The Trend from UNIX to Linux in SAP® Data Centers:

Large. Critical. Beyond Limits.

Helmut Spöcker
Consulting Manager
REALTECH Consulting

October 2012
Contents

Management Summary ................................................................. 4

What Happened Since .................................................................. 8

Statistics Reloaded ..................................................................... 9

  General OS Directions ............................................................. 10
  OS Directions Specific for Linux ............................................... 17
  Database Talk ......................................................................... 18

Development of Price / Performance Ratio .................................. 22

Virtualization Reviewed ............................................................. 35

Green IT Reviewed ..................................................................... 36

Large. Critical. .......................................................................... 40

  Large Systems ........................................................................ 40
  Large Customers & Large Migration Projects ............................ 43

High Availability & Other Forms of High Criticality ..................... 49

  High Availability Tools for SAP on Linux ................................. 49
    SUSE Linux Enterprise Server High Availability Extension .......... 49
    High Availability with Red Hat Enterprise Linux ..................... 52
    SteelEye LifeKeeper ................................................................ 52
    Veritas Cluster ..................................................................... 53
    HP MC ServiceGuard ............................................................ 53
    IBM PowerHA / HACMP ......................................................... 54

Other Forms and New Understandings of HA and Criticality ......... 54

Beyond Limits .......................................................................... 55

  Beating Lower Limits .............................................................. 55

  Pushing Upper Limits ............................................................. 60

Final Conclusions ..................................................................... 62
Epilogue

Appendices

Full Evaluation Table (Order EUR/SAPS)

Comparison of Basic OS Support Costs

Comparison of Server Waste Heat for Identical CPU

Sources and References

About REALTECH
Management Summary

When the first “UNIX to Linux” whitepaper came out in 2008, no one could have anticipated the impact it would have. The messages were clear: Linux is ready for the SAP data center. The performance is there. The features are. Costs are significantly lower with x64 than with any other CPU architecture. Transition of operational procedures is significantly easier from UNIX to Linux than from UNIX to Windows. And costs are not a matter of the Operating System (OS), but of the CPU architecture. REALTECH published a second whitepaper that demonstrated adding to the proven supremacy in price/performance ratio, development and environmental aspects would deliver additional reasons to consider Linux/x64. In this U2L whitepaper, almost four years later, we will check if our assumptions and predictions of 2008 and 2009 were correct, but we will also look at limits and restrictions we have encountered, and discuss experiences we have made.

Taking into account all regions, all sources, and all targets of REALTECH migrations including a change of OS in the evaluation period, 92% of the sources (but only very few of the migration targets) come from UNIX, confirming our earlier observations and predictions. UNIX loses an overall 77% market share with HP-UX the major loser in the field at 46%. On the other hand, Linux gains 56%, Windows 23%. For the x64 CPU architecture, this adds up to an overall gain in market share of 79%, with all other architectures losing at this pace. Regarding specifically Linux, 95% of all REALTECH migrations going there come from one of the three major UNIX flavors. As for the database to choose, DB2 LUW seems to be perceived as the alternative to Oracle in the world of Linux and UNIX.

Looking at nothing but the price/performance ratio, it is striking that this is more than ever dominated by x64 platforms. The top 13 CPUs in the price/performance ranking come from the x64 family. The only competitive UNIX processor is Power, and indeed IBM did an excellent job in pushing the competitive limits for AIX in their advantage with the introduction of Power7. Still, even a Power7 blade platform increases cost per SAPS by 74% even if you stay with IBM as your vendor of choice, with more cost-efficient offers from other vendors available. As for the other UNIX processors, none even comes close to a competitive range. If your worry as an SAP customer is the total cost of your SAP IT infrastructure and you want to start cutting cost on the server side by getting more SAPS performance for less money, both SPARC and Itanium are simply out. We will demonstrate that just by moving to Linux and x64, a REALTECH
migration customer lowered their SAP server costs by over 80%, while at the same time at least tripling their available SAP computing power.

There is another distinct and important technical trend: Multi-socket server systems have become an outdated approach simply because they are too expensive. We will show in two examples in this whitepaper that REALTECH customers replacing this kind of architecture have saved or are about to save hundreds of thousands of EUR per year.

The performance achieved per core is especially significant for customers who have core-based licensing for their SAP databases, since the number of cores needed to achieve performance requirements amounts to whatever license costs come up. Usually, larger corporations have such contracts extending both to their SAP and Non-SAP database landscapes. Power is very good in this criterion. If this KPI has any significance for you and you don’t want to go for the Power architecture, possibly because you have selected x64 as your processor architecture of choice already, then go for Intel (not AMD) CPUs. They dominate pretty much the rest of the ranking. While per core performance is important for the database, per thread performance is the indicator on how overall performance will be concerning the SAP application level. The ideal CPU architecture for SAP applications is multi threads with maximum performance per thread, and this ranking is clearly dominated by Intel, clearly beating Power and AMD. Again, Itanium and SPARC are off any competitive range both regarding performance per core as performance per thread. **64-bit X86 Xeon CPUs from Intel are the probably best solution for both your SAP application and your SAP database. They are the only processor architecture that ranges in the best top 10 of every aspect of our evaluation.**

There are several technically mature virtualization solutions for Linux in SAP environments, and performance limits are of a rather theoretical than of practical nature. The only restriction we want to make is that we believe that XEN-based technologies may get into trouble in the long run and possibly will not survive. Apart from that, **virtualization has become a commonplace solution in the x86 world.**

The topic that generated the greatest interest in our 2009 whitepaper was our look at Green IT aspects. Due to some contradictions, we decided to take a different approach in our Green IT evaluation this time. The trend to Linux in SAP data centers is very much an architectural movement in favor of the x86_64 processor architecture. Therefore, our Green IT discussion focusses more on the energy consumption qualities of the CPUs rather than on the servers. The
A major trend can be summarized very distinctively: x64 processors from both Intel and AMD provide very reasonable results concerning energy consumption, as does the Power. Each of those has specific advantages and distinct qualities for certain use cases. In regard to SAP applications, the 64-bit X86 Xeon processor from Intel seems to be the best overall blend of optimum qualities. And, as usual, SPARC and Itanium don’t compete.

As predicted earlier, the performance of Linux server systems has reached or surpassed almost everything that can be delivered on UNIX side. The performance deliverable is beyond anything anyone would ever need in computing power for a single system today. The kind of x64 server available now simply will not be the bottleneck to any kind of application you want to run. Potential bottlenecks will come from somewhere else, and they are not connected to Linux (or any other OS). As for daily operations, there is no real limit what size of system or database can be run on Linux. We have seen really large databases run on this platform. We have set up or migrated production systems up to 8 TB, larger systems are currently in work. The one critical factor to consider is available downtime for the migration process itself, especially for the production system. But this has nothing to do with the target CPU architecture or target OS.

If the size of single systems is not a real question (or handicap) any more, neither is the size of a customer as an organization nor is the system landscape. REALTECH has done full scale projects with multi-billion revenue companies, has tackled system landscapes with about 30 production systems and hundreds of terabytes of data. It’s a matter of planning: Migrating all of a large and historically grown SAP system landscape in a large organization is a technically and organizationally complex process, and in such, there are a number of decisions and approaches to be made that will make the difference on weal and woe of a migration project. Please read through the respective chapters to find out about the keys for success in detail. The winning points in large migrations are realistic planning, a feasible timeline, experienced project management on both sides and knowledgeable migration specialists. If approached in the right way there is no size or criticality of customer, project or landscape that cannot be transformed from UNIX to Linux. However there is one thing to be emphasized: The error potentials on migration projects we will discuss in this analysis apply to all kinds of migrations, but they are in a very special way typical of UNIX to Linux migration projects. This again, has a lot to do with the fact that UNIX and Linux are so similar to each other they are frequently mistaken to be identical. They are not! – To avoid errors connected to this similarity, make sure to get good migration consulting.
High Availability, especially in SAP environments, is a process and should strictly be regarded as such. Accordingly, whatever solution you purchase to achieve High Availability, it will not solve your stability problems if your IT administration does not live up to the challenge of running a critical environment. There is an easy check for IT managers. If you ever thought something like “I don’t understand our problems. I bought High Availability!” then you are on the wrong track. However, there are HA tools available for Linux suitable to help you to establish the High Availability process. Among those HA frameworks available for Linux, we have found SUSE Linux Enterprise Server High Availability Extension to be the one most closely and best integrated into SAP applications, including the necessary certification for SAP’s new generic HA interface. SUSE has bundled SUSE Linux Enterprise Server and the HA Extension into “SUSE Linux Enterprise Server for SAP Applications” as a one stop, fully integrated bundle of services that was put together to address the specific needs of SAP on Linux users, which we consider a very attractive offering. The importance of this bundle and SUSE in general is enhanced by the fact that SAP ships several important products from its stack (e.g. HANA) exclusively on SUSE Linux.

Linux and the x64 CPU architecture have arrived in SAP data centers as mainstream solutions. They are excellently suited to deliver system landscapes of both high performance requirements and high criticality. On the other hand some UNIX flavors are doomed in the long run. Customers waiting too long with the replacement of obsolete architectures might get into trouble either on technical, or economic level, or by running out of time when large infrastructures will have to be replaced quickly. Thus our advice is to act soon. Start the transition process now!
What Happened Since

When the first “UNIX to Linux”, or short U2L, whitepaper came out in 2008, no one could have anticipated the impact it would have. In some respects it felt as if had been outspoken what quite a few knew, and many more suspected, but no one dared to say. The messages were clear: Linux is ready for the SAP data center. The performance is there. The features are. Costs are significantly lower with x86_64 (“x64” as of here) than with any other CPU architecture. Transition of operational procedures is significantly easier from UNIX to Linux than from UNIX to Windows. And as far as costs are concerned, reality is that they are not a matter of the Operating System (OS), but of the CPU architecture. The whitepaper triggered a significantly enlarged interest in REALTECH’s infrastructure analysis and migration services, and established or reestablished service contact with some global industry leaders, among them the world’s largest re-insurance company, the world’s largest chemical company, some of Europe’s largest car manufacturers, leading banks, and several others, all willing to discuss options, paths, costs, consequences and benefits of deploying x64 and Linux for SAP instead of whatever CPU architecture and UNIX OS they had been used to in the past.

The world’s largest chip manufacturer, Intel, approached REALTECH with the request to do a research, and dig deeper into the architectural aspects of SAP computing. We did, and we published a second whitepaper that demonstrated adding to the proven supremacy in price/performance ratio, development and environmental aspects would deliver additional reasons to get on a train inexorably taking on speed and momentum. In terms of market interest created, this second whitepaper, published in 2009, was even more successful than the first one – Novell (then, now SUSE) and REALTECH lost count at about 20,000 downloads¹ and numerous direct contacts.

What the second whitepaper was lacking was a sound statistical basis to confirm or refute some of the observations and trends that we had given in the first whitepaper. This was simply because it was too close in time to the first one. This is one important aspect that will be addressed with this third U2L whitepaper: In this U2L whitepaper we want to go back and check out if our assumptions and predictions of 2008 and 2009 were correct and evaluate them on a basis of several hundred production system migration go-lives delivered by REALTECH over the last three and a half years. We also evaluate if the originally predicted reduction in price/performance ratio was actually achieved, and as a result which CPU architectures were impacted.

¹ Some of them as late as Q3/2012.
However this is not where this whitepaper will stop. With four more years of experience on SAP on Linux, we will take a look at the limits and restrictions we have encountered, discuss experiences we have made, and look at how critical large implementations have become, and what will make large and critical migration projects successful. Beyond that, we will discuss progress in virtualization technologies and review Green IT aspects.

**Statistics Reloaded**

For a number of reasons, neither the first nor the second whitepaper gave an overview on general migration trends. However, since the last evaluation period we think we have collected sufficient data by all characteristics (OS, DB, regions) not only to look at sources of Linux target migrations (as was done in the 2008 WP), but to give a more comprehensive insight on what is going on in the SAP server infrastructure market. We honestly hope that this is as exciting to our readers as it was to us when the numbers first made it to charts and diagrams, with some highly surprising, fascinating and for some people probably disturbing trends and results.

The following rules apply to all statistics and evaluations given in this section:

1. The statistics always and exclusively count and refer to production systems that actually went live for productive usage on the target platform.
2. Only SAP database instances go into the count. Application servers and application instances are of no interest for these statistics.
4. The go-lives were actually performed by certified REALTECH migration specialists.
5. Since this whitepaper is focused on OS and CPU architecture developments, we excluded database migrations with no change of OS from the evaluations given here.²
6. The statistical basis is broad enough for any evaluation per criteria given, generally basing on a three-digit count. For protection of both our own business as well as our customers’ environments, we will however not give absolute numbers or exact counts.
7. Due to the statistical bandwidth reached, we rounded to whole percentages. Thus, if the numbers don’t add up to exactly 100% or don’t exactly match between one chart and the other this is due to rounding inaccuracies.

---

² We have these statistics, of course, and interested parties may inquire directly with REALTECH on terms & conditions to get this insight.
We cannot mathematically prove our statistics to be a statistically representative cross-section of worldwide trends. However, due to the strict vendor neutrality of REALTECH, we feel to get a well-mixed share of most things going on in the SAP market. Our statistical observations of the first whitepaper were, as a matter of fact, later largely confirmed on both a national level for Germany by RAAD Research and on an international scope by both Gartner and IDC. Since the absolute number of migrations is definitely rising and the evaluation period is longer than any before, we consider our data and the deductions taken from it to be highly accurate.

**General OS Directions**

First, let’s have a look at the general trends and movements regarding operating systems in the SAP data center. Taking into account all regions, all sources, and all targets of REALTECH migrations including a change of OS in the evaluation period, 92% of the sources come from UNIX, 3% each from OS/400 and Windows, and 2% from … Linux. Yes, this might well be the first surprise, there are migrations away from Linux, not many, but they do exist. We will later take a closer look into what the possible reasons for this might be. On the other hand, and not so much surprising, UNIX has been suffering big, very big. Even regarding all possible targets, not only Linux, every single UNIX that is still on the market has increased its relative and its absolute share as a source compared to the 2008 evaluation – although that one only referred to Linux targets. The only UNIXs that have disappeared from our statistics are the ones already dead. Since 2009, REALTECH has not performed any migrations away from Tru64 or Reliant, although both the relative and absolute number of migrations away from UNIX has risen significantly. These platforms have vanished definitely, and others will follow.

Who is losing most? – Well, quite unsurprisingly to connoisseurs of the topic and the market, HP-UX with PA-RISC (rather rare, too few left over) and Itanium (the vast majority) is the by far most frequent single migration source, with 47% overall share. Whether or not the next Itanium generation will make another “impressing” 13% jump in performance, or whether or not HP will win the legal battle over Oracle to continue support for HP-UX/Itanium with Oracle 12, most customers have made up their minds already. It’s not the question if they will leave the platform, just when, how and where to. However, the other UNIX vendors Oracle and IBM should be alarmed as well. After all, AIX (29%) and Solaris (15%) combine to another 44% of UNIX sources. And as the win/-loss-statistics will show shortly, it is not that those customers just switch from one UNIX to the other, a frequent path during the early years of the last decade. Most of them in fact leave the family of proprietary UNIXs for good.
Mainframes have disappeared as a migration source to REALTECH, probably due to their almost negligible market share in the overall SAP customer base. According to our (usually well-informed) sources, there are less than 300 customers left (worldwide) running SAP products on zSeries or OS/390, not many compared to an overall 78,000 customers SAP reports. But since we cannot prove this assumption, and we do not want to speculate, we will not spend any more attention to the mainframe platform in this whitepaper. Looking at overall numbers, it simply doesn’t have much importance. The same applies to iSeries and OS/400 – almost whenever we meet it, it is a migration source, but due to the low market share, these are rare events.

So, if the sources are 92% UNIX and there is a little bit of movement within almost any OS family, what are the migration targets? – Again, counting all migrations with a change of OS (and excluding those without) over all regions in the evaluation period, we have unambiguous winners and losers of a worldwide trend: 58% of all REALTECH migrations went to Linux, and 27% to Windows. While this is certainly good news for SUSE, Red Hat and Microsoft, it is even more so for Intel and AMD, since our statistics is equivalent to the statement that 85% of our migrations target the x64 CPU architecture. Neither Linux on Power, nor Linux or Windows on Itanium, no

---

3 Listed in statistics and charts as “AS/400” for simplicity although not fully compliant with IBM naming conventions.
longer supported by Red Hat and Microsoft anyway (and SUSE suspected to follow with SUSE Linux Enterprise Server 12), have any market significance.

Where there are clear winners, there must be losers around. AIX and Solaris defend a poor 7% target share each. And yes, trust your eyes, we indeed had a project and a customer going towards HP-UX on Itanium. However, this project contributes a mere 1% targets, occurred in the very first quarter of the evaluation period and stands out as the sole one with that migration target on a worldwide level. It is also a great example of what we call a “political migration”: Triggered neither by technical nor economic reasons, political migrations usually are the result of a merger & acquisition process where the larger IT absorbs the smaller one into their SAP platform of choice, whether it makes sense or not. In 2005, we even had such a project where an American company with an AS/400 based SAP IT acquired a German one with a pretty new Linux-based SAP IT – and forced them to migrate. And there is something to say on this the numbers don’t reveal: While the 7% AIX targets are to a very high degree the result of companies consolidating their SAP IT on the Power platform, and doing so consciously, the 7% Solaris targets largely feed on a very large political project: A quite big financial institution with a Solaris-based SAP IT merged with an almost equally large one based on AIX – and forced them to migrate. However the process took three years, and in the meantime a new cost reduction program was set up, with the result that new SAP products will be implemented exclusively on
Linux, with existing SAP systems to follow as soon as possible. Thus, quite some of Solaris’ 7% gain of this evaluation period will become the loss of the next one, added by those systems running on Solaris and the SPARC CPU in this financial institution for about 10 to 15 years. Therefore, 7% target share for both Solaris and AIX seem to be the same, but they have very different meanings. The later discussion of CPU properties and the development in the price/performance ratio will demonstrate why.

For ease of interpretation, we have put this together into a win-/loss-statistics as shown frequently with elections. As a matter of fact, it is an election, kind of. And of course, the logic of mathematics holds: UNIX loses an overall 77% market share, with HP-UX being the major loser in the field at 46%. On the other hand, Linux gains 56%, Windows 23%. For the x64 CPU architecture, this adds up to an overall gain in market share of 79%, with all other architectures losing at this pace.

So far, we have answered the questions about who is losing and who is winning, but we have not shed any light on where in the world this is going on. It is highly interesting for us, that although our overall organizations in Europe are larger than in the Americas or the APAC region, the absolute number of migrations performed is absolutely comparable, with only a slight advance in
numbers on the European side. Again, for all regions we have a sufficient statistical basis as a result.

The regional distribution of migration projects is very interesting indeed, and if the champagne corks haven’t popped yet with Intel and AMD, they should do so now: In the Americas, with a strong emphasis on Canada and the U.S., Windows and Linux combine to a 100% migration target market share. It is not really surprising that in this part of the world, Windows as a migration target still has the edge over Linux. There are two major reasons for this: The average American or Canadian SAP customer migrating now still is considerably smaller in size compared to the size of customers migrating anywhere in Europe, usually too small to care to keep up running both OS worlds. And the American SAP market lags behind the European one roughly two to three years, something you can easily verify by taking a look at SAP product and release distribution on both sides of the Atlantic Ocean. With about that delay, larger UNIX shops now consider leaving this platform, and the clear trend is that the larger they get, the more likely they will move their SAP infrastructure to Linux, not Windows, the same trend we have observed in Europe, just a couple of years earlier. In the Americas, being traditionally more Microsoft friendly,

---

4 SAP system landscape wise.
the long term trend could well result in a clean tie between Linux and Windows. Currently the
distribution is 37% for Linux and 63% for Windows. But what a message is this for UNIX? – Wow!

So, let’s have a look at Europe, probably still SAP’s most important market. Again, we have
excellent news to spread for Intel and AMD with a combined 83% migration targets. However, the
split between Linux and Windows is sensational: Linux provides 80% of the migration targets, or
in other words, “Europe goes Linux.” This has to do a lot with the customer structure the
movement to x64 and Linux has reached in Europe, which are the largest enterprises on the
market. REALTECH alone has discussed SAP Linux projects with 14 companies listed in the
DAX®30 index. Several of them chose to implement in the near future or have already done so.
And some of those we didn’t talk to are known to have implemented on their own, e.g. Deutsche
Telekom, a SUSE Linux reference customer as early as with the first U2L whitepapers. All of
those companies have been running very large UNIX environments for several years before, and
none of them known to REALTECH has gone for Windows instead of Linux, while virtually all of
them opted to go for x64\(^5\), mostly due to costs. Unlike in the Americas, commercial UNIXs keep a
17% target share in Europe, the sources usually consisting of other commercial UNIXs. The trend
to that is clearly showing downwards, however. Outside Germany, by the way, we have
discussed SAP on Linux with some of Europe’s largest banks, largest airlines, and largest high-
tech companies. No one is missing, no size of enterprise omitted.

What Linux is to Europe, Windows is to the APAC region, at least for now. 69% of our migrations
in the region target the Microsoft operating system, with the UNIXs taking the second place (22%)
and Linux yet to catch on from a disappointing 9%. As in the previous discussion of the regional
distribution, this has a lot to do with two things: The market, and the customer structure. If the
American market is in many respects delayed by two or three years compared to the European,
the Asian-Pacific SAP markets lag behind the American by another two or three years. This
applies to many developments, and the trend from UNIX to Linux is most certainly one of them.
As a consequence, many customers have comparably small SAP landscapes and few SAP
products in their stacks, mainly ERP and BW, matching perfectly with the customer structure
REALTECH had in Europe ten years ago. And in those times, we had many more migrations to
Windows than to the just emerging Linux. Usually those were smaller companies who just
couldn’t afford UNIX environments that time. The larger companies in the APAC region still have
a tendency to switch from one commercial UNIX to the other. But one trend has reached APAC

\(^5\) None of these “Big 30” in Germany we have talked to, so far has chosen to go for Solaris on x64, not even long-term
Solaris on SPARC customers. Nor has anyone else from our customer base, regardless of size.
already: The fading away of the Itanium. Not only is it that neither Windows nor Linux on Itanium have any significance, but when we say that 22% of the targets are commercial UNIXs in the APAC region this implies exclusively AIX on Power and Solaris on SPARC.

By the way: No business in Africa? - Right. At least for REALTECH, this is the part of the world we hardly ever get in touch with, at least so far.
OS Directions Specific for Linux

In the 2009 whitepaper, we made the following statement: “If the current trend continues for the next one to two years, supported UNIX flavors will provide well over 80 percent of REALTECH’s Linux migration sources. The share of (currently) discontinued platforms will drop to zero or almost zero, …”

Now that we have just established that 92% of all migration sources are still supported UNIX flavors and 58% of all targets are Linux, it doesn’t provide much of a surprise that our prediction indeed came true. Today, 95% of all REALTECH migrations going to Linux come from one of the three UNIX flavors still to be found in SAP’s PAM\(^6\). And again, HP-UX is suffering by far the largest loss with 58% of the sources. The shares of AIX and Solaris have grown too, but the erosion has not the same dramatic pace. As predicted, Tru64 and Reliant are of no relevance any more. A bit surprising to us, IBM iSeries and zSeries have completely vanished as migration sources to Linux, with iSeries customers turning to Windows as their preferred target.

As for Microsoft, our forecast was that “…the number of Windows customers switching to Linux might drop below 10 percent.” – This provided a correct assumption as well, and even for the remaining 5% there are good explanations, none of them technical. About 2% of all Windows

---

\(^6\) Platform Availability Matrix.
sources going Linux are owned to political projects of some kind, from anything like mergers & acquisitions, or by centralizing company IT resources into fewer data centers, or a larger organization absorbing a smaller one. Vice versa, these reasons are also the usual origin of the 2% leaving Linux reported in an earlier section. The remaining 3% of Windows sources going towards Linux usually come as a “side dish” of any kind of large UNIX migration. The usual scenario in these cases is that some smaller system landscapes set up at a later stage of the overall SAP environments’ lifecycle came to life on Windows instead of more expensive UNIXs, and with the consolidation to Linux, they are taken along. Typical product stacks for this are EBP, Enterprise Portals, and the Solution Manager.

Database Talk

What we haven’t discussed at all so far is what all of this means for the database worlds, if it means anything. In the 2008 whitepaper, we established the trend that Oracle and MaxDB were winning market shares at about the same pace, while DB2 and SQL Server were losing with regard to Linux targets.

In this respect, many things have changed fundamentally. Not that Microsoft has come up with a SQL Server version for Linux, but apart from that … Let’s look at the general development first.

Again, only taking into account migrations that involved a change of OS, and looking at worldwide developments as observed and executed by REALTECH, SQL Server wins a striking 19% in market share. With Windows having an overall target share of 27%, this is equivalent with the statement that more than two out of three customers turning to Windows as their OS of choice also opt for the database from the same vendor. The other winner in market share is DB2, or to be more accurate, DB2 LUW. Clearly, the database profits from the iSeries and zSeries having become rare sources, reducing the loss count that comes from the mainframe DB2 version. And as we will see, DB2 LUW seems to be perceived as the alternative to Oracle in the world of Linux and UNIX.

So, who is losing? – Well the number of suspects has been reduced already. Yes, somewhere in the world we still found some Informix customers who had to leave. But these projects mostly took place in the early years of the evaluation period, and have lost significance towards today. More notably, MaxDB’s winning streak is over. In the earlier years of SAP on Linux, combining the open source OS with an (almost and for some time in fact) open source database was a very popular choice, mostly by smaller Linux migration customers coming from UNIX/Oracle or Windows with whatever database. Since the average Linux migration customer is significantly larger in size today, they now choose one of two other paths: Either they come from Oracle and
stay with it, or they come from Oracle and go to DB2\textsuperscript{7}. MaxDB has become a very static market environment. Smaller customers already on Linux/MaxDB simply don’t move anywhere, why should they? – For all reports we hear this OS/DB platform is unbreakably stable and causes almost no administrative overhead. On the other hand, larger shops simply don’t move there, why should they? – For all we know, MaxDB still has restrictions concerning the performance of large and very large BW environments, something usually very important to large and very large enterprises. Beyond that, MaxDB still only offers a UTF-16 based UNICODE format and there is no high-quality compression available comparable to any of the other database options on the market. Even worse, SAP has shown little to no ambition to change this lack of a highly desired feature, along with a general lack of a clear development roadmap. It does make a difference if your SAP storage landscape mounts up to 300 TB or just half of it, a difference in infrastructural cost, in energy consumption, in administrative overhead. And over the last two or three years, basically with any major data leak somewhere in the world, another important feature entered the discussion that MaxDB can’t provide: encryption. All that combined to the fact that customers seem to have lost interest in MaxDB. SAP’s adding Sybase ASE to their portfolio and announcing HANA as the database solution of the future along with the implicit contradictions of this already double-headed strategy hasn’t helped MaxDB either.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{database_win_loss.png}
\caption{Database Win/Loss - All Migrations}
\end{figure}

\textsuperscript{7} In further discussions, DB2 always means DB2 LUW if not explicitly indicated otherwise.
The other big loser in the SAP database market is ... Oracle. This feeds on two major trends: Globally, almost all customers going to Windows also go to SQL Server, no matter which OS they come from, but especially if they were running Oracle databases before. And second, we have a rising trend of migrations in the UNIX and Linux world targeting DB2, again especially if the source is Oracle. This applies both to UNIX to Linux (U2L) as well as UNIX to UNIX (U2U) migrations. And in a sense, Oracle is even lucky: Some of our major Linux migration customers have told us frankly that knowing then (in 2008, when decisions were made) what they know now (2012) about Oracle licensing models and, say, the “attitude” of some Oracle sales reps, would have paved the direct way to Linux/DB2 instead of the Linux/Oracle migration it became. Some of them added that the only reason not to repeat the process was not that they weren’t willing to invest in a 7-digit transformation project again but that they couldn’t burden key users and functional departments with another large migration project so shortly after the last one. All in all, Oracle seems to do a real great job in alienating their customers.

The database trend concerning all migrations is reflected in those migrations that target Linux with the applicable and natural restrictions, mostly the lack of available options. With Informix dead, MaxDB out of fashion, SQL Server not available for Linux, and Sybase ASE not ready yet, customers basically have the choice between Oracle and DB2. Thus, Oracle loses about 11% of
their customers going to Linux, while DB2 takes on the wins. Don’t let us be misunderstood: These figures also clearly state that Oracle maintains an overall market share in the Linux and UNIX worlds of at least 60%. Many of our largest Linux migration projects switch the OS but keep Oracle, even with customers who are stewing mad in misery about Oracle’s licensing models, or corporate policies, or both. The reasons for this enforced loyalty are multi-fold:

First of all, changing the database is the bigger step than changing the OS, at least if this step is from UNIX to Linux. While a U2L operating system migration enables customers to maintain many operational procedures, scripts, interfaces, automatisms and layouts, a change of the database always involves a steeper learning and implementation curve, and a redesign of fundamental mechanisms such as backup & recovery, performance tuning, storage layout and index optimization. And customers are really smart about this: They know that fifteen years of experience of running Oracle databases for SAP applications in large UNIX environments cannot be replaced easily within a couple of months.

The second major reason for staying with Oracle is that SAP is much in the world of business IT, but not everything. Many of our U2L migration customers also maintain large non-SAP landscapes with Oracle databases on UNIX or Linux. Most of those customers have direct licensing contracts with Oracle for both worlds, SAP and non-SAP, and they simply know that bailing out on one side very likely would pull the trigger for heavy rises in price on the other. So, instead of provoking Oracle unnecessarily they just stick with it, feeling unhappy about it or not.

There are other reasons for staying with Oracle, such as running FDA-validated environments (and facing the prospect of possibly having to repeat the validation process with a database change), or simply one’s history, e.g. coming from Informix and not being ready for another change of the database.

Region-wise, the trend away from Oracle is strongest in the American market, followed by Europe. This corresponds with the operating system trends described previously.
Development of Price / Performance Ratio

As in the 2009 whitepaper, we have established a set of rigorous rules and criteria for the price/performance evaluation.

[A] This white paper series deals with the connection between architectures and Linux in the SAP world. Therefore, we have taken into account only hardware vendors who currently are committed in the SAP LinuxLab. We have not considered those vendors with future intentions to make such a commitment.

[B] Only performance measurements backed by an official benchmark (2-tier-SD) of release ECC 6.0 EHP 4 UNICODE are listed. Unlike last time, we have taken into account all 2-tier SD benchmarks based on this benchmark release that were performed during the last two years. If multiple benchmarks for the exactly same server configuration were available in that timeframe, we only evaluated the newest one.

The two exceptions we have to this rule “all benchmarks of the last two years” rule concerns …

(1) … the Itanium processor: No 2-tier SD benchmark has been published since 2008, so we included the last available 2-tier SD ECC 6.0 NON-UNICODE into our cost and energy evaluations. Please keep this in mind when looking at graphics and charts, since this workaround makes Itanium look better than it is. For a real comparison we would have had to deduct a certain percentage from the SAPS measured with the more lightweight ECC 6.0 benchmark – but how much, 15%, or 20%, or 40%? – We simply don’t know, therefore we didn’t do it at all.

(2) … the SPARC processor: The available benchmarks are older than two years, but due to a lack of alternatives we chose these. At least, they were done on the same benchmark release as all those x86 and Power benchmarks available, contrary to Itanium.

[C] Please note that the new benchmark basis increases performance requirements significantly compared to the EURO/SAPS evaluation in the 2009 whitepaper, which was based on

---

*They have been performed, but for good reasons affected hardware vendors chose not to publish.*
benchmark release ECC 6.0 NON-UNICODE. Therefore, the price/performance ratios of 2009 and 2012 are not comparable – today’s hardware would do a lot better than the 2009 one in identical benchmarks.

[D]
We did not include hardware vendors into our evaluation where no official pricing was available for the benchmarked servers, or where official pricing information was limited to certain local markets only (e.g. Japan). This is a global whitepaper dealing with global vendors offering global products and services only.

[E]
The cost for one (1) blade server was determined as follows: We calculated the cost for a fully equipped blade-center of the respective vendor with that server in identical configuration, included the cost for the blade center and divided the total cost of the configuration by the total number of blade servers fitting in, thus getting realistic total cost per single blade server.
Apart from this particularity for blade servers, we used the same methods and sources to determine server prices as in the first two whitepapers, supplemented and aided by downloadable configuration and pricing programs most hardware vendors provide nowadays.

[F]
We are aware that there have been newer 2-tier-SD-benchmarks based on SAP ECC 6.0 EHP5 UNICODE. However, the number of these newer benchmarks is still by far too small to support our investigation. In fact, using this benchmark would have restricted us to four hardware vendors, five benchmarks and x64 only (as of August 31st, 2012).

[G]
Our total cost calculation is based on an enterprise-critical 7x24 support for the original benchmark OS – unlike 2008 and 2009, when we transferred all support cost calculations for x64 hardware to the SUSE support model. We will show in an example that the differences for basic server support in the x64 world are negligible at least concerning SUSE and Red Hat Enterprise Linux as well as Windows Server. There are – in parts significant – cost differences concerning additional features such as high-availability, virtualization capabilities and control, licensing and support cost of virtualized environments. Both SUSE and Red Hat will likely have a clear edge over Windows in these categories, but these features have always been excluded in our price/performance evaluations since the sheer number of possible variants makes a fair comparison almost impossible.
Consequential to this change in our evaluation policy, Oracle x64 servers have been calculated with Solaris as supported OS if benchmarked so and under the same assumptions of enterprise-critical 7x24 support.

Having settled the rules, we will now look at the new figures. Many conclusions are fully in line with our statements and predictions three or four years ago, a few others need to be analyzed and explained, mostly because they include some new technical developments.

Looking at nothing but the price/performance ratio in EURO/SAPS\(^9\), it is striking and obvious that this is more than ever dominated by x64 platforms. The only competitive UNIX processor is Power, and indeed IBM did an excellent job in pushing the competitive limits for AIX in their advantage with the introduction of Power7\(^10\). Still, even a Power7 blade platform increases cost per SAPS by 20 cents or 74% even if you stay with IBM as your vendor of choice, with more cost-efficient offers from other vendors available. And the more cost-efficient x64 solution from IBM comes in a four-socket server, thus offering more room for memory, more cores, more threads to distribute over a number of applications if not a single one is consuming available performance. And available performance is abundant in both cases – we are talking about servers with 64.130 (x3755 M3) or 41.700 SAPS (Blade Center PS702), roughly the equivalents of 10,000 or 7,000 concurrent SD users. As for the other UNIX processors, none even comes close to a competitive range, and there are two messages in it: First, it is not enough to claim development progress and improvements, but you have to prove it by making yourself comparable to the competition. Second, both Oracle and HP have chosen not to make themselves comparable by either not publishing SAP benchmarks at all any more, as HP does for the Itanium, or by turning to a benchmark no one else does, the path Oracle has selected: Yes, there was a benchmark with SPARC in 2011, but the benchmark type chosen was ATO, with a total of 27 published benchmarks since 1998, and the last competitor having published a result for that type in 2002 (or 2003 if you consider Fujitsu a competitor to Oracle concerning SPARC). The only undoubted message in this is that even with SPARC there have been some improvements over the last nine (!) years … But if your worry as an SAP customer is the total cost of your SAP IT infrastructure and you want to start cutting cost on the server side by getting more SAPS performance for less money, both SPARC and Itanium are simply out.

\(^9\) For convenience of our non-European readers we present this table in both EURO/SAPS and US-$/SAPS. We converted the ratio with a static and rather conservative exchange rate of 1,000 EURO = 1,250 US-$. Our discussion is related to EURO, reflecting the fact that Europe has the strongest momentum towards Linux, but of course the basic conclusions are exactly the same in both currencies.

\(^10\) And as of October 3rd, 2012, Power7+ has been introduced to the market, likely pushing the limits somewhat more.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2012005</td>
<td>HP</td>
<td>ProLiant DL385 G7</td>
<td>AMD Opteron 6282SE</td>
<td>30.920</td>
<td>2</td>
<td>15.460</td>
<td>16</td>
<td>2600</td>
<td>2012</td>
<td>0,29</td>
</tr>
<tr>
<td>2011048</td>
<td>HP</td>
<td>ProLiant BL685c G7</td>
<td>AMD Opteron 6276</td>
<td>55.030</td>
<td>4</td>
<td>13.758</td>
<td>16</td>
<td>2300</td>
<td>2011</td>
<td>0,30</td>
</tr>
<tr>
<td>2012004</td>
<td>HP</td>
<td>ProLiant BL465c G7</td>
<td>AMD Opteron 6276</td>
<td>27.980</td>
<td>2</td>
<td>13.990</td>
<td>16</td>
<td>2300</td>
<td>2012</td>
<td>0,30</td>
</tr>
<tr>
<td>2011046</td>
<td>HP</td>
<td>ProLiant DL585 G7</td>
<td>AMD Opteron 6282SE</td>
<td>62.570</td>
<td>4</td>
<td>15.643</td>
<td>16</td>
<td>2600</td>
<td>2011</td>
<td>0,34</td>
</tr>
<tr>
<td>2011051</td>
<td>IBM</td>
<td>System x3755 M3</td>
<td>AMD Opteron 6282SE</td>
<td>64.130</td>
<td>4</td>
<td>16.033</td>
<td>16</td>
<td>2600</td>
<td>2011</td>
<td>0,34</td>
</tr>
<tr>
<td>2012012</td>
<td>HP</td>
<td>ProLiant DL380p G8</td>
<td>Intel Xeon E5-2690</td>
<td>42.920</td>
<td>2</td>
<td>21.460</td>
<td>8</td>
<td>2900</td>
<td>2012</td>
<td>0,36</td>
</tr>
<tr>
<td>2012021</td>
<td>Cisco</td>
<td>UCS B200 M3</td>
<td>Intel Xeon E5-2690</td>
<td>41.700</td>
<td>2</td>
<td>20.850</td>
<td>8</td>
<td>2900</td>
<td>2012</td>
<td>0,37</td>
</tr>
<tr>
<td>2012017</td>
<td>Dell</td>
<td>PowerEdge R720</td>
<td>Intel Xeon E5-2690</td>
<td>35.970</td>
<td>2</td>
<td>17.985</td>
<td>8</td>
<td>2900</td>
<td>2012</td>
<td>0,39</td>
</tr>
<tr>
<td>2012009</td>
<td>HP</td>
<td>ProLiant BL460c Gen8</td>
<td>Intel Xeon E5-2680</td>
<td>40.180</td>
<td>2</td>
<td>20.090</td>
<td>8</td>
<td>2700</td>
<td>2012</td>
<td>0,40</td>
</tr>
<tr>
<td>2011050</td>
<td>Cisco</td>
<td>UCS C460 M2</td>
<td>Intel Xeon E7-4870</td>
<td>72.250</td>
<td>4</td>
<td>18.063</td>
<td>10</td>
<td>2400</td>
<td>2011</td>
<td>0,53</td>
</tr>
<tr>
<td>2011016</td>
<td>HP</td>
<td>ProLiant BL680c G7</td>
<td>Intel Xeon E7-4870</td>
<td>73.970</td>
<td>4</td>
<td>18.493</td>
<td>10</td>
<td>2400</td>
<td>2011</td>
<td>0,53</td>
</tr>
<tr>
<td>2012008</td>
<td>Fujitsu</td>
<td>PRIMERGY RX300 S7</td>
<td>Intel Xeon E5-2690</td>
<td>41.320</td>
<td>2</td>
<td>20.660</td>
<td>8</td>
<td>2900</td>
<td>2012</td>
<td>0,55</td>
</tr>
<tr>
<td>2011024</td>
<td>IBM</td>
<td>BladeCenter P702</td>
<td>POWER7</td>
<td>41.700</td>
<td>2</td>
<td>20.850</td>
<td>6</td>
<td>3700</td>
<td>2011</td>
<td>0,59</td>
</tr>
<tr>
<td>2012019</td>
<td>Cisco</td>
<td>UCS B230 M2</td>
<td>Intel Xeon E7-2870</td>
<td>28.080</td>
<td>2</td>
<td>14.040</td>
<td>10</td>
<td>2400</td>
<td>2012</td>
<td>0,59</td>
</tr>
<tr>
<td>2012010</td>
<td>Dell</td>
<td>PowerEdge R910</td>
<td>Intel Xeon E7-2870</td>
<td>61.600</td>
<td>4</td>
<td>15.400</td>
<td>10</td>
<td>2400</td>
<td>2012</td>
<td>0,61</td>
</tr>
<tr>
<td>2011026</td>
<td>Fujitsu</td>
<td>PRIMERGY RX600 S6</td>
<td>Intel Xeon E7-4870</td>
<td>72.650</td>
<td>4</td>
<td>18.163</td>
<td>10</td>
<td>2400</td>
<td>2011</td>
<td>0,63</td>
</tr>
<tr>
<td>2012014</td>
<td>Oracle</td>
<td>Sun Fire X4270 M3</td>
<td>Intel Xeon E5-2690</td>
<td>45.570</td>
<td>2</td>
<td>22.785</td>
<td>8</td>
<td>2900</td>
<td>2012</td>
<td>0,67</td>
</tr>
<tr>
<td>2011032</td>
<td>IBM</td>
<td>System x3690 X5</td>
<td>Intel Xeon E7-2870</td>
<td>37.370</td>
<td>2</td>
<td>18.685</td>
<td>10</td>
<td>2400</td>
<td>2011</td>
<td>0,73</td>
</tr>
<tr>
<td>2011042</td>
<td>IBM</td>
<td>Power System 730</td>
<td>POWER7</td>
<td>38.220</td>
<td>2</td>
<td>19.110</td>
<td>6</td>
<td>3700</td>
<td>2011</td>
<td>0,76</td>
</tr>
<tr>
<td>2011053</td>
<td>Cisco</td>
<td>UCS C260 M2</td>
<td>Intel Xeon E7-2870</td>
<td>36.900</td>
<td>2</td>
<td>18.450</td>
<td>10</td>
<td>2400</td>
<td>2011</td>
<td>0,81</td>
</tr>
<tr>
<td>2011052</td>
<td>HP</td>
<td>ProLiant DL980 G7</td>
<td>Intel Xeon E7-4870</td>
<td>124.430</td>
<td>8</td>
<td>15.554</td>
<td>10</td>
<td>2400</td>
<td>2011</td>
<td>0,87</td>
</tr>
<tr>
<td>2011031</td>
<td>HP</td>
<td>ProLiant DL580 G7</td>
<td>Intel Xeon E7-4870</td>
<td>66.680</td>
<td>4</td>
<td>16.670</td>
<td>10</td>
<td>2400</td>
<td>2011</td>
<td>1,00</td>
</tr>
<tr>
<td>2011034</td>
<td>IBM</td>
<td>System x3850 X5</td>
<td>Intel Xeon E7-8870</td>
<td>140.720</td>
<td>8</td>
<td>17.590</td>
<td>10</td>
<td>2400</td>
<td>2011</td>
<td>1,04</td>
</tr>
<tr>
<td>2011043</td>
<td>IBM</td>
<td>Power System 750</td>
<td>POWER7</td>
<td>94.730</td>
<td>4</td>
<td>23.683</td>
<td>6</td>
<td>3700</td>
<td>2011</td>
<td>1,23</td>
</tr>
<tr>
<td>2012016</td>
<td>IBM</td>
<td>Flex System x240</td>
<td>Intel Xeon E5-2690</td>
<td>43.520</td>
<td>2</td>
<td>21.760</td>
<td>8</td>
<td>2900</td>
<td>2012</td>
<td>1,81</td>
</tr>
<tr>
<td>2009052</td>
<td>HP</td>
<td>Integrity BL860C</td>
<td>Intel Itanium 9140M</td>
<td>5.850</td>
<td>2</td>
<td>2.925</td>
<td>2</td>
<td>1660</td>
<td>2008</td>
<td>2,48</td>
</tr>
<tr>
<td>2011017</td>
<td>Fujitsu</td>
<td>PRIMEQUEST 1800E2</td>
<td>Intel Xeon E7-8870</td>
<td>131.170</td>
<td>8</td>
<td>16.396</td>
<td>10</td>
<td>2400</td>
<td>2011</td>
<td>3,93</td>
</tr>
<tr>
<td>2009026,1</td>
<td>Oracle</td>
<td>SPARC Enterprise T5440 UltraSPARC T2 Plus</td>
<td>25830</td>
<td>4</td>
<td>6.458</td>
<td>8</td>
<td>1600</td>
<td>2009</td>
<td>7,72</td>
<td>6,33</td>
</tr>
<tr>
<td>2009038,2</td>
<td>Oracle</td>
<td>SPARC Enterprise M9000</td>
<td>SPARC64 VII</td>
<td>95480</td>
<td>32</td>
<td>2.984</td>
<td>4</td>
<td>2880</td>
<td>2009</td>
<td>31,01</td>
</tr>
<tr>
<td>2009046,1</td>
<td>Oracle</td>
<td>SPARC Enterprise M9000</td>
<td>SPARC64 VII</td>
<td>175.600</td>
<td>64</td>
<td>2.744</td>
<td>4</td>
<td>2880</td>
<td>2009</td>
<td>37,71</td>
</tr>
</tbody>
</table>

Table 1: Evaluated servers ordered by price/performance ratio (EUR/SAPS), best to last.
There is something else quite interesting and important that can be derived by just looking at the three SPARC values listed: Servers and mainboards with many sockets come with a high price, the more, the higher. This is true for all architectures. Within the x64 family, all servers with 8 sockets range clearly at the unfavorable end of the price/performance ratio. And one might well guess why IBM, smart as they are, did not benchmark a 32-socket p795 system any more since 2010. Multi-socket server systems, where “multi” is any number greater than eight (or maybe even equal to eight), have become an ever increasingly outdated approach simply because they are too expensive. We will show in two examples in this whitepaper that REALTECH customers replacing large multi-processor servers by highly symmetrical two- and four-socket technologies have saved or are about to save hundreds of thousands of EUR per year.

Most interesting to us is that the general direction we indicated with the first two whitepapers still holds and cannot seriously be expected to ever change again: 2008, the top 4 in price/performance ratio were x64, in 2009 the top 8, and now in 2012 the top 13 come from the x64 family. Competition among the x64 vendors has even been intensified by the entry of Cisco, Hitachi, and, already announced, Huawei into the SAP server market, probably leading to even more competitive benchmarks being performed for x64 than ever before whereas the number of benchmarks performed or published for any of the UNIX platforms decreases every year. This also leads to a remarkable race between Intel and AMD, where AMD has chosen the path of massive parallelization by building as many cores into a socket as possible while Intel is pushing the limits of per core and per thread performance (rather targeting Power than Opteron as competition of choice). Both approaches have their pros and cons. Intel, for example, works in a frequency range between 2.600 and 3.600 MHz, while AMD stays slightly below that in a range of 2.300 to 2.800 MHz. Since energy emission is a third power of frequency but only in linear dependency of socket dimensions, this gives AMD a slight advantage over Intel concerning energy efficiency. Later evaluations and charts in the “Green IT” chapters will show this. However, to achieve the best SAP application performance and throughput, per core or even per thread performance is more important than massive parallelism in many important use cases, especially for Java and dual stack applications as well as with virtualized environments. And there is a strong economic aspect working against too many cores per socket: If your database licensing is core-based, no matter if for Oracle or DB2 or any other, the many cores approach is out very quickly. REALTECH has done evaluations where the database licensing cost over three years between Intel and AMD CPUs made up for a 30% (or, absolute, seven-digit EUROs) difference in favor of Intel in otherwise identical and already licensing-cost optimized configurations. This
Table 2: Evaluated servers in order of performance per main processing unit (socket), best to last.

usually will overcompensate the fact that hardware vendors tend to attach a higher price tag to their Intel offerings compared to their AMD ones (e.g. compare the HP ProLiant DL385 G7 with 0,23 EUR/SAPS to the HP ProLiant DL380p G8 with 0,29 EUR/SAPS, both benchmarked within
less than two months). However, if your database licensing is SAP-contract-value-based, this should not give you a headache at all, and the nice thing about the enormous competition in the x64 world is that you are completely free to build the environment that fits best your technical needs, financial capabilities and contractual situation.

The next topic we want to discuss in this whitepaper is how much money’s worth you get for what you pay, and we think that an excellent indicator for this is the overall performance of the main CPU, or “socket” (to avoid being mistaken with a virtual CPU in any context). Unsurprisingly, the oldest benchmarks do worst in this context. Please note that Itanium, not SPARC, would likely take the last place in the ranking if it had the same benchmark basis as all the others. Anyway, the discussion of the per-socket-performance of these two architectures is an erratic trip on the road to nowhere. None of the two is a competitive solution any more not only from an economic but also from a technical perspective. There are much more interesting things to look at.

First of all, the per-socket-performance ranking is dominated by two processor manufacturers, IBM and Intel. Clearly, those two compete while the rest are “also-rans”. This is especially true of AMD who seem to target a customer range that is more dedicated to minimize total cost than to find the best compromise of maximum performance and minimum cost. In other words, there is a clear reason why all server vendors offering AMD solutions do so with a policy of a lower price compared to their Intel-run counterparts – it opens the server market to customers with smaller SAP landscapes and smaller IT budgets. While large companies usually have to find a solution to provide performance of several hundred thousands of SAPS with a minimum number of servers (due to space & administration considerations) or processors and cores (due to licensing considerations), smaller customers with only one to three SAP production systems frequently encounter the problem of requiring anything between four and six servers for redundancy considerations, but doing so surpasses their performance requirements at lengths, even with the somewhat lower-performance AMD sockets. Needless to say that exactly this clientele usually has a contract-value-based licensing for their SAP databases, so AMD’s multi cores per socket approach doesn’t harm anyone.

Another interesting observation to us is that in this ranking the top 15 are two- or four-socket servers. This at least suggests that the optimum between multi-socket-reuse synergies and SMP administration losses lies in that server range as well. Interestingly, IBM gets more power per socket out of their four-socket servers than out of the two-socket ones. Maybe, and this is a very conceivable possibility, AIX has the more efficient and proficient multi-processor handling. This
also implies that in this respect, AIX is better than Linux or Windows. But before AIX advocates roar in triumph, it be said that due to the explosion in performance these differences become less and less important, as does the use of multiple sockets.

We are still not at an end in discussing this table. Please note that the top 5 Intel rankings have been achieved by five different server vendors, all with the same CPU (Xeon E5-2690), and all with two-socket servers. Now, while the differences in the performance achieved are within a sound and almost expectable 10% range, prices in our EUR/SAPS ranking quite aren’t. You can either pay around 30 Cents per SAPS with HP or Cisco, or almost EUR 1,50 with IBM, or anything in between with Oracle, or Fujitsu. Or you can acquire a server with the very same processor type, a two-socket setup (as all the others) and an acceptable 0,32 EUR/SAPS with Dell if you’re willing to live with over 5,000 SAPS less of performance in every server. We do not want to speculate on the reasons why Dell frequently seems to extract a bit less of performance out of the same processor types than most of their competitors, it is just striking to see that the same thing has happened with the Xeon E7-4870 in this benchmark family. But why is IBM so far off the mark with the pricing of their high-performance Intel-offering? – Again, we don’t have any evidence but we think that a bit of speculation is OK in this case. As early as in our 2008 U2L whitepaper (the first of the series), we assumed “political pricing” with IBM in at least some cases and for some products in order not to let the differences between IBM’s x64 and Power offerings become too large, too obvious, thus assuring customers loyal to IBM to also to remain loyal to the Power architecture. Basically we think this is still the case: Instead of cannibalizing themselves, IBM probably has set up internal pricing policies and sales directives giving Power an advantage but still rendering it possible to keep a customer if they prefer to go the other way architecture-wise but with loyalty to IBM. Thus, IBM will lose Power customers only if they opt for x64 and scrutinize competition in this market, and are willing to live with a rather slow Return on Invest (RoI), as the artificially small cost difference between Power and x64 sharpens the one-time effect of transition costs on that very measure. Together with keeping the Power technically competitive with regular updates and developments proven by well-accepted benchmarks, this policy can also be seen as a highly dedicated commitment to the Power architecture. This is reflected in our REALTECH experience, that analysis projects comparing existing Power infrastructures with new options are the ones with the lowest probability of change at about a 60/40 chance, while similar activities with Itanium SAP infrastructures always come to the same result: Go somewhere else, do so quickly.
<table>
<thead>
<tr>
<th>Benchmark ID</th>
<th>Vendor</th>
<th>Server Model</th>
<th>Processor Name</th>
<th>Benchmark Throughput [SAPS]</th>
<th>Number of Sockets</th>
<th>SAPS per Socket</th>
<th>Number of Cores</th>
<th>Performance per Core [SAPS]</th>
<th>Number of Threads per Socket</th>
<th>Performance per Thread [SAPS]</th>
<th>US-$ / SAPS p.a.</th>
<th>EURO / SAPS p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011049</td>
<td>IBM</td>
<td>Power System 750</td>
<td>POWER7</td>
<td>94.730</td>
<td>4</td>
<td>23.683</td>
<td>6</td>
<td>3.947</td>
<td>24</td>
<td>987</td>
<td>1,23</td>
<td>1,01</td>
</tr>
<tr>
<td>2011054</td>
<td>IBM</td>
<td>BladeCenter P5702</td>
<td>POWER7</td>
<td>41.700</td>
<td>2</td>
<td>20.850</td>
<td>6</td>
<td>3.475</td>
<td>24</td>
<td>869</td>
<td>0,59</td>
<td>0,48</td>
</tr>
<tr>
<td>2011049</td>
<td>IBM</td>
<td>Power System 730</td>
<td>POWER7</td>
<td>38.220</td>
<td>2</td>
<td>19.110</td>
<td>6</td>
<td>3.185</td>
<td>24</td>
<td>796</td>
<td>0,76</td>
<td>0,63</td>
</tr>
<tr>
<td>2011054</td>
<td>Oracle</td>
<td>Sun Fire X4270 M3</td>
<td>Intel Xeon E5-2690</td>
<td>45.570</td>
<td>2</td>
<td>22.785</td>
<td>8</td>
<td>2.848</td>
<td>16</td>
<td>1.424</td>
<td>0,67</td>
<td>0,55</td>
</tr>
<tr>
<td>2011054</td>
<td>IBM</td>
<td>Flex System x240</td>
<td>Intel Xeon E5-2690</td>
<td>43.520</td>
<td>2</td>
<td>21.760</td>
<td>8</td>
<td>2.720</td>
<td>16</td>
<td>1.640</td>
<td>1,81</td>
<td>1,49</td>
</tr>
<tr>
<td>2011052</td>
<td>HP</td>
<td>ProLiant DL380p G8</td>
<td>Intel Xeon E5-2690</td>
<td>42.920</td>
<td>2</td>
<td>21.460</td>
<td>8</td>
<td>2.683</td>
<td>16</td>
<td>1.341</td>
<td>0,36</td>
<td>0,29</td>
</tr>
<tr>
<td>2011052</td>
<td>Cisco</td>
<td>UCS B200 M3</td>
<td>Intel Xeon E5-2690</td>
<td>41.700</td>
<td>2</td>
<td>20.850</td>
<td>8</td>
<td>2.606</td>
<td>16</td>
<td>1.303</td>
<td>0,37</td>
<td>0,30</td>
</tr>
<tr>
<td>2011052</td>
<td>Fujitsu</td>
<td>PRIMERGY RX100 S7</td>
<td>Intel Xeon E5-2690</td>
<td>41.320</td>
<td>2</td>
<td>20.660</td>
<td>8</td>
<td>2.583</td>
<td>16</td>
<td>1.291</td>
<td>0,55</td>
<td>0,45</td>
</tr>
<tr>
<td>2011054</td>
<td>HP</td>
<td>ProLiant BL460c Gen8</td>
<td>Intel Xeon E5-2680</td>
<td>40.180</td>
<td>2</td>
<td>20.900</td>
<td>8</td>
<td>2.511</td>
<td>16</td>
<td>1.256</td>
<td>0,40</td>
<td>0,33</td>
</tr>
<tr>
<td>2011054</td>
<td>Dell</td>
<td>PowerEdge R720</td>
<td>Intel Xeon E5-2690</td>
<td>35.970</td>
<td>2</td>
<td>17.985</td>
<td>8</td>
<td>2.248</td>
<td>16</td>
<td>1.124</td>
<td>0,39</td>
<td>0,32</td>
</tr>
<tr>
<td>2011054</td>
<td>IBM</td>
<td>System x3690 X5</td>
<td>Intel Xeon E7-8870</td>
<td>37.370</td>
<td>2</td>
<td>18.685</td>
<td>10</td>
<td>1.869</td>
<td>20</td>
<td>934</td>
<td>0,73</td>
<td>0,60</td>
</tr>
<tr>
<td>2011054</td>
<td>HP</td>
<td>ProLiant BL680c G7</td>
<td>Intel Xeon E7-4870</td>
<td>73.970</td>
<td>4</td>
<td>18.493</td>
<td>10</td>
<td>1.849</td>
<td>20</td>
<td>925</td>
<td>0,53</td>
<td>0,43</td>
</tr>
<tr>
<td>2011052</td>
<td>Cisco</td>
<td>UCS C460 M2</td>
<td>Intel Xeon E7-4870</td>
<td>36.900</td>
<td>2</td>
<td>18.450</td>
<td>10</td>
<td>1.845</td>
<td>20</td>
<td>923</td>
<td>0,81</td>
<td>0,67</td>
</tr>
<tr>
<td>2011052</td>
<td>Fujitsu</td>
<td>PRIMERGY RX6600 S6</td>
<td>Intel Xeon E7-4870</td>
<td>72.650</td>
<td>4</td>
<td>18.163</td>
<td>10</td>
<td>1.816</td>
<td>20</td>
<td>908</td>
<td>0,63</td>
<td>0,51</td>
</tr>
<tr>
<td>2011052</td>
<td>Cisco</td>
<td>UCS C460 M2</td>
<td>Intel Xeon E7-4870</td>
<td>72.250</td>
<td>4</td>
<td>18.063</td>
<td>10</td>
<td>1.806</td>
<td>20</td>
<td>903</td>
<td>0,53</td>
<td>0,43</td>
</tr>
<tr>
<td>2011054</td>
<td>IBM</td>
<td>System x3850 X5</td>
<td>Intel Xeon E7-8870</td>
<td>140.720</td>
<td>8</td>
<td>17.590</td>
<td>10</td>
<td>1.759</td>
<td>20</td>
<td>880</td>
<td>1,04</td>
<td>0,86</td>
</tr>
<tr>
<td>2011054</td>
<td>HP</td>
<td>ProLiant DL580 G7</td>
<td>Intel Xeon E7-4870</td>
<td>66.680</td>
<td>4</td>
<td>16.670</td>
<td>10</td>
<td>1.667</td>
<td>20</td>
<td>834</td>
<td>1,00</td>
<td>0,82</td>
</tr>
<tr>
<td>2011054</td>
<td>Fujitsu</td>
<td>PRIMERGY RX800E2</td>
<td>Intel Xeon E7-8870</td>
<td>131.170</td>
<td>8</td>
<td>16.396</td>
<td>10</td>
<td>1.640</td>
<td>20</td>
<td>820</td>
<td>3,93</td>
<td>3,22</td>
</tr>
<tr>
<td>2011054</td>
<td>HP</td>
<td>ProLiant DL980 G7</td>
<td>Intel Xeon E7-8870</td>
<td>124.430</td>
<td>8</td>
<td>15.854</td>
<td>10</td>
<td>1.555</td>
<td>20</td>
<td>778</td>
<td>0,87</td>
<td>0,71</td>
</tr>
<tr>
<td>2011054</td>
<td>Dell</td>
<td>PowerEdge R910</td>
<td>Intel Xeon E7-4870</td>
<td>61.600</td>
<td>4</td>
<td>15.400</td>
<td>10</td>
<td>1.540</td>
<td>20</td>
<td>770</td>
<td>0,61</td>
<td>0,50</td>
</tr>
<tr>
<td>2009052</td>
<td>HP</td>
<td>Integrity BL860C</td>
<td>Intel Itanium 9140M</td>
<td>5.850</td>
<td>2</td>
<td>2.925</td>
<td>2</td>
<td>1.463</td>
<td>4</td>
<td>731</td>
<td>2,48</td>
<td>2,03</td>
</tr>
<tr>
<td>2011053</td>
<td>Cisco</td>
<td>UCS B230 M2</td>
<td>Intel Xeon E7-8570</td>
<td>28.080</td>
<td>2</td>
<td>14.040</td>
<td>10</td>
<td>1.404</td>
<td>20</td>
<td>702</td>
<td>0,59</td>
<td>0,48</td>
</tr>
<tr>
<td>2011054</td>
<td>IBM</td>
<td>System x3755 M3</td>
<td>AMD Opteron 6282SE</td>
<td>64.130</td>
<td>4</td>
<td>16.033</td>
<td>16</td>
<td>1.002</td>
<td>16</td>
<td>1.002</td>
<td>0,34</td>
<td>0,28</td>
</tr>
<tr>
<td>2011054</td>
<td>HP</td>
<td>ProLiant DL585 G7</td>
<td>AMD Opteron 6282SE</td>
<td>62.570</td>
<td>4</td>
<td>15.643</td>
<td>16</td>
<td>978</td>
<td>16</td>
<td>978</td>
<td>0,34</td>
<td>0,28</td>
</tr>
<tr>
<td>2011054</td>
<td>HP</td>
<td>ProLiant DL585 G7</td>
<td>AMD Opteron 6282SE</td>
<td>30.920</td>
<td>2</td>
<td>15.460</td>
<td>16</td>
<td>966</td>
<td>16</td>
<td>966</td>
<td>0,29</td>
<td>0,23</td>
</tr>
<tr>
<td>2011054</td>
<td>HP</td>
<td>ProLiant BL465c G7</td>
<td>AMD Opteron 6276</td>
<td>27.980</td>
<td>2</td>
<td>13.990</td>
<td>16</td>
<td>874</td>
<td>16</td>
<td>874</td>
<td>0,30</td>
<td>0,25</td>
</tr>
<tr>
<td>2011054</td>
<td>HP</td>
<td>ProLiant BL685c G7</td>
<td>AMD Opteron 6276</td>
<td>55.030</td>
<td>4</td>
<td>13.758</td>
<td>16</td>
<td>860</td>
<td>16</td>
<td>860</td>
<td>0,30</td>
<td>0,25</td>
</tr>
<tr>
<td>2009052</td>
<td>Oracle (Sun)</td>
<td>SPARC Enterprise TS440</td>
<td>UltraSPARC T2 Plus</td>
<td>25830</td>
<td>4</td>
<td>6.458</td>
<td>8</td>
<td>807</td>
<td>64</td>
<td>101</td>
<td>7,72</td>
<td>6,33</td>
</tr>
<tr>
<td>2009052</td>
<td>Oracle (Sun)</td>
<td>SPARC Enterprise M9000</td>
<td>SPARC64 VII</td>
<td>95480</td>
<td>32</td>
<td>2.984</td>
<td>4</td>
<td>746</td>
<td>8</td>
<td>373</td>
<td>31,01</td>
<td>25,42</td>
</tr>
<tr>
<td>2009052</td>
<td>Oracle (Sun)</td>
<td>SPARC Enterprise M9000</td>
<td>SPARC64 VII</td>
<td>175.600</td>
<td>64</td>
<td>2.744</td>
<td>4</td>
<td>686</td>
<td>8</td>
<td>343</td>
<td>37,71</td>
<td>30,91</td>
</tr>
</tbody>
</table>

Table 3: Evaluated servers in order of performance per core, best to last.

Now, let’s dig one layer deeper and look at the performance achieved per core. This indicator of processor performance is especially significant for customers who have core-based licensing for their SAP databases, since the number of cores needed to achieve performance requirements amounts to whatever license costs come up. Usually, larger corporations have such contracts.
extending both to their SAP and Non-SAP database landscapes; giving them little to no room to maneuver themselves to a different database vendor.

As we can see in the table sorted by core performance, Power7 looks – and is – very good in this criterion. There is a reason why e.g. Oracle assumes a different calculation factor for Power cores than for x64 or SPARC – aside from the desire to steer customers into a preferred direction which CPU to choose. If a customer opts for Power anyway, this policy makes up at least a bit for the excellent performance per core.

If this KPI has any significance for you and you don’t want to go for the Power architecture, possibly because you have selected x64 as your processor architecture of choice already, then go for Intel CPUs. They dominate pretty much the rest of the ranking. Vice versa, if you have core-based licensing for your database, don’t go for AMD as the processor to run it on. Even the Itanium would likely beat the AMDs on this one, given the same benchmark basis. Is there anything to be said on SPARC here? – We don’t think so. Just look at the numbers, and make your own judgment.

Pretty much the same applies to SPARC on the next and last layer – performance per thread. While per core performance is important for the database, per thread performance is the indicator on how overall performance will be concerning the SAP application level. Since one batch job or dialogue process or JAVA thread will always run on exactly one processor thread with currently available technologies, it is decisive that you have as many threads as possible per socket to have maximum capacity for parallelization and that you simultaneously have as powerful single threads as possible to achieve maximum throughput for your SAP processes. Thus, the ideal CPU architecture for SAP applications is multi threads with maximum performance per thread.

This ranking is clearly dominated by the Intel Xeon E5-26xx series, followed by AMD’s SE Opterons, the IBM Power7 CPU and other Intel series. Since AMD assigns one thread to one core, they do a lot better here than in the per core sorting. If you will, AMD processors are better suited to run SAP applications than to run SAP databases. This could be utilized for designing a layered, performance and cost-optimized SAP environment by utilizing Power or Intel for the database layer, and AMD for the SAP application layer. However, such a design has to be considered carefully in order not to gain an advantage on one side and lose it on the other.
<table>
<thead>
<tr>
<th>Benchmark ID</th>
<th>Vendor</th>
<th>Server Model</th>
<th>Processor Name</th>
<th>Benchmark Throughput [SAPS]</th>
<th>Number of Sockets</th>
<th>SAPS per Socket</th>
<th>Number of Cores</th>
<th>Performance per Core [SAPS]</th>
<th>Number of Threads per Socket</th>
<th>Performance per Thread [SAPS]</th>
<th>US-$ / SAPS p.a.</th>
<th>EURO/ SAPS p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011016</td>
<td>Oracle</td>
<td>Sun Fire x4270 M3</td>
<td>Intel Xeon E5-2690</td>
<td>45,570</td>
<td>2</td>
<td>22,785</td>
<td>8</td>
<td>2.848</td>
<td>16</td>
<td>1.424</td>
<td>0.67</td>
<td>0.55</td>
</tr>
<tr>
<td>2011016</td>
<td>IBM</td>
<td>Flex System x240</td>
<td>Intel Xeon E5-2690</td>
<td>43,520</td>
<td>2</td>
<td>21,760</td>
<td>8</td>
<td>2.720</td>
<td>16</td>
<td>1.360</td>
<td>1.81</td>
<td>1.49</td>
</tr>
<tr>
<td>2011022</td>
<td>HP</td>
<td>ProLiant DL380p G8</td>
<td>Intel Xeon E5-2690</td>
<td>42,920</td>
<td>2</td>
<td>21,460</td>
<td>8</td>
<td>2.683</td>
<td>16</td>
<td>1.341</td>
<td>0.36</td>
<td>0.29</td>
</tr>
<tr>
<td>2011088</td>
<td>Fujitsu</td>
<td>UCS B200 M3</td>
<td>Intel Xeon E5-2690</td>
<td>41,700</td>
<td>2</td>
<td>20,850</td>
<td>8</td>
<td>2.606</td>
<td>16</td>
<td>1.303</td>
<td>0.37</td>
<td>0.30</td>
</tr>
<tr>
<td>2012069</td>
<td>HP</td>
<td>ProLiant BL460c Gen8</td>
<td>Intel Xeon E5-2680</td>
<td>40,180</td>
<td>2</td>
<td>20,090</td>
<td>8</td>
<td>2.511</td>
<td>16</td>
<td>1.256</td>
<td>0.40</td>
<td>0.33</td>
</tr>
<tr>
<td>2011077</td>
<td>Dell</td>
<td>PowerEdge R720</td>
<td>Intel Xeon E5-2690</td>
<td>35,970</td>
<td>2</td>
<td>17,985</td>
<td>8</td>
<td>2.248</td>
<td>16</td>
<td>1.124</td>
<td>0.39</td>
<td>0.32</td>
</tr>
<tr>
<td>2011051</td>
<td>IBM</td>
<td>System x3755 M3</td>
<td>AMD Opteron 62825E</td>
<td>64,130</td>
<td>4</td>
<td>16,033</td>
<td>16</td>
<td>1.002</td>
<td>16</td>
<td>1.002</td>
<td>0.34</td>
<td>0.28</td>
</tr>
<tr>
<td>2011043</td>
<td>IBM</td>
<td>Power System 750</td>
<td>AMD Opteron 62825E</td>
<td>94,730</td>
<td>4</td>
<td>23,683</td>
<td>6</td>
<td>3.947</td>
<td>24</td>
<td>987</td>
<td>1,23</td>
<td>1,01</td>
</tr>
<tr>
<td>2011046</td>
<td>HP</td>
<td>ProLiant DL385 G7</td>
<td>AMD Opteron 62825E</td>
<td>62,570</td>
<td>4</td>
<td>15,643</td>
<td>16</td>
<td>978</td>
<td>16</td>
<td>978</td>
<td>0.34</td>
<td>0.28</td>
</tr>
<tr>
<td>2011005</td>
<td>HP</td>
<td>ProLiant DL385 G7</td>
<td>AMD Opteron 62825E</td>
<td>30,920</td>
<td>2</td>
<td>15,460</td>
<td>16</td>
<td>966</td>
<td>16</td>
<td>966</td>
<td>0.29</td>
<td>0.23</td>
</tr>
<tr>
<td>2011012</td>
<td>IBM</td>
<td>System x3690 X5</td>
<td>Intel Xeon E7-2870</td>
<td>37,370</td>
<td>2</td>
<td>18,685</td>
<td>10</td>
<td>1.869</td>
<td>20</td>
<td>934</td>
<td>0.73</td>
<td>0.60</td>
</tr>
<tr>
<td>2011016</td>
<td>HP</td>
<td>ProLiant BL680c G7</td>
<td>Intel Xeon E7-4870</td>
<td>73,970</td>
<td>4</td>
<td>18,493</td>
<td>10</td>
<td>1.849</td>
<td>20</td>
<td>925</td>
<td>0.53</td>
<td>0.43</td>
</tr>
<tr>
<td>2011063</td>
<td>Fujitsu</td>
<td>UCS C260 M2</td>
<td>Intel Xeon E7-2870</td>
<td>36,900</td>
<td>2</td>
<td>18,450</td>
<td>10</td>
<td>1.845</td>
<td>20</td>
<td>923</td>
<td>0.81</td>
<td>0.67</td>
</tr>
<tr>
<td>2011026</td>
<td>Fujitsu</td>
<td>PRIMERGY RX600 S6</td>
<td>Intel Xeon E7-4870</td>
<td>72,650</td>
<td>4</td>
<td>18,163</td>
<td>10</td>
<td>1.816</td>
<td>20</td>
<td>908</td>
<td>0.63</td>
<td>0.51</td>
</tr>
<tr>
<td>2011050</td>
<td>Fujitsu</td>
<td>UCS C460 M2</td>
<td>Intel Xeon E7-4870</td>
<td>72,250</td>
<td>4</td>
<td>18,063</td>
<td>10</td>
<td>1.806</td>
<td>20</td>
<td>903</td>
<td>0.53</td>
<td>0.43</td>
</tr>
<tr>
<td>2011034</td>
<td>IBM</td>
<td>System x3850 X5</td>
<td>Intel Xeon E7-8870</td>
<td>140,720</td>
<td>8</td>
<td>17,590</td>
<td>10</td>
<td>1.759</td>
<td>20</td>
<td>880</td>
<td>1,04</td>
<td>0,86</td>
</tr>
<tr>
<td>2012004</td>
<td>HP</td>
<td>ProLiant BL465c G7</td>
<td>AMD Opteron 6276</td>
<td>27,980</td>
<td>2</td>
<td>13,990</td>
<td>16</td>
<td>874</td>
<td>16</td>
<td>874</td>
<td>0.30</td>
<td>0.25</td>
</tr>
<tr>
<td>2011024</td>
<td>IBM</td>
<td>BladeCenter P5702</td>
<td>POWER7</td>
<td>41,700</td>
<td>2</td>
<td>20,850</td>
<td>6</td>
<td>3.475</td>
<td>24</td>
<td>869</td>
<td>0.59</td>
<td>0.48</td>
</tr>
<tr>
<td>2011048</td>
<td>HP</td>
<td>ProLiant BL685c G7</td>
<td>AMD Opteron 6276</td>
<td>55,030</td>
<td>4</td>
<td>13,758</td>
<td>16</td>
<td>860</td>
<td>16</td>
<td>860</td>
<td>0.30</td>
<td>0.25</td>
</tr>
<tr>
<td>2011051</td>
<td>HP</td>
<td>ProLiant DL380 G7</td>
<td>Intel Xeon E7-4870</td>
<td>66,680</td>
<td>4</td>
<td>16,670</td>
<td>10</td>
<td>1.667</td>
<td>20</td>
<td>834</td>
<td>1.00</td>
<td>0.82</td>
</tr>
<tr>
<td>2011017</td>
<td>Fujitsu</td>
<td>PRIMEQUEST 1800E2</td>
<td>Intel Xeon E7-8870</td>
<td>131,170</td>
<td>8</td>
<td>16,390</td>
<td>10</td>
<td>1.640</td>
<td>20</td>
<td>820</td>
<td>3.93</td>
<td>3.22</td>
</tr>
<tr>
<td>2011042</td>
<td>IBM</td>
<td>Power System 730</td>
<td>POWER7</td>
<td>38,220</td>
<td>2</td>
<td>19,110</td>
<td>6</td>
<td>3.185</td>
<td>24</td>
<td>796</td>
<td>0.76</td>
<td>0.63</td>
</tr>
<tr>
<td>2011052</td>
<td>HP</td>
<td>ProLiant DL980 G7</td>
<td>Intel Xeon E7-4870</td>
<td>124,410</td>
<td>8</td>
<td>15,554</td>
<td>10</td>
<td>1.555</td>
<td>20</td>
<td>778</td>
<td>0.87</td>
<td>0.71</td>
</tr>
<tr>
<td>2011001</td>
<td>Dell</td>
<td>PowerEdge R910</td>
<td>Intel Xeon E7-4870</td>
<td>61,600</td>
<td>4</td>
<td>15,400</td>
<td>10</td>
<td>1.540</td>
<td>20</td>
<td>779</td>
<td>0.61</td>
<td>0.50</td>
</tr>
<tr>
<td>2008062</td>
<td>HP</td>
<td>Integrity BL860C</td>
<td>Intel Itanium 9100M</td>
<td>5,850</td>
<td>2</td>
<td>2,925</td>
<td>2</td>
<td>1.463</td>
<td>4</td>
<td>731</td>
<td>2.48</td>
<td>2.03</td>
</tr>
<tr>
<td>2008003</td>
<td>Fujitsu</td>
<td>UCS B230 M2</td>
<td>Intel Xeon E7-2870</td>
<td>28,080</td>
<td>2</td>
<td>14,040</td>
<td>10</td>
<td>1.404</td>
<td>20</td>
<td>702</td>
<td>0.59</td>
<td>0.48</td>
</tr>
<tr>
<td>2008008_2</td>
<td>Oracle</td>
<td>SPARC Enterprise M9000</td>
<td>SPARC64 VII</td>
<td>95,480</td>
<td>32</td>
<td>2,984</td>
<td>4</td>
<td>746</td>
<td>8</td>
<td>373</td>
<td>31,01</td>
<td>25,42</td>
</tr>
<tr>
<td>2008006_1</td>
<td>Oracle</td>
<td>SPARC Enterprise M9000</td>
<td>SPARC64 VII</td>
<td>175,600</td>
<td>64</td>
<td>2,744</td>
<td>4</td>
<td>686</td>
<td>8</td>
<td>343</td>
<td>37,71</td>
<td>30,91</td>
</tr>
<tr>
<td>2008026_1</td>
<td>Oracle</td>
<td>SPARC Enterprise TS440</td>
<td>UltraSPARC T2 Plus</td>
<td>258,300</td>
<td>4</td>
<td>6,458</td>
<td>8</td>
<td>807</td>
<td>64</td>
<td>101</td>
<td>7,72</td>
<td>6,33</td>
</tr>
</tbody>
</table>

Table 4: Evaluated servers in order of performance per thread, best to last.

The overall differences in per thread performance are quite significant and range around 30% of an Intel advantage towards their competition. And the evaluation confirms something REALTECH...
has encountered a few times\textsuperscript{11} over the last years: AIX customers switched their environments from Power6 to Power7 and, in the aftermath, were not satisfied with the subsequent SAP application performance. This was hard to explain and believe for us, since all performance indicators like benchmarks, server throughput, memory equipment told us to think into a different direction. Maybe, the explanation simply lies in the per thread performance, and if this is true, Intel x64 CPUs are the only choice if you want to run one processor design for database and application and you have to do so in a very-high-performance environment.

At this point we have exploited almost everything that can be said on the evaluation of this benchmark. As a last thing and pretty much retrospectively to the 2008 whitepaper, let's have a look at the absolute server performance available. Here at last, some will say, the table takes on a different color coding.

In the 2008 evaluation, the absolute server performance was clearly reigned by multi-socket UNIX servers, providing the top 5 of 14 evaluated. The paper discussed that “the rise of x64-based servers into the midrange section of server performance is the real problem for UNIX.” Now, this has changed a bit … or better, worsened for UNIX. x64 processors, namely from Intel, have been on the passing lane for some time, and with them, the server performance available has reached the top range and has left behind the UNIX architectures with the exception of Power. Yes, the ranking is led by a SPARC Enterprise M9000, but it takes 64 SPARC sockets to outrun 8 Intels, which is clearly reflected in the price/performance column: Higher numbers of sockets in a server come with a higher price, for any architecture. So if you lower the number of sockets in one server and if you return to standard (2- and 4-way) or near-standard (8-way) configurations, you will lower your costs significantly. IBM, the UNIX-stronghold who has decided to put up a fight, is not naïve about this. Their 4-way server with Power7 beats all the x64 4-way servers, but at a significantly higher EUR/SAPS ratio, and there might well be good reasons they decided not to prove that a Power7 8-way can beat all the Intel 8-way configurations.

The really enlightening message of this evaluation is that whether you will go for multiple, highly symmetric (and likely blade-based) 2-way server configurations in your data center, or if you want to consolidate and virtualize on high-performance 4- or 8-way servers, the performance is available with x64 for Linux or Windows. As a matter of fact, this provides the chance to reduce the procurement and provisioning process for your data center to one (1) server architecture and two (2) operating systems.

\textsuperscript{11} This did not happen really frequently, maybe three or four times, but in very large AIX environments.
<table>
<thead>
<tr>
<th>Benchmark ID</th>
<th>Vendor</th>
<th>Server Model</th>
<th>Processor Name</th>
<th>Benchmark Throughput (SAPS)</th>
<th>Number of Sockets</th>
<th>SAPS per Socket</th>
<th>Number of Cores per Socket</th>
<th>Performance per Core (SAPS)</th>
<th>Number of Threads per Socket</th>
<th>Performance per Thread (SAPS)</th>
<th>US$ / SAPS p.a.</th>
<th>EURO / SAPS p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>201106_1</td>
<td>Oracle</td>
<td>SPARC Enterprise M9000</td>
<td>SPARC64 VII</td>
<td>175.600</td>
<td>64</td>
<td>2.744</td>
<td>4</td>
<td>686</td>
<td>8</td>
<td>343</td>
<td>37.71</td>
<td>30.91</td>
</tr>
<tr>
<td>201106</td>
<td>IBM</td>
<td>System x3850 X5</td>
<td>Intel Xeon E7-8870</td>
<td>140.720</td>
<td>8</td>
<td>17.590</td>
<td>10</td>
<td>1.759</td>
<td>20</td>
<td>880</td>
<td>1.04</td>
<td>0.86</td>
</tr>
<tr>
<td>201107</td>
<td>Fujitsu</td>
<td>PRIMEQUEST 2800R2</td>
<td>Intel Xeon E7-8870</td>
<td>131.170</td>
<td>8</td>
<td>16.396</td>
<td>10</td>
<td>1.640</td>
<td>20</td>
<td>820</td>
<td>3.93</td>
<td>3.22</td>
</tr>
<tr>
<td>201106</td>
<td>HP</td>
<td>ProLiant DL380 G7</td>
<td>Intel Xeon E7-4870</td>
<td>124.430</td>
<td>8</td>
<td>15.554</td>
<td>10</td>
<td>1.555</td>
<td>20</td>
<td>778</td>
<td>0.87</td>
<td>0.71</td>
</tr>
<tr>
<td>201106_1</td>
<td>Oracle</td>
<td>SPARC Enterprise M9000</td>
<td>SPARC64 VII</td>
<td>95.480</td>
<td>32</td>
<td>2.984</td>
<td>4</td>
<td>746</td>
<td>8</td>
<td>373</td>
<td>31.01</td>
<td>25.42</td>
</tr>
<tr>
<td>201104</td>
<td>IBM</td>
<td>Power System 750</td>
<td>POWER7</td>
<td>94.730</td>
<td>4</td>
<td>23.683</td>
<td>6</td>
<td>3.947</td>
<td>24</td>
<td>987</td>
<td>1.23</td>
<td>1.01</td>
</tr>
<tr>
<td>201106</td>
<td>HP</td>
<td>ProLiant BL660c G7</td>
<td>Intel Xeon E7-4870</td>
<td>73.970</td>
<td>4</td>
<td>18.493</td>
<td>10</td>
<td>1.849</td>
<td>20</td>
<td>925</td>
<td>0.53</td>
<td>0.43</td>
</tr>
<tr>
<td>201106</td>
<td>Fujitsu</td>
<td>PRIMEGERY RX600 S6</td>
<td>Intel Xeon E7-4870</td>
<td>72.650</td>
<td>4</td>
<td>18.163</td>
<td>10</td>
<td>1.816</td>
<td>20</td>
<td>908</td>
<td>0.63</td>
<td>0.51</td>
</tr>
<tr>
<td>201106</td>
<td>Cisco</td>
<td>UCS C460 M2</td>
<td>Intel Xeon E7-4870</td>
<td>72.250</td>
<td>4</td>
<td>18.063</td>
<td>10</td>
<td>1.806</td>
<td>20</td>
<td>903</td>
<td>0.53</td>
<td>0.43</td>
</tr>
<tr>
<td>201101</td>
<td>HP</td>
<td>ProLiant DL580 G7</td>
<td>Intel Xeon E7-4870</td>
<td>66.680</td>
<td>4</td>
<td>16.670</td>
<td>10</td>
<td>1.667</td>
<td>20</td>
<td>834</td>
<td>1.00</td>
<td>0.82</td>
</tr>
<tr>
<td>201105</td>
<td>IBM</td>
<td>System x3755 M3</td>
<td>AMD Opteron 6282SE</td>
<td>64.130</td>
<td>4</td>
<td>16.033</td>
<td>16</td>
<td>1.002</td>
<td>16</td>
<td>1.002</td>
<td>0.34</td>
<td>0.28</td>
</tr>
<tr>
<td>201106</td>
<td>HP</td>
<td>ProLiant DL585 G7</td>
<td>AMD Opteron 6282SE</td>
<td>62.570</td>
<td>4</td>
<td>15.643</td>
<td>16</td>
<td>978</td>
<td>16</td>
<td>978</td>
<td>0.34</td>
<td>0.28</td>
</tr>
<tr>
<td>201106</td>
<td>Dell</td>
<td>PowerEdge R9510</td>
<td>Intel Xeon E7-4870</td>
<td>61.600</td>
<td>4</td>
<td>15.400</td>
<td>10</td>
<td>1.540</td>
<td>20</td>
<td>770</td>
<td>0.61</td>
<td>0.50</td>
</tr>
<tr>
<td>201108</td>
<td>HP</td>
<td>ProLiant BL665c G7</td>
<td>AMD Opteron 6276</td>
<td>55.030</td>
<td>4</td>
<td>13.758</td>
<td>16</td>
<td>860</td>
<td>16</td>
<td>860</td>
<td>0.30</td>
<td>0.25</td>
</tr>
<tr>
<td>201114</td>
<td>Oracle</td>
<td>SunFire X4270 M3</td>
<td>Intel Xeon E5-2690</td>
<td>45.570</td>
<td>2</td>
<td>22.785</td>
<td>8</td>
<td>2.848</td>
<td>16</td>
<td>1.424</td>
<td>0.67</td>
<td>0.55</td>
</tr>
<tr>
<td>201106</td>
<td>IBM</td>
<td>Flex System x240</td>
<td>Intel Xeon E5-2690</td>
<td>43.520</td>
<td>2</td>
<td>21.760</td>
<td>8</td>
<td>2.720</td>
<td>16</td>
<td>1.360</td>
<td>1.81</td>
<td>1.49</td>
</tr>
<tr>
<td>201112</td>
<td>HP</td>
<td>ProLiant DL380 G8</td>
<td>Intel Xeon E5-2670</td>
<td>42.920</td>
<td>2</td>
<td>21.460</td>
<td>8</td>
<td>2.683</td>
<td>16</td>
<td>1.341</td>
<td>0.36</td>
<td>0.29</td>
</tr>
<tr>
<td>201106</td>
<td>Cisco</td>
<td>UCS B200 M3</td>
<td>Intel Xeon E5-2690</td>
<td>41.700</td>
<td>2</td>
<td>20.850</td>
<td>8</td>
<td>2.606</td>
<td>16</td>
<td>1.303</td>
<td>0.37</td>
<td>0.30</td>
</tr>
<tr>
<td>201104</td>
<td>IBM</td>
<td>BladeCenter PS702</td>
<td>POWER7</td>
<td>41.700</td>
<td>2</td>
<td>20.850</td>
<td>6</td>
<td>3.475</td>
<td>24</td>
<td>869</td>
<td>0.59</td>
<td>0.48</td>
</tr>
<tr>
<td>201108</td>
<td>Fujitsu</td>
<td>PRIMEGERY RX300 S7</td>
<td>Intel Xeon E5-2690</td>
<td>41.320</td>
<td>2</td>
<td>20.660</td>
<td>8</td>
<td>2.583</td>
<td>16</td>
<td>1.291</td>
<td>0.55</td>
<td>0.45</td>
</tr>
<tr>
<td>201109</td>
<td>HP</td>
<td>ProLiant BL460c G8</td>
<td>Intel Xeon E5-2680</td>
<td>40.180</td>
<td>2</td>
<td>20.090</td>
<td>8</td>
<td>2.511</td>
<td>16</td>
<td>1.256</td>
<td>0.40</td>
<td>0.33</td>
</tr>
<tr>
<td>201104</td>
<td>IBM</td>
<td>Power System 730</td>
<td>POWER7</td>
<td>38.220</td>
<td>2</td>
<td>19.110</td>
<td>6</td>
<td>3.185</td>
<td>24</td>
<td>796</td>
<td>0.76</td>
<td>0.63</td>
</tr>
<tr>
<td>201102</td>
<td>IBM</td>
<td>System x6890 X5</td>
<td>Intel Xeon E7-2870</td>
<td>37.370</td>
<td>2</td>
<td>18.685</td>
<td>10</td>
<td>1.869</td>
<td>20</td>
<td>934</td>
<td>0.73</td>
<td>0.60</td>
</tr>
<tr>
<td>201103</td>
<td>Cisco</td>
<td>UCS C260 M2</td>
<td>Intel Xeon E7-2870</td>
<td>36.900</td>
<td>2</td>
<td>18.450</td>
<td>10</td>
<td>1.845</td>
<td>20</td>
<td>923</td>
<td>0.81</td>
<td>0.67</td>
</tr>
<tr>
<td>201107</td>
<td>Dell</td>
<td>PowerEdge R720</td>
<td>Intel Xeon E5-2690</td>
<td>35.970</td>
<td>2</td>
<td>17.985</td>
<td>8</td>
<td>2.248</td>
<td>16</td>
<td>1.124</td>
<td>0.39</td>
<td>0.32</td>
</tr>
<tr>
<td>201105</td>
<td>HP</td>
<td>ProLiant DL385 G7</td>
<td>AMD Opteron 6282SE</td>
<td>30.920</td>
<td>2</td>
<td>15.460</td>
<td>16</td>
<td>966</td>
<td>16</td>
<td>966</td>
<td>0.29</td>
<td>0.23</td>
</tr>
<tr>
<td>201103</td>
<td>Cisco</td>
<td>UCS B230 M2</td>
<td>Intel Xeon E7-2870</td>
<td>28.080</td>
<td>2</td>
<td>14.040</td>
<td>10</td>
<td>1.404</td>
<td>20</td>
<td>702</td>
<td>0.59</td>
<td>0.48</td>
</tr>
<tr>
<td>201104</td>
<td>HP</td>
<td>ProLiant BL465c G7</td>
<td>AMD Opteron 6276</td>
<td>27.980</td>
<td>2</td>
<td>13.990</td>
<td>16</td>
<td>874</td>
<td>16</td>
<td>874</td>
<td>0.30</td>
<td>0.25</td>
</tr>
<tr>
<td>201106_1</td>
<td>Oracle</td>
<td>SPARC Enterprise T5440</td>
<td>UltraSPARC T2 Plus</td>
<td>25.830</td>
<td>4</td>
<td>6.458</td>
<td>8</td>
<td>807</td>
<td>64</td>
<td>101</td>
<td>7.72</td>
<td>6.33</td>
</tr>
<tr>
<td>201106</td>
<td>HP</td>
<td>Integrity BL860C</td>
<td>Intel Itanium 9140M</td>
<td>5.850</td>
<td>2</td>
<td>2.925</td>
<td>2</td>
<td>1.463</td>
<td>4</td>
<td>731</td>
<td>2.48</td>
<td>2.03</td>
</tr>
</tbody>
</table>

Table 5: Evaluated servers in order of absolute server performance, best to last.

All in all, it has to be mentioned that the only processor architecture that ranges in the best top 10 of every aspect of this evaluation, i.e. price/performance ratio, performance per socket, per core, per thread, and absolute server performance available, comes from Intel.
Virtualization Reviewed

The chapter on virtualization will become very short, for some probably disappointingly so. But there is a very simple reason for this: From being a niche solution, designed to accomplish just a very few and very special landscape scenarios like training or low-performance, and being regarded as such in the 2008 whitepaper, virtualization in connection with x64 architectures has become a commodity in both the Linux and the Windows world, something almost everybody utilizes and with only a very few if any restrictions left over. There are several technically mature virtualization solutions for Linux in SAP environments, namely VMware and KVM, and several benchmarks by various hardware vendors have proven performance limits to be of a rather theoretical than of any relevant practical nature, and that performance losses due to virtualization lie in a very acceptable 10% or less range. The only restriction we want to make is that we believe that XEN-based technologies may get into trouble in the long run and possibly will not survive. But even here we have to admit that we have done consulting for very large customers in very large environments that are running on exactly this technology, and these customers have shown no intention to switch.

REALTECH has implemented and automated production landscapes fully virtualized for SUSE and for Red Hat Linux, using Oracle or DB2, running on VMware, KVM, or XEN on hardware from virtually any vendor in the field, and providing SAP application services for several thousand concurrent users feeding multi-terabyte databases. The probably only challenge on this topic is to find the best (i.e. being cost-optimized, delivering high performance, causing low administrative effort and fitting the know-how profile of your IT staff) combination of solutions as named above. Apart from that, we have to steal a slogan from a sports company: Just do it!
Green IT Reviewed

The topic that generated the greatest interest and, doubtlessly, the most vivid and controversial discussions, was our look at Green IT aspects. We got feedback from several engineers from several hardware vendors that electrical power input and thermal output should, due to the physical rule of energy conservation, yield the same ranking – which wasn't the case. I, the author of this whitepaper, hold a diploma in physics, so it was hard to argue these valid objections and still being able to take myself seriously. Funny enough, upon our email discussion of the possible origins of the deviation, one of the engineers had to discover that according to the data sheets his own company (exactly – the hardware division he worked for) had published, there was also a difference between electrical input and thermal output, and that roughly 10% of the energy just … vanished.

In the end, I think we found a good explanation for the differences: Electrical input is in most cases, but not in any standardized way, given as a peak value in server data sheets and is meant as an indication to correctly dimension electrical equipment in data centers. But these peak values must not be used to calculate average power consumption or output. This is what the thermal output values are meant for. They are usually given in an average per hour. Thus, this is what we used in this whitepaper, exclusively.

We also decided to take a different approach in our Green IT evaluation discussion. As we have established previously, the trend to Linux in SAP data centers is very much an architectural movement in favor of the x64 processor architecture. Therefore, our Green IT discussion focusses more on the energy consumption qualities of the CPUs rather than on the servers. And as single values are always prone to attack, we want to give tendencies for processor families. It will be all you need to decide which architecture will give you the lowest carbon dioxide footprint. And that’s a promise!

Let’s first look at the waste heat output the processors generate in the respective servers. The further right and the lower relative to the vertical axis, the better is the position of a CPU in this graphics. The first thing we noticed was that CPU families with recent (benchmark-proven) developments obviously have multiplied capacity while about keeping the energy consumption at

---

12 In this chapter, we use CPU and socket and processor in an identical manner and with identical meaning.
Energy Chart 1: Waste heat per socket in relation to capacity per socket. Please notice the much higher capacity of x64 and Power at comparable levels of consumption.

a constant level compared to older processors. As shown before, the Power family averages the highest capacity per socket, and at the same time has very reasonable environmental qualities. But in terms of capacity you can almost match the best Power CPUs with the best Intels while doing even better on energy. And as indicated in a previous discussion, AMD does especially well in overall energy consumption per socket, which is probably due to their handling slightly lower frequencies than Power or Xeon.

Concerning Green IT aspects, there is no difference towards the economic aspects in the sense that if there is no progress, there will be no progress. That is if you don't develop new processors and don't prove them in benchmarks you will look bad in comparison. Standing still means falling back, and this is exactly what has happened to SPARC and Itanium. And again, the Itanium even looks better than it is due to the benchmark basis different to all the others.
Energy Chart 2: Waste heat efficiency in SAPS per Watt per socket, related to benchmark date. Please notice the increase in efficiency with newer architectures.

Which brings us to the next chart: As shown here, better results on environmental behavior usually come with newer developments. This is not a strict law, mostly due to the fact the energy consumption values also have to do with the server type and its designated use, and the mix of servers in the 2-tier SD benchmark is various, and not all of them really compare. But the overall tendency is obvious. Between early 2011 and mid of 2012, Intel, for example, has managed to at least double average waste heat efficiency.

So, what is the promising technology to save energy? – Well, obviously newer generations of CPUs have lower dimensions, which provide for better qualities on energy. But that is common knowledge. The other thing that has a clearly positive impact on energy consumption is a higher number of cores per socket. It seems that the resulting synergy effects within a socket contribute to a desirable energetic behavior. The graphic on the next page shows that the waste heat per
core clearly decreases almost linearly with the number of cores while the capacity per core remains at least constant or increases with multi-core CPUs. As a result, you get more SAPS performance while wasting less energy, exactly the desired result. Again, CPUs that couldn’t provide anything new look bad in comparison.

Energy Chart 3: Capacity per core related to waste heat emission per core. Multi core architectures show slightly better energy efficiency.

There are further aspects that could be evaluated in this chapter, for example not all servers are created equal, and that even with the same CPU energy consumption qualities may vary significantly. We provide an example with the appendices, but do not want to spend more time on commenting this.
Large. Critical.

Probably the most frequent questions we get to hear in the context of SAP on Linux are:

- “How large may the systems be before they are too large for Linux?”
- “What size of project can REALTECH (or anyone in the migration market) do?”
- “What is the maximum system landscape that can be migrated?”

As in other fields of everyday life, the question of size is overrated. Anyway, concerning the SAP on Linux topic, a thorough discussion and some examples may be helpful to explain why we think so.

### Large Systems

As predicted in the earlier whitepapers, the performance of Linux server systems has reached or surpassed almost everything that can be delivered on UNIX side. But what’s more important, the performance deliverable is beyond anything anyone would ever want in computing power for a single system, at least as far as we’re talking about today’s generation of SAP software and databases. In the benchmark generation reviewed in this whitepaper, three Intel-based servers provide more than 120,000 SAPS (IBM System x3850 X5, Fujitsu PRIMEQUEST 1800E2, HP ProLiant DL980 G7) with only eight sockets, outdone only by a 64-socket SPARC server (175,600 SAPS). However, servers with this kind of performance simply will not be the bottleneck to any kind of application you want to run. Why? – Because the bottlenecks will come from somewhere else, and they are not connected to Linux (or any other OS). There are two main suspects REALTECH has identified in this respect: I/O throughput and the SAP application software itself.

The first one is easy: Obviously, if your database or your storage systems are not capable of streaming and writing the information passed by the application servers in whatever bandwidth, at some point all caches will be filled and restrict further input to and until the commit of the written information. REALTECH knows about an experiment done by an x64 hardware vendor in one of their labs: With a new-generation four-socket Intel server, their favorite SAP high-end database and their best high-end storage, designed and optimized to accept far more than 100,000 IOPS in continuous write, they managed to completely jam the storage system with that one four-socket server just by assigning a series of parallelized batch jobs with heavy write load. The original intent of the experiment, to find the I/O limits of the specific x64 server generation, failed. However, the results were nonetheless promising and encouraging, since they also proved that in...
designing high end SAP systems, server I/O is not necessarily the area where to look for restrictions (at least if the mainboard has four sockets and corresponding I/O busses).

This gets us to the second one: In 2011, REALTECH had an architectural role in a proof of concept in the financial industry comparing several systems that had to meet the following specs: Run a chained series of batch jobs in the SAP bank analyzer with a maximum application throughput of 20 million transactions in a less than 8 hour timeframe, leading to a 20 - 25 TB database once fully operational. Calculated I/O performance required would be 120.000 IOPS sustained bandwidth in an 80/20 write/read distribution, application performance required would be 200.000 SAPS in a heavy-load 60/40 database/application distribution. These were the minimum requirement capabilities which were to be proven in a benchmark proof of concept. Two out of the four hardware vendors invited for the benchmark PoC offered solutions based on x64/Linux, one with x64 and another operating system. All of the vendors chose their respectively preferred high-end storage solution.

None of them was able to fulfill the performance requirements specified and to finish the defined job chain in time. And none of them got stuck with the hardware, or the operating system, or the database. The real problem was that at a certain point of the job chain the SAP application software was not able to parallelize certain tasks but returned to a single threaded sequential process for some time and some steps. During this time all of the high-end servers and storage virtually idled with almost nothing to do, while other phases of batch processing indeed challenged the systems to the edge of their capabilities. However, the combination of processing steps mainly proved that SAP application software is not necessarily designed for mainframe style mass transaction processes, and that this may rather be the true bottleneck than any physical limit. On the other hand, everything SAP software is actually designed for works with satisfying performance on several operating systems, and Linux is just one of them and, in a positive sense, nothing special, or nothing special any more.

To satisfy our readers’ curiosity: There were differences in processing times of the heavy-load phases between the solutions evaluated as well as there were clear differences in the ease of configuration, handling, maintenance and operations, other important aspects for the customer. A SUSE Linux environment running Intel CPUs on Fujitsu FlexFrame hardware finally got the award. From a functional point of view, the long-term answer to meet all high-end specs in this project may be HANA, but this will require SAP to completely redesign a number of procedures in the bank analyzer job chain, omitting some time intense aggregational steps and collecting data directly from in-memory tables instead.
As for daily operations, our discussion intends to show there is no real limit\textsuperscript{13} what size of system or database can be run on Linux. We have seen 10, 15, 20 TB databases run on this platform. We have set up or migrated production systems up to 8 TB, larger systems are currently in work.

There is one limit that needs to be considered, though. It is the available downtime for the migration process itself, especially for the production system. We recently had an informational telephone conference with a customer running a business-critical 86 TB BW system, unfortunately on HP-UX/Oracle\textsuperscript{14}. Now, this system will be a challenge to migrate, and as a matter of fact, it won’t make much of a difference which target platform they will choose. So far, in migration projects we have achieved maximum migration throughputs of anything up to 300 GB/hour for single systems, depending on source and target OS and DB, available hardware, storage setup, migration procedure, and the number of optimization runs. Usually, the final limiting factor in downtime minimization is the maximum I/O capabilities of the storage. Utilizing more advanced (and more expensive) storage options, namely SSD, this could be boosted to maybe 800 GB/hour. But this has two important drawbacks: First of all, even more than doubling the current best values in classical migrations here would lead to more than 100 hours, i.e. over four full days of migration runtime, with no testing, no backup done yet – which all add up to the technical downtime to become a total downtime. The second drawback is obvious: Just for a minute, imagine the invoice you get from your storage vendor if you opt for 86 TB of SSD storage net, mirrored, and you may well want an identical setup for your quality assurance system in such a business-critical and very large environment …

There is a point in not letting systems get too large. Archiving still is important – don’t neglect this if your system environment allows for it, since beyond a certain size of a system, technical processes become unmanageable. We are not sure what this specific customer is going to do. Maybe the answer lies in an emerging technology like HANA with a reported average compression factor of 5:1, thus reducing this BW database to some 17 TB. Or maybe the customer has to opt for a specialized and individually tailored project such as an incremental migration where much of the data is transferred before the actual downtime. It can be done, but exclusive technologies tend to express themselves in the price tags attached.

\textsuperscript{13} But there are important rules to follow, as described in this and other chapters of this WP.
\textsuperscript{14} So there is a certain pressure to change something …
Large Customers & Large Migration Projects

After having established the point that there is no real size limit for running single SAP systems on Linux and x64, let's have a look at the size of the overall environments and customers going to this platform. Don't expect any surprises in this chapter, but some impressive figures and examples as well as crucial information what to look out for in setting up a large migration project.

In one of the earlier two whitepapers we stated that British Telecom had announced an Intel-only strategy. REALTECH is not directly involved in any way with this customer, but looking around we have met other market leaders in other industries going the same direction. As said in the statistics section of this document, the largest accounts heading for Linux are of European origin, but we have also been contacted from large American corporations with the same intentions. This whitepaper is not intended to deliver success stories or references in a marketing sense, but rather to give facts, figures and examples to establish the in fact credibility of SAP on Linux as one viable solution among others, which is why this section will focus on the industries we have worked with as well as structure and size of the SAP environments involved rather than the company names.

In the 2008 whitepaper, the financial sector apart from some rather small insurances was marked as the one lacking drive in the otherwise widening interest in Linux. Since then, this has changed fundamentally. The first really large company that tackled us with the intention to migrate their complete SAP system landscape to x64 (which was the first landmark decision) and finally, Linux (which was the second one) was one of the world’s largest insurance/reinsurance companies, a 50 billion EUR premium income corporation administrating assets worth 200 billion EUR in more than 70 countries. Their current main data center houses more than 1.000 applications on more than 1.650 Windows and Linux servers, SAP included but not alone, all totaled on 4 PB of data storage. To that date, companies playing in this league and contacting us about the Linux topic usually did so with the intention to migrate or newly set up certain system landscapes or SAP products but not to do the whole thing. The system landscape held and still holds 13 SAP production systems as well as a variety of development, quality assurance and project systems with a total SAP database volume of 100 TB net. The largest two production lines to be migrated had stakeholders in 14 functional departments. How do you organize such a migration? What is the key for success?

15 No UNIX servers any more as of 2011.
16 Yes, that is 4.000 Terabytes total data volume.
Migrating all of a large and historically grown SAP system landscape in a large organization is a technically and organizationally complex process. In such, there are a number of decisions and approaches to be made that will make the difference on weal and woe of a project.

The first level of important decisions is organizational. Where we have met (or were called into, usually late) migration projects that already had gone or were about to turn sour, one or more of the following was true:

- Lack of planning, or unrealistically tight project budget, or both
- Lack of time to accomplish all necessary tasks
- Total lack of or at least significant shortage in internal and external project management
- Missing capacity of important internal or external project staff members during the project, including too few certified migration specialists
- Missing acceptance of the new OS or DB with internal staff members, along with limited knowledge of the new environment
- Solutions do not fit management expectations and have not been evaluated thoroughly before the final “Go”
- Missing technology components are “worked around” instead of buying necessary licenses

Let us explain.

An SAP server infrastructure migration of the size described above takes time, money, and man power if you want it to succeed. As a matter of fact, this applies to any SAP server infrastructure migration, even to much smaller and certainly to larger ones.

And the most crucial factor of the three is probably time, namely and especially the time you grant yourself for planning and making decisions before project work itself even starts. Why? – Because time is the only resource you can’t restock once you are short of it. The customer in the above example first took a year of internal research and studies to get to the decision of running exclusively x64 processor architectures in the future. It took them another half a year to discuss and decide on Linux vs. Windows. And then they took themselves another four months to find the right migration partner and to define and negotiate a contract on a fixed price migration project. With the main project kick-off, we started a high-level planning for the migration.
of the whole landscape including the order in which to migrate the production systems. For the most critical of these systems, the next and only available downtime slot was eighteen (18) months away with exactly one buffer weekend one week later. All other weekends over that period were blackened out due to business requirements for a variety of reasons. It was a good thing that the customer was aware of this situation and did not try to rush things, to get to the RoI any faster. But frequently, restrictions also provide chances. In this case, the timeline provided the chance to accustom the whole of the organization to the new platform, and to raise acceptance for Linux especially within the rather skeptical, Superdome-acustomed UNIX and server administration. REALTECH worked out a migration sequence for all of the ninety systems that went from lightweight to heavy, from easy to hard, from somewhat important to highly business-critical. And we introduced all mechanisms and instruments of migration project management with the earliest migrations, even to those systems where this might have seemed to be overkill. As a result, expectable friction, inherent in any IT project of this size, took place in the engagement process in an early phase of the project, far away in time from the critical production migrations. And our customer used the long planning period to allocate functional departments and key users early for testing and approval processes, including weekend planning. In the end, every single go-live was a success on the first try, all budgets and all timelines did hold.

As mentioned before, all this comes with a price: Meticulous and repeated testing of all technical migrations provided for up to six migration specialists working in parallel, providing several hundred days of technical consulting. An additional 30% of consulting effort went into project management from our side. The customer provided about the same efforts for infrastructure services, SAP basis, testing and their share of internal project management. The graphics on the next page shows the process we have learned to implement on every single system landscape in every migration project, big or small.

The winning points in this project were realistic planning, a feasible timeline, experienced project management on both sides, knowledgeable specialists and REALTECH’s capability to extend this team in man power if, where and when necessary. These are the things you should look for when defining your migration project. And to answer the entry question, deducting from this experience and already on the way with larger ones, we think that if approached in the right way there is no size of customer, project or landscape that cannot be transformed from UNIX to Linux.
Not all lessons we learned on migration projects came from this one. There are other hidden traps, as our little list suggests. The last organizational one is usually connected with too high expectations on potential savings and the desire to squeeze out the last percent of this potential. In such cases, technical decisions are taken by management rather than the technical specialists and the technically best solution is replaced by a second or in some cases third-best workaround which – apparently – causes lower direct costs in licenses or implementation. The worst case scenario is that features or functionalities are looked at and decided upon on the basis of paper work only, and afterwards don’t meet requirements or expectations at all.

Usually such solutions strike back, either by failing on technical level, thus causing downtimes or requiring reconfiguration, or by permanently complicating and thus increasing the administrative effort to be applied to the new landscape. Our remedy is simple: Avoid workarounds. Always go for the technically fittest solution for your environment. Put the best solution into your budget – it will save you money in the end. It’s really as simple as that. And as for functionalities and new concepts – look for valid references you can talk to, or, much better, prove the validity of your concept with a PoC implementation in your very own environment before you go for production. It’s the only way to be really sure!
The second level of decisions to be made is of technical nature, and there are some important things to consider and typical ways leading astray as well. The ones we have seen are the following:

- Underestimating the complexity of the target environment
- Not using the “best of breed” approach – especially the “one to one mapping” mistake
- Implementing functionality in wrong layers of the architecture
  - Leave infrastructure functionality in infrastructure layer(s)
  - Leave application functionality in application layer(s)
- Giving key components too high ratings regarding robustness and functionality

This is, as you might have noted, a whitepaper on Linux. The error potentials listed above apply to all kinds of migrations, but they are in a very special way typical of UNIX to Linux migration projects. This again, has a lot to do with the fact that UNIX and Linux are so similar to each other they are frequently mistaken to be identical. They are not!

Not using the best of breed solution is, of course, the technical twin to the organizational “save money at all costs” error. And in conjunction with UNIX and Linux, we have met an exceptionally frequent subspecies, the one to one (1:1) mapping mistake. If you transfer a landscape from UNIX to Windows, from iSeries to Linux, or between any other fundamentally different operating systems, it goes without saying that you redesign certain functionalities of your environment from scratch, e.g. bonding, storage mapping, file system layout, interfaces, or cluster setups. It’s simply necessary because source and target environments don’t compare and don’t match. The commercial UNIXs and Linux, however, are so similar to each other that all too frequently those layouts (and many more) are carried over from source to target as if they were identical. This always leads to technical complications.

You have no clue what we are talking about? – Well, let’s look at a simple, real life example we encountered in a recent UNIX to Linux migration project.

The graphic next page shows all the layers you need to consider laying out disk space for an SAP system running on Oracle all the way from the file system down to the physical hard disk. There is only one, seemingly minor difference between the layout of the HP-UX source and the Linux target: The latter introduces an additional layer for storage mirroring control, MDRAID. The source system was laid out as an extended campus cluster over two data centers with software mirroring.
on two HP EVAs, one EVA in each DC. Mirroring was accomplished through HP LVM and Mirror Disk UX, with HP MC ServiceGuard running as the corresponding cluster solution. On target side, MDRAID was chosen as successor for Mirror Disk UX, theoretically capable of fulfilling all customer requirements. In real life, however, MDRAID proved to be too difficult for the HP-UX administrators of this specific customer. – We have other Linux migration customers who can handle this component wonderfully. But they usually do not transfer their designs one to one, and they are aware of the differences between source and target. This one wasn’t. As a result, an administrator mistake resulted in file system corruption and data loss. Everybody involved was even lucky that this happened during a production go-live migration since there was a defined point in time to fall back to, and the damage was basically that we had to repeat the go-live migration. It could have been a lot worse, with data loss occurring in daily operation.

To avoid the one to one mapping mistake in this case, it would have been better to move the RAID functionality needed one layer down and to implement transparent storage failover through a storage hypervisor – a storage hypervisor is transparent for Linux, and much easier to handle for the administrators.

Nobody is perfect – and REALTECH doesn’t claim to be an exception. We should have checked on this error earlier in this very project, and we should have intervened finding it. Now, we do.
High Availability & Other Forms of High Criticality

To put this first, and to put it straight: High Availability is a way of life for an IT administration, not a collection of tools. Accordingly, whatever solution you purchase promising you High Availability, it will not solve your stability problems if your IT administration does not live up to the challenge of running a critical environment. Therefore, this chapter in this whitepaper may give an overview over the HA tools currently available for Linux, but really making an environment highly available takes a lot more than just choosing and correctly configuring the right tool for your system landscape. HA should rather be considered a permanent process.

There is an easy check for IT managers responsible for critical environments. If you ever thought something like “I don't understand our problems. I bought High Availability!” then you are on the wrong track.

Having said this, let’s have a look at the HA tools available for Linux, and how well they are suited to help you to establish the High Availability process.

High Availability Tools for SAP on Linux

High availability, a core domain and long-time key selling argument for large UNIX platforms has made significant progress on Linux in the past few years. With this chapter we give an overview about available HA solutions, particularly failover cluster software products for Linux, briefly touching their history and then discussing the pros and cons of each product as we have encountered them in recent projects.

SUSE Linux Enterprise Server High Availability Extension

The “SUSE Linux Enterprise Server High Availability Extension” is an add-on to SUSE Linux Enterprise Server. Due to the length of the product name, we will abbreviate this as “SLES HA Extension” although we know this shortcut is not an official product name. As for licensing, you need to purchase SUSE Linux Enterprise High Availability Extension or SUSE Linux Enterprise Server for SAP Applications that has the High Availability Extension included along with other software and services designed to specifically meet the needs of SAP users.
SLES HA Extension consists of three main components:

- Pacemaker
- Corosync
- OpenAIS

These three main components imply or utilize other parts of the Open Cluster Framework (OCF), such as STONISH support, OCFS2, cLVM2, DRBD, and other functionalities. Overall, it’s a pretty mighty HA environment, but also a very complex one that might leave some work to your IT or your implementation partner, and requires skillful and understanding staff.

Pacemaker grew out of the Heartbeat project and is the cluster resource manager. The core messaging and membership capabilities are developed under the Corosync project. OpenAIS retains the layer containing the implementation of the “Application Interface Specification” (AIS) standard. AIS is “a collection of open specifications that define application programming interfaces (API) of the most required common functionality for building high availability applications”\(^\text{18}\).

Pacemaker was introduced into the SAP world with SLES 11 GA. According to the release notes, there is an update path from Heartbeat on SLES 10 to Pacemaker on SLES 11 SP1 (via the hb2openais.sh tool). However, due to many changes we found the best practice to rebuild clusters from scratch when upgrading existing SLES 10 clusters to SLES 11 SP1.

The Resource Agents are part of the OCF (Open Cluster Framework). An OCF compliant resource agent can be implemented in any programming language since the API is not language-specific. However, most OCF RAs are implemented as shell scripts. Available resource agents for SLES HA Extension include among others such for SAP instances and SAP databases as part of the package (no additional fees). The benefit of the OSS model is that your consulting partner or your IT administration yourself can add own RAs if capable and knowledgeable enough to do so.

There are many parties involved in support for the Resource Agents – the authors, some REALTECH consultants, the Linux distributors SUSE and Red Hat and/or the community. Binaries are supported by the open source project and/or SUSE. Due to the unrestricted support of nearly all possible hardware combinations, we have found it difficult not to run into errors, and they are frequently difficult to reproduce and tedious to fix. Support of new hardware or software

versions might take some time. But, we don’t want to get negative spin into this discussion, Pacemaker has some quite important technical advantages important and unique for SAP environments:

- Pacemaker supports master/slave resources, making it easy and rather uncomplicated to implement SAP Enque Replication.
- Pacemaker resources or resource groups may be configured with a simple syntax (whereas the combination of rgmanager & cman & SAP can only be configured via an XML file, which is pretty tedious).
- Pacemaker supports complex cluster rules (location, co-location, order).
- Pacemaker & corosync support encryption of all of the cluster communication – no root passwords are sent with open protocols or stored in readable files.

And please get us right on this: Supporting nearly all hardware out there until proven otherwise was a decision SUSE has taken in favor of their customers and in order to be able to support the vast majority of system landscapes. But due to this policy, Pacemaker configurations are more than any other Linux HA solution in the market a prime candidate for a scrutinizing PoC within your specific environment. Both for the Linux distributors as well as for SAP it is impossible to test each HW/SW combination, therefore it is necessary to validate desired core components before going productive. And honestly speaking, if you are worried about the cost of a PoC in this context, your environment might not need or deserve High Availability.

Certainly on the positive side, there is no additional vendor in the overall architecture if you go for either of the above. Beyond, we expect significant progress in maturity of the solution with Red Hat switching to Pacemaker as well, thus unifying the technical approach the two leading Linux distributors take for SAP High Availability. Beyond, SLES HA with Pacemaker is one of the few\(^\text{19}\) Linux HA solutions already certified from SAP for their generic HA interface. SUSE Linux Enterprise High Availability Extension 11 Service Pack 2 (SP2) has also recently been certified for SAP NetWeaver. This, we assume to be a really significant advantage of the solution. Regarding virtualization with integrated HA features, we want to mention the close cooperation between SUSE and VMware to build enterprise-class high-available virtualized SAP environments.

\(^{19}\) Since this is a moving target we have restricted ourselves to “soft” statements on what is certified.
High Availability with Red Hat Enterprise Linux

Until recently, Red Hat used the rgmanager based Red Hat High Availability add-on to provide continuous service availability in their clusters. Since rgmanager is technologically obsolete (see previous list of Pacemaker advantages, pretty much the missing points of rgmanager), Red Hat has announced to switch to a Pacemaker-based solution with their next major RHEL release. And for cross campus clusters and other big picture solutions, Red Hat cooperates with Symantec and recommends Veritas Cluster.

SteelEye LifeKeeper

SteelEye LifeKeeper has a long history and is around for a while on several operating systems, which we found an important aspect when evaluation qualities and quality of HA tools. A first version was developed in the mid-1990s as a high availability solution from AT&T. Since more than a decade LifeKeeper is developed and distributed by SIOS Technology Corp.

LifeKeeper supports Linux & Windows and it has a clear upgrade path. Application Recovery Kits (ARKs) are available for several enterprise applications, including SAP, and for enterprise-class database products such as DB2 and Oracle.

In 2007 SteelEye LifeKeeper won the “Best Clustering Solution Award” at LinuxWorld. LifeKeeper has a well-defined support matrix. Lifekeeper is another Linux HA solution already certified from SAP for their generic HA interface which will be decisive quick integration of the solution into SAP HA environments in the future.

Using SteelEye LifeKeeper incurs additional license fees and it means an additional vendor in the overall architecture. However, LifeKeeper Application Recovery Kits are maintained from a single vendor, support of new hardware or software versions is pretty fast in our experience, and HA is a core competence of SIOS.

LifeKeeper supports three of the four main x64 virtualization solutions without restrictions: Citrix XEN, Microsoft Hyper-V and VMware, and it provides plug-ins for VMware HA Application Monitoring. Since KVM is simply a kernel module of the Linux kernel, we assume that KVM is fully supported as well.

All in all, LifeKeeper usually is one of the tools we take into evaluation to check if it suits a certain customer environment.
Veritas Cluster
As the previously discussed Lifekeeper, Veritas Cluster has quite a history in HA and SAP HA environments; it is available since mid of the 1990s. The product supports several UNIX systems, Linux and Windows and it has a clear upgrade path. Veritas Cluster offers application agents for major enterprise software including SAP and major databases. The support matrix is well defined. Veritas Cluster incurs additional license fees (and in this respect might well be regarded as the Rolls Royce among cluster tools for Linux), and with Symantec an additional vendor is included in the overall architecture.

Veritas Cluster provides unrestricted support for VMware, and additional integrations are available for storage subsystems. New hardware or software versions might be integrated faster, as cluster technology is a core competence of Veritas/Symantec. It is a mature and extremely comprehensive tool, and correctly configured and implemented it will probably provide a technical solution for your technical application scenario – but as aforesaid, don’t mistake HA as a question of tools. However, some of our customers have had varied experiences with Symantec support of Veritas Cluster, especially for Linux, not all of them positive and both regarding turnaround times and quality of the support responses. Some of our major Linux migration customers have turned away from Veritas Cluster or are on the way to do so due to these “mixed experiences”.

HP MC ServiceGuard
HP MC ServiceGuard, too, is an old fellow in the HA tool market; first versions were available with HP-UX 10.00 in 1995. HP-UX and Linux are supported and the product has a clear technical upgrade path.

The product is well tested on HP hardware and support of new hardware (especially HP) or software versions might be comparably fast. Integrations for HP storage subsystems are available, too (i.e. EVA Cluster Extension for HP EVA continuous access). On Linux HP MC ServiceGuard supports virtualized guests with VMware ESX, and also Red Hat and SUSE Xen hosts (DOM0).

ServiceGuard and application integrations are being maintained from a single vendor, offering out of the box integrations for major enterprise products including SAP and Oracle. The support matrix is well defined but HP MC ServiceGuard incurs additional license fees and it means having an additional vendor in the overall architecture.
In the past customers have had bad experiences with HP’s commitment to the product, since Linux support had been discontinued 2010 and was then re-announced in 2011. As continuity is a major asset in critical installations, we consider HP's chop and change policy a significant drawback for the product. No one outside the HP top management can or will guarantee there won't be another switchback. Therefore, REALTECH is reluctant to recommend even considering this product.

IBM PowerHA / HACMP
IBM PowerHA (a.k.a. HACMP) has been around for a long time as well. However, currently only Linux on System i and System p but not on System x are supported. Since this policy ignores x64, the major processor platform for SAP on Linux, we do not recommend to consider HACMP for SAP environments running on Linux, since even if you might run SAP on Linux with the Power CPU today you might want to switch later. However, given the situation today, you then likely will be forced to find and implement a new HA tool, and to abandon acquired know-how.

Other Forms and New Understandings of HA and Criticality
Just as High Availability is more than the question of the right tools on organizational level, it is also more than classic 1:1 clustering technologies on a technical one. As a matter of fact, SAP has somewhat changed the fundamental architecture of their software stack which allows for separation of layers and a distinction between critical and non-critical services. Thus, you can utilize different technologies in different layers to maintain or establish high availability, getting you closer to N+1 (instead of 1:1) clustering and round robin maintenance procedures, which in turn will allow you to cut down not only on unforeseen downtimes but also on the planned ones.

An example on how we exploited the new architectural possibilities is described in the next chapter.
Beyond Limits.

Beating Lower Limits

A large customer from the health sector asked us to review their SAP platform strategy for the future five years and beyond, looking for a future-proof platform that provides the same levels – or higher, of course – of performance and availability as their current platform: IBM Power servers running AIX and Oracle databases. With about 100 SAP systems, several 100,000 SAPS and about 90 TB of databases, the environment is an important and critical part of the customer’s overall infrastructure.

The new environment needed to meet validation/qualification, FDA and GMP requirements, provide high availability and disaster recovery. It also should support future SAP versions and trends such as In-Memory-Computing and provide a path towards cloud computing.

As in all REALTECH architecture studies, the platform alternatives are always compared to the status quo of the customer. For the future platform, we first did a resizing of the environment for the latest IBM Power servers, with AIX and Oracle Database. Then we developed multiple alternatives, including options with IBM Power blades and x64 blade servers based on AMD or Intel processors. Changing from Oracle Database to a different product was not an option for our customer, because they are running a large non-SAP environment on Oracle, and changing that standard would have led to immense cost, if at all possible in a qualified and validated environment.

In order to get a complete picture of the financial implications, we analyzed hardware cost, software licenses, transition and training cost, and we estimated future cost of and potential savings in operation.

Since our customer has licensed their databases on a per-core model, the number of CPU cores for the databases needed to be kept to a minimum in order to keep database cost low. SAP’s layer model, available since the introduction of NetWeaver, provides the flexibility to separate the overall stack into multiple layers, isolating the database on a small number of servers. The next graphic shows our general approach.
All alternatives – including the current platform with the latest server models – were compared against each other, looking at criteria such as technical details, risks and many more. Finally all options were compared from a financial perspective. The current setup, a classical CI/DB configuration supplemented by application servers where necessary, was calculated first, as a baseline, shown as 100% below. Of course, just keeping the existing setup and transferring it from Power6 to Power7 does not generate any transition costs.
Not even looking at the technical advantages, our approach with a layered architecture pays off immediately from an economic standpoint, even if there is no change of the processor architecture. Not changing the OS has the significant advantage of not producing noteworthy transition costs due to the lack of necessity of a heterogeneous migration. However, please note that Oracle would have profited disproportionately from this move. Due to the core-based licensing and the different core factors assigned to Power and x64, this option would have provided overall savings of a bit more than 20% but shifted revenue from IBM to Oracle.

REALTECH was convinced there is a better way, and that it should be possible to create a layered architecture that would push the limits of availability up while still lowering operational costs more than 20%. Our cost comparisons of all alternatives then showed that moving to x64 with Linux and Oracle RAC in a layered setup would provide significant savings per year, of course requiring a large initial investment for a transition project. Annual cost is about 54% of the baseline and the cost of transition is about 127% of the annual cost of today’s architecture.
By automating deployment and daily operations to a maximum degree and by strictly using standards for components and configurations, the cost of operation can be limited, despite a slightly higher number of components in the new architecture.

The new architecture is strictly based on a layered model, using virtual machines for the application layer. Every SAP system uses at least two application servers, one in each data center. In this setup, SAP central services share a two-node cluster based on two virtual machines with SLES HA Extension.

At the database layer, the customer benefits from rich experience with Oracle RAC in their non-SAP environment. Compared to many 2-node clusters for the databases, using Oracle RAC significantly reduces the number of servers for the database layer and therefore also minimizes the amount of database licenses, although RAC licenses are more expensive than standard ones.
Besides purely financial aspects the customer has decided to move to x64 with SLES for SAP Applications because this combination meets their performance & availability requirements and because it offers a roadmap towards affordable In-Memory-Computing as well as moving into a private cloud computing model. It also will enable our customer to streamline their procurement and provisioning processes. After completion of the project, our customer will run x64 servers exclusively and Linux and Windows as their only operating systems, at least in their SAP data centers.

The new architecture is being implemented in a phased approach and the pilot environment for the development systems is about to be finalized at the same time as this whitepaper.
Pushing Upper Limits

The next and final discussion will show no more or less that by moving to Linux and x64 it is possible to multiply your available SAP data center performance while at the same lowering costs significantly. Of course, this depends on where you come from, but this specific customer came from a high-end Itanium based HP-UX infrastructure, which provided for a maximum savings potential. Believe it or not, these are numbers given to us by the customer, percentages calculated on the basis of real-life budgets.

Our first chart shows the increase in SAPS performance over the period the customer was replacing their Itanium-based infrastructure by an Intel-based one, running Linux instead of HP-UX. Quite unsurprisingly, this leads to a significant increase in available computing power.

However, the surprise comes with the next picture, showing infrastructural server cost over basically the same period. Just by moving to Linux and x64, this customer lowered their costs in this field by over 80%, while at the same time at least tripling their available SAP computing
power. And, to object any skeptics, neither stability nor real-life performance have suffered, nor administrative efforts gone up. That is, if you want to boost power in your SAP data center, go for Linux and x64.

While the customer of our first example is going to SUSE, this one went to Red Hat. As discussed earlier, the main cost effects come from the CPU architecture. Coming from UNIX, you can save a lot of many with either Linux distribution.

Just to point this out clearly: These two charts were given to us by our migration customer, and they represent performance in the SAP data center and cost development according to real budgets as they were reported by the customer itself. REALTECH has even seen the real figures, not only percentages. This is neither mock-up nor marketing. It's real life.
Final Conclusions

In a nutshell, one might well say that Linux and the x64 CPU architecture have arrived in SAP data centers as mainstream solutions. They are excellently suited to deliver system landscapes of both high performance requirements and high criticality. We think we have shown with this whitepaper that a wide range of SAP customers agrees with our views, and either already have or are on the way to explore the possibilities of when and how to introduce Linux and x64 into their data centers. We also think that SAP is very much on the same track – many new and many important solutions such as HANA, just to name the most spectacular one, are delivered on a “Linux first” or “Linux only” basis.

On the other hand we also think this whitepaper shows that quite some familiar friends from the UNIX family are doomed in the long run, at least in regard to SAP data centers. We even have to aggravate this statement: We think that customers waiting too long with the replacement of the most endangered species might get into dire straits either on technical level regarding SAP product availability, or economic level by paying too much money for too little value, or by running out of time when large infrastructures will have to be replaced quickly with a deadline in your neck. Therefore, and in order not to run into the typical project errors described in previous chapters, our advice is to act soon. We have seen tight-scheduled projects, and believe us, it is much better to be early than to be late.
Epilogue

This project started as something unusual, and it will end this way. When SUSE approached REALTECH with the idea of digging into the origins and the targets of Linux migrations connected to SAP, we had no clue about the avalanche of interest we would generate. As a matter of fact, we didn't even exactly know which direction this would take. The "UNIX to Linux" title was selected after the content of the first whitepaper was settled. However, there was something else unusual about this, something I'm very grateful for: Yes, all three whitepapers were sponsored by SUSE, and the latter two ones also by Intel. This was simply necessary because REALTECH can't afford to put aside hundreds of hours of work in plain research. But both SUSE and Intel respected my impartiality and independence, and never interfered with my statements and judgments as long as they were based on correctly researched facts. True enough, especially the Intel engineers scrutinized our data, and basically their detailed examination provided for the second paper to be better than the first one, and for this to be better than the last. But they always did so on behalf of technical correctness, not political one, or, worse, on behalf of marketing interest. I didn't want to and I didn't have to save Intel from some quite unfavorable statements about Itanium. And SUSE is aware that there are two important Linux distributions in the SAP world, SLES and RHEL, and that REALTECH has good relations to both distributors, and this is fully intentional. In times when large banks manipulate interest rates to increase their profits, I think professional integrity is an exceptionally high value. I'm deeply grateful to SUSE and Intel they allowed me to keep mine.

Thanks Naji, thanks Jonny!

Will there be another one? - Honestly speaking, I don't think so. There have been too many great movies (Terminator, Bourne, ...) that generated just one sequel too much. I don't want to do the same with this whitepaper series. And for this one, my great team of architects, especially Margit, Manuel, and Holger, flooded me with tons of material. Thus, I would join Bill Watterson when he stopped his wonderful Calvin & Hobbes cartoon series: It's all been said.

"Never say never", another great movie ... but this is where I am now.

Sincerely yours,

Helmut Spöcker
| Benchmark ID | Vendor | Server Model | Processor Name | Performance per Thread [SAPS] | Number of Cores | Performance per Socket [SAPS] | Number of Threads per Socket | Performance per Core [SAPS] | Number of Cores | Performance per Core [SAPS] | Server Model | Processor Name | Performance per Thread [SAPS] | Number of Cores | Performance per Socket [SAPS] | Number of Threads per Socket | Performance per Core [SAPS] | Number of Cores | Performance per Core [SAPS] | Server Model | Processor Name | Performance per Thread [SAPS] | Number of Cores | Performance per Socket [SAPS] | Number of Threads per Socket | Performance per Core [SAPS] | Number of Cores | Performance per Core [SAPS] |
|--------------|--------|--------------|----------------|-----------------------------|----------------|-----------------------------|-------------------------------|-----------------------------|----------------|-----------------------------|--------------|----------------|-----------------------------|----------------|-----------------------------|-------------------------------|-----------------------------|----------------|-----------------------------|--------------|----------------|-----------------------------|----------------|-----------------------------|-------------------------------|-----------------------------|----------------|-----------------------------|--------------|----------------|-----------------------------|----------------|-----------------------------|-------------------------------|-----------------------------|----------------|-----------------------------|
Comparison of Basic OS Support Costs

Just as an example, we want to list the basic support cost as charged for the HP DL580 G7 for the three operating system flavors for x64 discussed in this whitepaper as calculated by HP’s own web tool.

<table>
<thead>
<tr>
<th>OS Maintenance 3 Years</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUSE Linux Enterprise Server 11 SAP</strong></td>
<td>€ 6.310 incl. 3y, 24 x 7, 2 + sockets</td>
</tr>
<tr>
<td><strong>Microsoft Windows Server 2008 R2</strong></td>
<td>€ 2.140 € 3.421 3y, 24 x 7, Difference between Combined HW/SW support and HW support only care pack</td>
</tr>
<tr>
<td><strong>Red Hat Enterprise Linux</strong></td>
<td>€ 6.440 incl. 3y, 24 x 7, 4 sockets, 1 guest</td>
</tr>
</tbody>
</table>

As you can see, the differences for basic support over three years are almost negligible, and this is all we used to calculate the price/performance ratios for the servers. There are cost differences as soon as you want to run a number of virtualized guests or if you want HA features included. But since this would lead to a confusing number of pricing configurations, it’s omitted anyway.

This holds for virtually any x64 vendor of relevance in this whitepaper. We could have chosen any other.
Comparison of Server Waste Heat for Identical CPU

As indicated in the Green IT discussion, servers utilizing the same CPU might generate quite a range of energy consumption values. Please make your own picture with the example given below.

<table>
<thead>
<tr>
<th>Processor-Name</th>
<th>Intel Xeon Processor E7-4870</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor-Cores-Nr</td>
<td>10</td>
</tr>
<tr>
<td>Processor-Clock [Mhz]</td>
<td>2400</td>
</tr>
<tr>
<td>Server-Model</td>
<td></td>
</tr>
<tr>
<td>HP ProLiant BL680c G7</td>
<td>large databases, higher-density virtualization, general data-intensive applications</td>
</tr>
<tr>
<td>Fujitsu PRIMERGY RX600 S6</td>
<td>critical company IT services: database management system for large corporations, consolidation platform to host an immensely large number of applications using virtualization technologies</td>
</tr>
<tr>
<td>Cisco UCS C460 M2</td>
<td>mission-critical business solutions, for server consolidation and resource-intensive workloads</td>
</tr>
<tr>
<td>HP ProLiant DL580 G7</td>
<td>large databases that require scale-up compute processing, large memory, I/O intensive applications Traditionally, mission-critical RAS (Reliability, Availability and Serviceability) features</td>
</tr>
<tr>
<td>HP ProLiant DL980 G7</td>
<td>single and very large data intensive, or many consolidated or virtualized workloads, I/O intensive applications</td>
</tr>
<tr>
<td>Dell PowerEdge R910</td>
<td>mission-critical applications in corporate data centers and workloads needing the highest performance, reliability and I/O scalability</td>
</tr>
</tbody>
</table>
Sources and References

http://www.sap.com/benchmark
http://www.xware.net/sapbench.html
http://www.tpc.org/
http://www.ibm.com/
http://www.oracle.com/
http://www.dell.com/servers
http://www.fujitsu.com/
http://www.cisco.com
http://www.suse.com/
https://www.suse.com/products/sles-for-sap/
http://www.redhat.com/
http://www.amd.com/
http://www.intel.com/
http://www.gartner.com
http://www.idc.com
http://www.realtech.com/linux
http://clusterlabs.org/wiki/Pacemaker#Project_History
http://clusterlabs.org/wiki/FAQ#Why_was_the_Project_Started.3F
http://www.linux-ha.org/wiki/
http://www.linux-ha.org/doc/dev-guides/
http://scn.sap.com/docs/DOC-26718
About REALTECH

The company was founded in 1994 as a basis technology specialist with close ties and good connections to SAP from the very beginning. Specialized in the implementation of SAP R/3® landscapes on Intel servers, which automatically implied Microsoft Windows at the time, REALTECH immediately recognized the potential importance of Linux as a new strategic server platform with its beginning emergence in the second half of the 90s. Thus, with the official publication of the availability of SAP R/3 on Linux, REALTECH was a founding member of the SAP LinuxLab to then become and stay until today the only independent consulting company in SAP’s flagship Linux organization.

REALTECH is a full service company taking care of all technological aspects of SAP ERP and SAP NetWeaver® and SAP Business Suite® implementation, optimization, or migration projects. We set up requests for proposal, evaluate hardware vendors’ bids and project suggestions, scrutinize hardware configurations and sizing as well as project plans, set up, examine and document lab configurations for refereeing decisions, perform benchmarking and specialized set-ups for hardware vendors. We also do project planning, project management and project controlling for our customers. Of course, REALTECH will deliver the plain doing of installations, migrations, and upgrades as well as the previously described analytical work whenever the customer feels more comfortable with REALTECH’s technical and business expertise than anyone else’s. With respect to Linux, REALTECH is responsible for some of the world’s most spectacular and successful SAP Linux migration projects, and especially those were provided to our customers as a full service engagement at a fixed price. For references and success stories, see www.realtech.com/linux.

REALTECH has a plentitude of customer references for Linux migration projects and is the preferred SAP migration partner for SUSE, Red Hat and a number of hardware and service vendors in various parts of the world. We will be very happy to investigate, plan and implement your individual path to the advantages of utilizing Linux.

If you are interested in our services, contact REALTECH via www.realtech.com or customer-services@realtech.com.