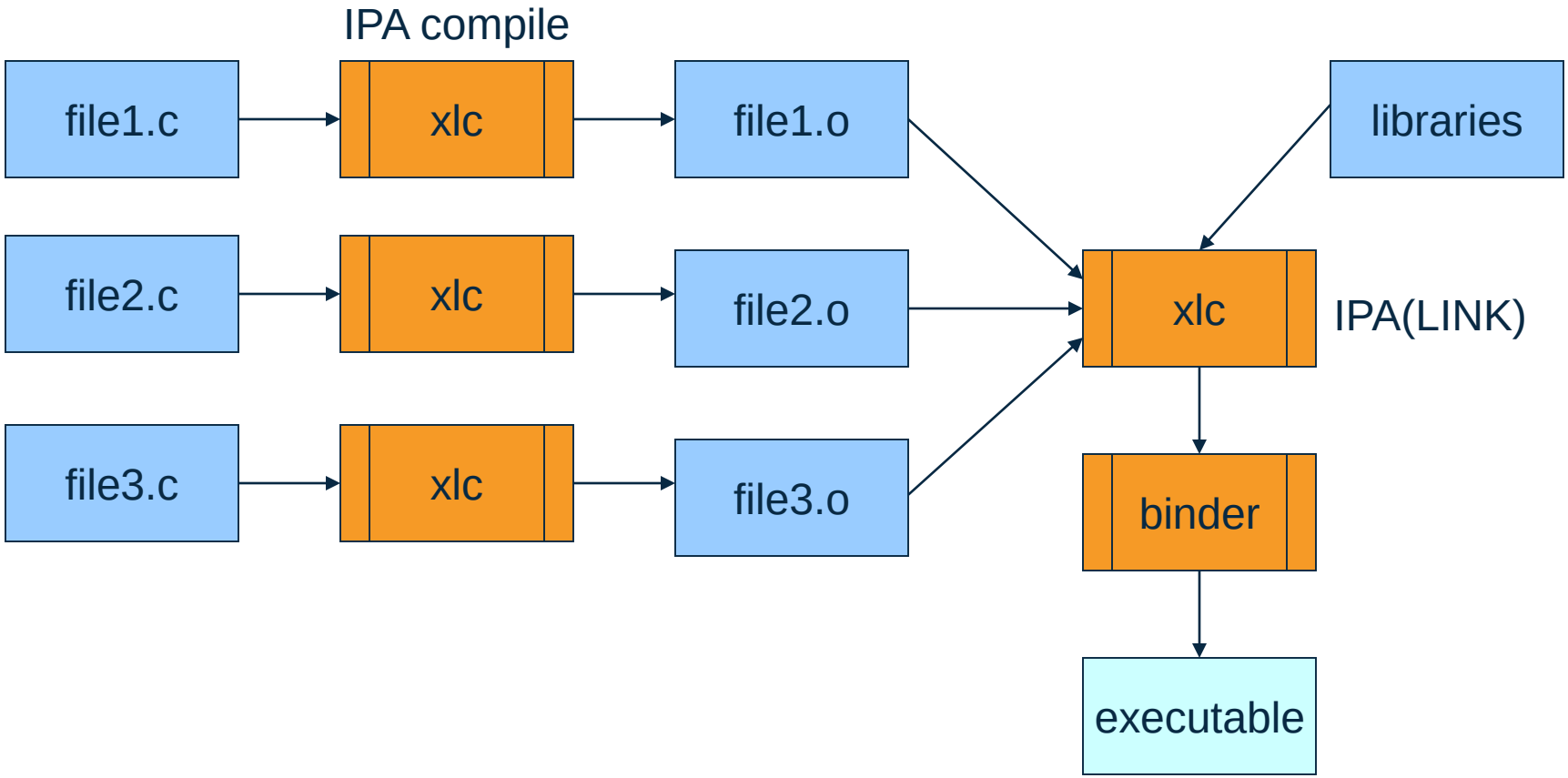
OPTIMIZE Option (cont'd)

- OPT(2):
  - Start enabling the optimizer
  - A balance between compile speed and code quality
- OPT(3):
  - Optimizer much more aggressive
  - Tips balance towards code quality over compile speed
  - C/C++ compiler will alter other options defaults:
    - ANSIALIAS, IGNERRNO, STRICT, etc
- The C/C++ and PL/I compilers use the same optimizing backend
  - But there are differences in what the OPT sub-options does

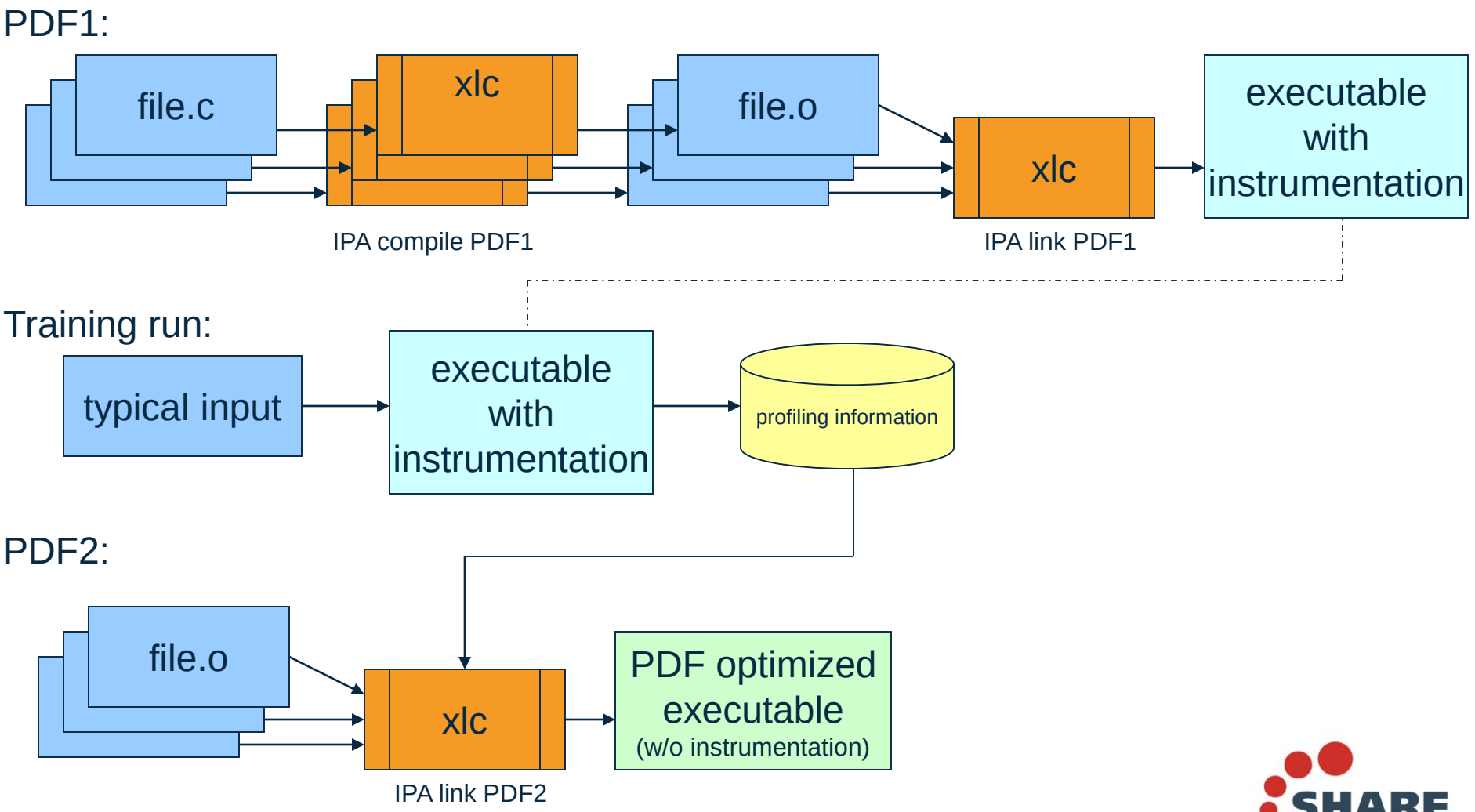
Other C/C++ Options Related to OPT

- HOT option
  - High-Order loop analysis and Transformations
    - More aggressive optimization on the loops
    - Requires OPT(2) or higher
- IPA option
  - Inter-Procedural Analysis
    - Optimization decisions made based on the entire program
    - 3 sub-levels to control aggressiveness
    - Requires OPT(2) or higher
  - PDF sub-option
    - Profile Directed Feedback
      - Sample program execution to help direct optimization
      - Requires a training run with representative data

IPA Option [C/C++] (cont'd)



IPA PDF Sub-Option [C/C++]



ANSIALIAS Option [C/C++]

- Optimizer presumes pointers can point only to objects of the same type
  - The simplified rule is that you cannot safely dereference a pointer that has been cast to a type that is not closely related to the type of what it points at
    - The ISO C and C++ standards define the closely related types
- If this assumption is false, wrong code could be generated
  - The INFO(ALS) option might able to help you find potential violation of the ANSI type-based aliasing rule

- OPT(3) defaults to ANSIALIAS
- OPT(2) defaults is NOANSIALIAS
- Has no effect to NOOPT/OPT(0)

IGNERRNO Option [C/C++]

- Informs the compiler that the program is not using errno
- Allows the compiler more freedom to explore optimization opportunities for certain library functions
  - For example: sqrt
- Need to include the system header files to get the full benefit

- OPT(3) defaults to IGNERRNO
- NOOPT and OPT(2) defaults are NOIGNERRNO

LIBANSI Options [C/C++]

- Indicates the name of an ANSI C library function are in fact ANSI C library functions and behave as described in the ANSI standard
- The optimizer can generate better code based on existing behavior of a given function
  - E.g. whether or not a particular library function has any side effects
- Provides additional benefits when used in conjunction with IGNERRNO

- Defaults is NOLIBANSI

NOTHREADED Option [C/C++]

- For user to assert their application is single-threaded
- Allows for non-thread-safe transformations be performed

- Defaults is THREADED

NOSTRICT Option [C/C++]

- Allows the optimizer to alter the semantics of a program
  - Performing code motion and scheduling on computations such as loads and floating-point computations that may trigger an exception
  - Relax conformance to IEEE rules
  - Reassociating floating-point expressions

- OPT(3) defaults is NOSTRICT
- NOOPT and OPT(2) defaults are STRICT

NOSTRICT_INDUCTION Option [C/C++]

- Asserts to the compiler the induction (loop counter) variables do not overflow or wrap-around
  - Use STRICT_INDUCTION only if your program logic has such intent
- Only affects loops which have an induction variable declared with a different size than a register

- Default is NOSTRICT_INDUCTION
  - Except with the c99 invocation command on USS

XPLINK Option [C/C++]

- XPLINK stands for eXtra Performance LINKage
  - A modern linkage convention that is 2.5 times more efficient than the conventional linkage conventions
  - We have seen some programs improved by 30%
  - XPLINK and non-XPLINK parts can work across DLL and fectch() boundaries
    - Must tell compiler about this, so the (expensive) switching code get executed
    - If your application contains few switches, then mixing will still be beneficial
- Defaults:
  - ILP32: NOXPLINK
  - LP64: XPLINK

REDUCE and RESEXP Options [PL/I]

- REDUCE option
  - Specifies that the compiler is permitted to reduce an assignment of a null string to a structure into a simpler operation
    - Even if that means padding bytes might be overwritten or zerored out

- RESEXP option
  - Specifies that the compiler is permitted to evaluate all restricted expressions at compile time even if this would cause a condition to be raised and the compilation to end with S-level messages

RULES(NOLAXCTL) Option [PL/I]

- Specifies that the compiler disallows a CONTROLLED variable to be declared with a constant extent and yet to be allocated with a differing extent
- To allocate a CONTROLLED variable with a variable extent, that extents must be declared either with an asterisk or with a non-constant expression.
- When the compiler sees a reference to a structure, or to any member of that structure, it knows the lengths, dimensions or offsets of the fields in it

DEFAULT Sub-Option CONNECTED REORDER NOOVERLAP

- CONNECTED sub-option
  - Compiler presumes application never passes nonconnected parameters
- REORDER sub-option
  - Indicates that the ORDER option is not applied to every block, meaning the compiler doesn't have to insure that variables referenced in ON-units (or blocks dynamically descendant from ON-units) have their latest values
- NOOVERLAP sub-option
  - Compiler presumes the source and target in an assignment do not overlap

COMPACT Option [C/C++]

- Compiler favors optimizations that tend to limit the growth of the code
- Depending on your specific program, the object size may increase or decrease and the execution time may increase or decrease

- Default is NOCOMPACT

- PL/I effectively always has NOCOMPACT on

INLINE Option [C/C++]
DEFAULT(INLINE) Option [PL/I]

- Inlining eliminates the overhead of the function call and linkage, and also exposes the function's code to the optimizer
- Too much inlining can increase the size of the program

- AUTO sub-option [C/C++]
  - Inliner runs in automatic mode
  - Threshold sub-option
    - Maximum relative size of a subprogram to inline
  - LIMIT sub-option
    - Maximum relative size a subprogram can grow before auto-inlining stops

UNROLL Option

- Instructs the compiler to perform loop unrolling
- It replicates a loop body multiple times, and adjusts the loop control code accordingly
- It increases code size in the new loop body

- Auto sub-option
  - Compiler decides via heuristics the appropriate candidate and amount of unrolling

Code for Performance

- Writing good code
- Make use of built-in functions
- Make use of #pragmas [C/C++]
- Make use of attributes and keywords
- OpenMP [C/C++]

Writing Good Code

- Keep it simple and concise
  - Good for both the programmer and the compiler to understand the code easily
- Don’t ignore the compiler informational and warning messages, even if the program appears to work
- Attempts to be clever and produce “optimal” code might produce:
  - Code that is unreadable
  - Code that cannot be maintained
  - Code that performs worse than the straightforward solutions
  - Code that fails

Warnung

- Wegen des Versuchs klug zu erscheinen und optimalen Code zu schreiben habe ich zu oft folgendes gesehen:
  - **Programme, die keiner verstehen kann**
  - **Programme, die keiner reparieren kann**
  - **Programme, die langsamer laufen als einfachere Loesungen**
  - **Programme, die einfach abbrechen**
- Lesbarkeit vor Schnelligkeit !

Make Use Of Built-in Functions

- Library function example:
  - Less efficient comparison on a loop

```
int i, a[1000], b[1000];
…
for (i = 0; i < 1000; ++i)
  if (a[i] != b[i])
    break;
if (i == 1000)
  /* arrays are equal */
```

  - More efficient comparison with a memcmp() library function

```
int a[1000], b[1000];
…
if (!memcmp (a, b, sizeof(a)))
  /* arrays are equal */
```

Make Use Of Built-in Functions (cont'd)

- Hardware built-in function example
  - A naive implementation of population count

```
unsigned long popcount(unsigned long op) {
  unsigned long count = 0;
  unsigned long bit = 1;
  for (int i = 0; i < 64; i++) {
    if (op & bit)
     count++;
    bit = bit << 1;
  }
  return count;
}
```

  - with __popcnt() hardware built-in function

```
unsigned long __popcnt(unsigned long op)
```

    - Available from ARCH(9)
      - A single POPCNT instruction
    - Or as POPCNT built-in function in PL/I

Make Use Of #pragmas [C/C++]

- Provides more details about your code to help the optimizer
  - #pragma execution_frequency (C++only)
    - Marks program source code that you expect will be either very frequently or very infrequently executed
  - #pragma isolated_call
    - Lists functions that have no side effects (that do not modify global storage)
- For fine-grained control
  - #pragma inline
    - Hint to the compiler to inline this frequently used function
  - #pragma noinline
    - Prevents a function from being inlined
  - #pragma unroll
    - Informs the compiler how to perform loop unrolling on the loop body that immediately follows it

Make Use of Attributes & Keywords [C/C++]

- Provides more details about your code to help the optimizer
  - restrict keyword
    - Use with ASSERT(RESTRICT) to indicate disjointed pointers
      - Defaults is ASSERT(RESTRICT)
    - Two restrict qualified pointers, declared in the same scope, designate distinct objects and thus shouldn't alias each other
    - RESTRICT option (C only) can also be used to indicates to the compiler that pointer parameters in all functions or in specified functions are disjoint
      - Defaults is NORESTRICT
- For fine-grained control
  - inline keyword
    - Hint to the compiler to inline this frequently used function
  - always_inline function attribute
    - Instructs the compiler to inline a function

Make Use of Attributes & Keywords [PL/I]

- Use RETURNS(BYVALUE) for items that can be returned in registers (such as FIXED BIN and FLOAT)
- Use the BYVALUE attribute on parameters that are input-only and which can be passed in registers
- Use the INONLY, OUTONLY, and NONASSIGNABLE attributes on parameters and in ENTRY declares
- Routines with OPTIONS(LINKAGE(OPTLINK)) will outperform those with OPTIONS(LINKAGE(SYSTEM))

Make Use of Attributes & Keywords [PL/I]

- You should always fully prototype all ENTRY declarations
- Specify BYADDR/BYVALUE and (NON)ASGN for each parameter
- And specify (NON)CONNECTED for each array parameter
- Also specify BYADDR/BYVALUE for the RETURNS
- Also include an OPTIONS attribute and specify therein the LINKAGE as well as NODESCRIPTOR options (as appropriate)

OpenMP API 3.1 [C/C++]

- Industry-standard API designed to create portable C/C++ applications to exploit shared-memory parallelism
- Users can create or migrate parallel applications to take advantage of the multi-core design of modern processors
- Consists of a collection of compiler directives and library routines
- New SMP option to allow OpenMP parallelization directives to be recognized
  - Only supported in 64-bit
  - Executable must be run under USS
  - Thread-safe version of standard library must be used inside the parallel regions
  - Not supported with Metal C

Declare your variables

- A common sign in Texas:
  - **Trespassers will be prosecuted or shot**
- Those who don't declare their variables deserve the same fate
- Use the RULES(NOLAXDCL) compiler option to enforce this in PL/I

Declare your variables with good names

- Generally, you should not name a variable after its type,
- i.e. do not code the following

```
DCL BASED_FB15  FIXED BIN(15) BASED;

DCL
   1 ELEMENT_REC BASED,
     2 NEXT_PTR   PTR,
     2 PREV_PTR   PTR,
     2 DATA, ….
```

- Because this name becomes meaningless if PTR becomes OFFSET

Declare your variables with attributes

- Simply declaring the name is not good
- i.e. don't code: DCL RC;
- Because then RC is FLOAT DEC(6) when FIXED BIN(31) was probably what was wanted.
- The compiler will issue warning message IBM1215 for such declares – or message IBM1216 if part of a structure

Declare your variables with attributes

- A common way this error occurs is in code such as
  - **DCL RC1, RC2 FIXED BIN(31) INIT(0);**
- Enterprise PL/L issues message IBM1215 saying that RC1 is declared without any attributes
- And like the old compiler, Enterprise PL/I will give RC1 the attributes FLOAT DEC(6) – not FIXED BIN
- The declare above is not the same as
  - **DCL (RC1, RC2) FIXED BIN(31) INIT(0);**

Declare your variables with attributes

- Some customer code contained this code

```
DCL
  PARDIASE CHAR(20),
  1 INDIASE1 BASED (PTPDIASE),
    2 C1CODIA   CHAR(1),
    2 C1FECDI   DEC FIXED(9),
    2 C1DIADI   CHAR(9),
    2 C1ABRDI   CHAR(3),
    2 C1RESDI;
```

- Here the compiler issues the message IBM1216 saying that C1RESDI is declared without any attributes

- Again, C1RESDI will get the attributes FLOAT DEC(6)

Declare your variables with attributes

- However, this means the structure needs 22 bytes

```
DCL
  PARDIASE CHAR(20),
  1 INDIASE1 BASED (PTPDIASE),
    2 C1CODIA   CHAR(1),
    2 C1FECDI   DEC FIXED(9),
    2 C1DIADI   CHAR(9),
    2 C1ABRDI   CHAR(3),
    2 C1RESDI;
```

- And then this later bit of code overwrites 2 bytes of storage

```
PTPDIASE = ADDR(PARDIASE);
INDIASE1 = ‘’;
```

- This leads to a protection exception in some circumstances, and remember, this is a user error, not a compiler error

Declare your variables with sensible attributes

- You will get warning message IBM1091 with text
  - **FIXED BIN precision less than storage allows**
- If you declare (or use in a built-in)
  - **SIGNED FIXED BIN with precision other than 7, 15, 31 or 63**
  - **UNSIGNED with precision other than 8, 16, 32 or 64**
- Most users would think this couldn't possibly be an issue for them

Declare your variables with sensible attributes

- But this banking code copies an array to a new array twice as large

```
40.1   UBSEMB:PROC(ACCOUNT_TABLE) REORDER;

42.1     DCL 1 ACCOUNT_TABLE(*)  CONTROLLED,
43.1           2 CUSTOMER_NAME       CHAR(120),
44.1           2 ACCT_INSTR_NUMBER   CHAR(17),
45.1           2 ACCT_INSTR_CODE     CHAR(8),
46.1           2 ORIGINAL_BLNCE_AMT  CHAR(9),
47.1           2 DATE_OF_LAST_TXN,
48.1             3 YEAR              CHAR(4),
49.1             3 MONTH             CHAR(2),
50.1             3 DAY               CHAR(2);

55.1     DCL   NEW_SIZE              FIXED BIN(5) INIT(0);
56.1     DCL   OLD_SIZE              FIXED BIN(5) INIT(0);
57.1     DCL   RECORD_NO             FIXED BIN(5) INIT(1);
58.1     DCL 1 TEMP_TABLE(*)     CONTROLLED,
59.1           2 CUSTOMER_NAME       CHAR(120),
60.1           2 ACCT_INSTR_NUMBER   CHAR(17),
61.1           2 ACCT_INSTR_CODE     CHAR(8),
62.1           2 ORIGINAL_BLNCE_AMT  CHAR(9),
63.1           2 DATE_OF_LAST_TXN,
64.1             3 YEAR              CHAR(4),
65.1             3 MONTH             CHAR(2),
66.1             3 DAY               CHAR(2);
```

Declare your variables with sensible attributes

- Via this small bit of code

```
68.1      NEW_SIZE = HBOUND(ACCOUNT_TABLE.CUSTOMER_NAME,1) * 2;
69.1      ALLOCATE TEMP_TABLE(NEW_SIZE);
70.1      TEMP_TABLE(*) = '';
71.1      OLD_SIZE = HBOUND(ACCOUNT_TABLE.CUSTOMER_NAME,1);
72.1      DO RECORD_NO = 1 TO OLD_SIZE;
73.1       TEMP_TABLE(RECORD_NO) = ACCOUNT_TABLE(RECORD_NO);
74.1      END;
75.1      FREE ACCOUNT_TABLE;
76.1      ALLOCATE ACCOUNT_TABLE(NEW_SIZE);
77.1      ACCOUNT_TABLE = TEMP_TABLE;
78.1      FREE TEMP_TABLE;
79.1    END; /*UBSEMB*/
```

- And it abends

- Only because the customer ignored message IBM1091 flagging that a variable was declared as FIXED BIN(5) (when 15 was almost certainly intended)

Declare your variables with sensible attributes

```
40.1   UBSEMB:PROC(ACCOUNT_TABLE) REORDER;

42.1     DCL 1 ACCOUNT_TABLE(*)  CONTROLLED,
43.1          2 CUSTOMER_NAME       CHAR(120),
44.1          2 ACCT_INSTR_NUMBER   CHAR(17),
45.1          2 ACCT_INSTR_CODE     CHAR(8),
46.1          2 ORIGINAL_BLNCE_AMT  CHAR(9),
47.1          2 DATE_OF_LAST_TXN,
48.1            3 YEAR              CHAR(4),
49.1            3 MONTH             CHAR(2),
50.1            3 DAY               CHAR(2);

55.1     DCL   NEW_SIZE             FIXED BIN(5) INIT(0);
56.1     DCL   OLD_SIZE             FIXED BIN(5) INIT(0);
57.1     DCL   RECORD_NO            FIXED BIN(5) INIT(1);
58.1     DCL 1 TEMP_TABLE(*)     CONTROLLED,
59.1          2 CUSTOMER_NAME       CHAR(120),
60.1          2 ACCT_INSTR_NUMBER   CHAR(17),
61.1          2 ACCT_INSTR_CODE     CHAR(8),
62.1          2 ORIGINAL_BLNCE_AMT  CHAR(9),
63.1          2 DATE_OF_LAST_TXN,
64.1            3 YEAR              CHAR(4),
65.1            3 MONTH             CHAR(2),
66.1            3 DAY               CHAR(2);
```

Describe your interfaces

- This starts with how you declare external routines
- Do not declare them without a parameter list as in
  - **DCL A EXT ENTRY;**
- This lets you pass any number of arguments of any type to this routine without the compiler being able to check your code
- The compiler would quietly accept all of these
  - **CALL A;**
  - **CALL A(TIMESTAMP);**
  - **CALL A(2, JJJJ);**

Describe your interfaces

- Be accurate – if the routine has no parameters, say so
  - **DCL A EXT ENTRY();**
- Or if the routine should receive one string, declare it as
  - **DCL A EXT ENTRY(CHAR(*));**
- Now the compiler can flag bad calls of this routine
- And if a string parameter must have a certain length, say that:
  - **DCL A EXT ENTRY(CHAR(17));**
- But then you need to be especially on watch for messages about “dummy” arguments

Recap

- Let the compiler work for you by telling it
  - The hardware to exploit
  - The importance of compile-time vs. execution performance
  - More precise details about the source code
  - Sensitiveness of module size

- Work together with the compiler
  - Writing good code
  - Make use of BIFs and #pragmas
  - Exploit the language features
  - Tell the compiler what you know

Additional Reading Materials

- z/OS C/C++ Programming Guide
  - Part 5. Performance optimization
  - http://pic.dhe.ibm.com/infocenter/zos/v2r1/topic/com.ibm.zos.v2r1.cbcpx01/cbc1p2399.htm

- Enterprise PL/I for z/OS Programming Guide
  - Chapter 13. Improving performance
  - http://publibfp.boulder.ibm.com/epubs/pdf/ibm4pg03.pdf

Quick Survey

- Users of:
  - PL/I
  - C/C++
  - NOOPTIMIZE/OPTIMIZE(0), OPTIMIZE(2), OPTIMIZE(3)
  - ARCH(7), ARCH(8), ARCH(9), ARCH(10)
  - C/C++ only:
    - TUNE
    - LP64
    - PDF
    - HOT
    - IPA

Questions?

- Connect with us
  - Email me at elderon@us.ibm.com
  - Rational Café - the compilers user community & forum
    - C/C++: http://ibm.com/rational/community/cpp
    - PL/I: http://ibm.com/rational/community/pli
  - RFE community – for feature requests
    - C/C++: http://www.ibm.com/developerworks/rfe/?PROD_ID=700
    - PL/I: http://www.ibm.com/developerworks/rfe/?PROD_ID=699
  - Product Information
    - C/C++: http://www-03.ibm.com/software/products/us/en/czos
    - PL/I: http://www-03.ibm.com/software/products/en/plicompfami

Thank You!