Porting Java applications to System z

Linux on System z Live Virtual Class (Jan 15th / 16th)

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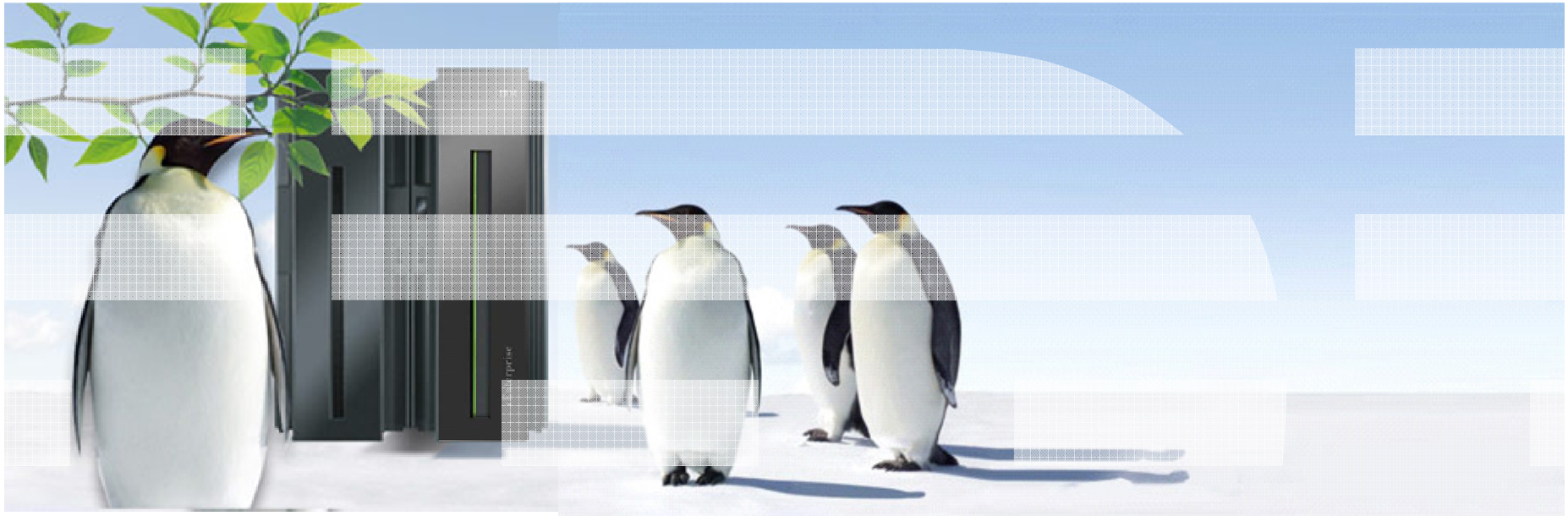

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Agenda

- **Java Workloads on System z**
  - Porting aspects
  - Consolidation aspects
  - Performance aspects

- **Field report: porting a real-life, large Java application to Linux on System z**

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Porting aspects

- **Problem: people think there is little or *no porting required***
  - Think about getting porting support right from the project start (and not only when the project is already about to fail)

- **Experience shows there are *subtle differences* between the different JVM™s**
  - ***Very important key point***: the IBM® Java® SDK is not a "special" version of Java, it is 100% pure Java, as it passes all compatibility tests from Sun™

- **Differences fall into *2 categories*:**
  - ***Infrastructure related*** differences (mostly Java command line parameter differences, for example: garbage collection settings)
  - ***Coding related*** differences (for example: Java class library implementation differences)

Source: http://www.smscs.com

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Porting aspects, *continued*

- **Question: Why are there such differences at all?**

- **Infrastructure related: many of the command line parameters are *non-standard* (those starting with `-X`…) and can be added / changed by the JVM vendor without notice**
  - Many customers heavily tweak their command line parameters for one particular JVM

- **Coding related: the Java API specification sometimes *leaves room for interpretation*. Specific example: `java.nio.channels.SelectionKey`**
  - *"… Exactly how this synchronization is performed is implementation-dependent: … reading or writing the interest set **may** block indefinitely if a selection operation is already in progress…"*
  - Developers' responsibility to ensure application's portability across JDK™s

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Porting aspects, *continued*

- **Next *important key point*: all of the problems arising out of those subtle differences *can be fixed***

- **Infrastructure related: some of the command line parameters can be adjusted / translated easily, some of them require additional analysis of the application**
  - There is ***no simple translation table*** since every application behaves differently

- **Coding related: sometimes, small changes (really just a few lines) in the Java application code are required**
  - Problem: there are only ***very few people*** able (and available) to perform the required Java debugging and coding

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Porting aspects, *continued*

- ***Best practice / strong recommendation*: try to evaluate the to-be-ported application with the IBM Java SDK on any other platform (for example Intel® x86), before going for System z®**
  - Most of the porting related issues are related to the mentioned subtle differences in the various JVMs and not System z
  - Following this best practice, the problems can be addressed where they belong to (which is either the application or the IBM Java SDK, but not System z)

- **Elements / patterns that are *known to cause trouble*:**
  - Heavy usage of platform native libraries / *Java Native Interface* (JNI)
  - Hard-coded path names (happens mostly with Java applications that were developed on / developed for Microsoft® Windows®)
  - Using vendor-specific APIs (for example Java packages starting with `com.sun`)

- **Additional problem (project management related): running a *large scale stress test* for the first time as part of the porting**
  - Issues in the application that are ***not related to the actual porting*** will surface

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Consolidation aspects

- **Problem: both real-world and benchmark type of Java applications tend to be both *CPU and memory intensive***
  - This is a general statement only – it does not hold true for all applications

- **Many reasons for this:**
  - Popular approach in software projects: reduce development cycle by ***re-using*** as much existing technology as possible (both Open Source and proprietary libraries)
  - Non-optimal code quality seems to be ***generally accepted***
  - Developers: ***performance follows functionality*** (not a specific Java issue)

- **However, Java is still the *de facto standard* for new applications *for good reasons*, so there is no need to go back to assembler et al.**
  - Broad industry / educational support
  - Excellent documentation (freely) available
  - High performance is really achievable if code is implemented wisely

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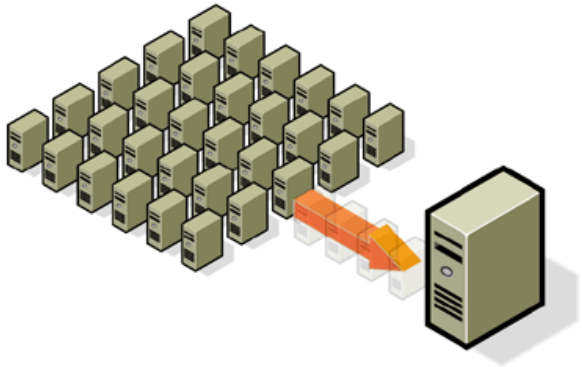
Consolidation aspects, *continued*

- **Question: Can Java workloads be consolidated *at all*?**



Source: http://www.maindec.com

- **Answer: *Yes they can*!**
  - See this and the next slides for some thoughts…

- **To cite an example: one customer in Austria that I supported *started with ~50 Java applications* (on WebSphere® for z/OS®), now after some years and after some performance tuning sessions, they are running *way more than 100* Java applications on just a couple of z114 processors**

- **Basically, look for *"small" applications* (with "small" I mean not consuming a lot of CPU and memory) for a successful consolidation project**
  - Same approach compared to other types of applications

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Consolidation aspects, *continued*

- **Being *honest* is important: you cannot have extremely high consolidation ratios and extremely high performance *at the same time***
  - This statement holds true for all types of applications, not just Java
  - It just doesn't work to have both – it will always be a trade-off

- **Comparable to Oracle® workloads, many Java workloads are extremely *oversized from a memory* point of view**
  - Tools available for determining how much memory a Java application really requires
  - However, besides the tools, expert knowledge is also required…

- **If you think in z/VM® terms, *right-sizing* the memory is absolutely key**
  - The Java heap can hardly be paged out by z/VM at all, so you definitely won't be able to achieve high memory overcommitment ratios

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Consolidation aspects, *continued*

- **From an infrastructure (z/VM, Linux®, JVM, WebSphere) point of view, there are possibilities to *reduce the CPU "noise"* caused by idle guests**
  - Steve Wehr – Dealing with Noisy Guests
  - WebSphere Application Server – Idle Server Tuning: http://www.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/WP101894

- **Most of the Java applications can be (more or less ☺) easily tuned in order to *save both CPU cycles and memory***
  - See the performance part of this presentation for a more detailed discussion

- **There is an IBM answer to the Apache® Tomcat® / JBoss® *Open Source* discussion**
  - WebSphere Liberty Profile

Source: http://josh-jarvis.com

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Performance aspects

- **Problem: many customers think that Java on System z (in general) is *slower than on other platforms***
  - Simply not true – I did my own experiments and we are ***actually faster*** in a very popular CPU-intensive Java benchmark (tests were done on a IBM zEnterprise® 196 (z196) compared to latest / greatest Nehalem back then)

- **Next problem: once you are in a performance discussion, people start thinking *it's all about performance***
  - Performance is important, but it is not the one and only aspect of a "good" server
  - There is ***much more*** than just performance when it comes to System z
  - Fit-for-Purpose discussions help to get the broader picture

- **A *holistic approach* is required for improving performance**
  - All layers (complete stack: hardware, hypervisor, operating system, middleware, application) have to be checked for bottlenecks / tuning potentials
  - Not an easy task – requires a team of experts in many cases

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Performance aspects, *continued*

- **Personally, I prefer the *bottom-up approach* for analyzing the stack**
  - Many real-world examples for improvements in all layers
  - Check for the easy things first (LPAR configuration, # of virtual CPUs, etc.)

- **The ultimate tuning discipline (when all else fails) is *application-level tuning***
  - Should only be used as a last resort if really everything else did not lead to significant improvements
  - Make use of standard offerings before (healthcheck, etc.)

- **It is a *very powerful instrument* and should be treated as such**
  - Can be used ***pro-actively*** (retain customer satisfaction with System z, accelerate new System z deals)
  - Can also be used ***re-actively*** (CritSit support)
  - Not a standard IBM offering

Source: http://www.appian.com

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Performance aspects, *continued*

- **How does an *application tuning session* work?**
  - Step 1: explain to the customer how to install Jinsight and how to take application traces
  - Step 2: customer has to identify (with IBM support if required) the "hot spots" in the application – a whole application simply cannot be analyzed and tuned due to the massive amount of data that gets produced; in all cases up to now, tuning the most important parts was ***way enough*** (80/20 rule)
  - Step 3: customer takes the traces and sends them to IBM
  - Step 4: remote analysis of the traces
  - Step 5: on-site presentation and discussion of the observations

- **What *people from the customer* do I need for this?**
  - Step 1-3 and 5: infrastructure people (systems programmers and / or WebSphere administrators)
  - Step 4: usually, customer support is not required
  - Step 5 (and sometimes step 2 also): application developers and management

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Performance aspects, *continued*

- **What can you *expect* from such an engagement?**
  - Experience shows that ***20 – 30% reduction in CPU consumption*** (which is equal to an increase in throughput of 25 – 43%) is achievable in virtually any engagement
  - Very often, CPU consumption can be ***reduced to 50%*** of the original value (which is equal to 2 x throughput compared to before)
  - Sometimes, even more is possible (up to a factor of 17 in throughput increase, or 5.9% of the original CPU consumption)

- **How much does the application *need to be changed* in order to achieve the above numbers?**
  - I am always trying to make the proposed changes as small as possible, in all cases so far usually a change of a couple of lines of code (10 or less) are enough
  - Important to remember is that this is not about completely rewriting the application

Source: http://techamt.com

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- **Field report: porting a real-life, large Java application to Linux on System z**

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Field report

- **Customer is a *large European bank* that is active in many countries**
  - In their home country, they have one of the ***largest branch networks***

- **Project context: *Linux on System z* Proof of Concept**
  - Customer ***heard a lot*** about the z/VM / Linux on System z platform and wanted to get to know the environment from a technical perspective in order to ***evaluate*** whether it is a viable option for them
  - Prior to the project start, the customer had ***very limited z/VM expertise*** only

- **Project objectives / success criteria**
  - Successfully port one of their ***largest Java applications*** to Linux on System z
  - Run some ***basic performance tests*** with the ported application
  - On top of this, the goal was also to run a number of ***additional tests*** with some other workload (not part of this field report, though)

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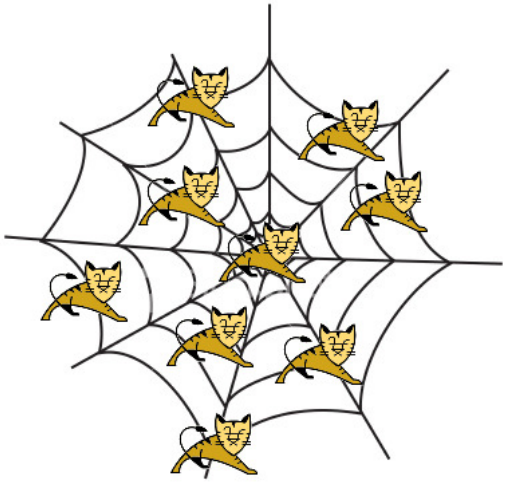
Field report, *continued*

- **Application is a *typical banking application* as it is found in many other international banks**
  - Today, it is running on Intel x86 based servers
  - ***Possible candidate*** for Linux on System z in the future, once the customer has gained enough working knowledge with the environment

- **It consists of ~20-25 Apache Tomcat instances with 2-5 web applications deployed on each, so around *60-70 web applications* in total**
  - Largest porting I have ever done so far



Source: http://tomcat.apache.org

- **Java web applications are *heavily intertwined* with each other**
  - One end-user request touches a lot of different applications under the covers
  - If one component in this chain fails, it becomes visible immediately in the user interface

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Field report, *continued*

- **First problem that I encountered was a** `java.lang.NoClassDefFoundError: org.apache.harmony.security.fortress.Services$NormalServices (initialization failure)`
  - Obviously, this is ***related to security*** settings
  - Turned out to come from a ***security provider*** that the customer had written themselves
  - Core of the problem: ***hard-coded Sun class name*** `(sun.security.rsa.SunRsaSign)`

- **Workaround was to *change 2 existing* lines of Java code and *add 5 additional* lines of code**
  - In other words, the required changes were ***minimal***
  - From a systems programmer point of view, one `.jar` file had to be exchanged

- **Besides this, the `java.security` file had to be adjusted by changing 1 line**
  - Before: `security.provider.9=myProvider`
  - After: `security.provider.10=myProvider`

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Field report, *continued*

- **After fixing the first problem, most of the Tomcat servers could at least be *started successfully* (i.e. no errors in `catalina.out`)**
  - Be careful: a successful Tomcat startup doesn't mean that the application also started successfully

- **Second problem: `java.security.NoSuchAlgorithmException: MessageDigest MD5 implementation not found`**
  - Obviously, ***related to security*** again – one could think that the MD5 algorithm isn't supported by the runtime (which is not true, of course)

- **Turned out to be a Tomcat *configuration issue* (no coding changes required)**
  - The ***Java extension directories*** setting had to be extended to include `${JAVA_HOME}/jre/lib/ext`

Source: http://www.bobslocks.co.uk

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Field report, *continued*

- **After fixing the second problem, one of the Tomcat servers started to *consume 100% CPU continuously***
  - For obvious reasons, this looked like an ***infinite loop***

- **Problem determination approach: analyze Java stack traces (by producing Javadumps, also called `javacore` files)**
  - Very easy to realize: send `SIGQUIT` signal to the JVM in trouble

- **Stack trace revealed that the Java thread got stuck in the *ajax4jsf* framework**
  - Internet research revealed that this was an ***already documented*** bug
  - See here: https://issues.jboss.org/browse/JBPAPP-4153

- ***Easy workaround*: use an alternative cache factory implementation**
  - From a systems programmer point of view, ***one additional `.jar` file*** (`oscache.jar`) and ***one additional Java command line option*** were required:
    `-Dorg.ajax4jsf.cache.CacheFactory=org.ajax4jsf.cache.OSCacheCacheFactory`

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Field report, *continued*

- **After fixing the third problem, the *biggest issue* surfaced:**
  `javax.xml.transform.TransformerConfigurationException: Could not compile stylesheet`
  - This problem required ***a lot of time*** and debugging
  - Turned out to be a ***complex class loading issue***, based on mixing old and new versions of the same Apache XML® related classes
  - In addition, the XML / XSLT "transformer factory" was ***hard-coded in the customer code***, not using the Java SDK default setting

- **In the user interface, the problem manifested itself in *empty panels***
  - We ***had to solve*** this issue, there was no way to circumvent it

Source: http://www.recruitment-specialist.de

- **Basically, there are *2 solutions* available**
  - Change the class loading order, so that the old versions of the Apache classes are preferred (by using Java's ***Endorsed Standards Override Mechanism***)
  - Change the application code in a way that the ***default Java SDK implementation of XSLT*** is used for the XSL transformation (preferred solution)

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Field report, *continued*

- **Since using the "endorsed standards" mechanism *did not require any code changes*, we chose this approach in order to prove that the application runs successfully on Linux on System z**
  - From a systems programmer point of view, the ***only required change*** to the configuration is to extend the `-Djava.endorsed.dirs` setting to include the directory containing the to-be-overridden `.jar` files
  - ***Easiest and quickest*** workaround

- **Nevertheless (after the end of the Proof of Concept), I gave the customer's developers *all the required code changes* in order to run the application with the Java SDK's built in XSLT implementation**
  - Rationale: the ***new XSLT is much faster*** compared to the old implementation

- **The customer's regression test team ran a *full range of test cases* and the application did not exhibit a single issue anymore -> success!**
  - Internally at the customer, this "officially proved" that the application runs on Linux on System z (and the IBM Java SDK)

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Summary of field report

- **Basically, the problems found fall into *2 categories* (again):**
  - ***Infrastructure related*** (Java command line adjustments for the IBM Java SDK)
  - ***Coding related*** (hard coded class names)

- **Very hard or even *impossible to predict* what exactly will surface when you start your own Linux on System z Proof of Concept**
  - In almost all of the cases (including this field report), the issues found were related to the mentioned ***subtle differences in the JVMs***
  - ***None*** of the issues found was related to Linux on System z

- ***Techniques*** **used for debugging:**
  - Interpreting Java ***stack traces***
  - Reading Java ***source code***
  - Generating ***Javadumps*** (and again interpreting stack traces)
  - ***Replicating*** the problem on my workstation
  - Implement workarounds (***requires coding***) and test them

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Summary of field report, *continued*

- **Linux on System z *performed very nicely*, even with very limited resources (both CPU and memory)**
  - Nice little side story: during one of the additional tests, we ran with ***2 capped CPs at 10% weight*** and didn't even notice it until we stressed the environment really hard

- **Admittedly, this was a *very complex* porting**
  - Don't expect this many problems when porting
  - Even for this complex project, the time required for the actual porting of the application (not including infrastructure setup, etc.) was ***~10 working days***
  - In many cases, Java applications work ***out of the box*** when moving them from one platform to another

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Thank you

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