Welcome. I'm Sunil Kulkarni from Intel; I'm a senior software engineering manager and I'll be talking today about Intel’s enabling strategies for the 64-bit and multi-core platforms. I will be speaking to you about Intel’s enabling strategy, Linux’s enabling strategy and Intel’s platform strategy. We also would like to discuss the multi-core road map, specifically the success we had with you from hyper-threading that we enabled a few years ago, and then we will discuss the 64-bit computing choices. We will also talk about Intel’s multi-core plans, the Intel software development environment, and finally, I’ll leave you with this thought: Intel is more than processors.

Let’s talk about Intel’s enabling and Linux’s enablement strategy. Our objective is to create integrated and robust solutions on the Linux that take full advantage of Intel’s unique platforms. Here, if you see in front of you the building block, we are going to start from the bottom of the building blocks and go on the top. So on the bottom of the building block, the first thing is Intel’s platform readiness for Linux. Here, we’re going to find out that Intel delivers all the drivers necessary for whenever we announce a new processor. Intel makes sure that the drivers are already ready, all the DLLs and all the libraries that are necessary for that platform to be successful are already ready on Linux. So Intel in turn makes the platform ready for you to take advantage in the Linux environment.

Next we go to Linux enablement and the community. Intel basically works quite a lot with open source forums and is very much involved in the development of Linux kernel. Here,
Intel works with several OS vendors and makes their OS versions optimized for the Intel processor. So whenever there is a new processor that’s being announced, the OS from a particular vendor of Linux is already optimized to take full advantage of the features that Intel is bringing out in that processor.

Next we look at providing and facilitating development tools. Intel always works with Intel tools. Intel has a lot of investment in compilers and tools that work on Linux and take full advantage of the processing capabilities that Intel brings to the table. Intel also works with third-party tool providers and also makes sure that their tools are optimized for the Intel architecture. As soon as the new processor is announced, they also take full advantage of the capabilities of that particular processor.

Now let’s look at bringing solutions to the market. Intel works very closely with key ISPs in the market that have solutions on the particular platform of your choice. Here Intel works with the ISP and optimizes their software and makes sure that the software is fully optimized and ready to go on the particular processor that we’re announcing. So in turn, we are basically meeting all the customer requirements in every vertical market segment that you come across. And we are making sure that all the particular solutions are enabled on the Intel architecture. So here we are working at all the layers. In the same layers that we saw before, I’m going to give you a quick few examples of work we are doing in each of these layers.

On the bottommost layer, the platform readiness on Linux, you can see that we are working very closely with the industry consortiums; we brought out a new interface called the EFI, which is in the EFI/Tiano framework. EFI/Tiano is nothing but a futuristic BIOS environment. Here what we have done is created some industry standard robust interfaces and we brought out those interfaces. Now, the EFI framework, as it is called now, is now available not from Intel, but it is available from third party companies like American Megatrends and some other vendors that are supporting the EFI framework. So this will be moving forward. EFI will be the building block for all the new platforms that we will be bringing out. And EFI’s not platform-specific. The
vendors that are writing to EFI are basically writing it for Intel or non-Intel platforms as well. So it's practically open interface and can be used by other platform makers as well. Moving up onto the Linux enablement and the community, we at Intel have been a founding member of the OSDL. When the OSDL started, Intel actually donated some 16-way, 64-way, 8-way systems for the community to use those servers and do scalability on their applications. Intel is also a member in the Eclipse Consortium where software developers/tools developers gather together and design tools in a certain framework, so Intel is a very key contributor to that effort. Intel has also made a lot of contributions to the Eclipse Consortium.

Intel has also come out with its own Linux debugger. When you use Intel compiler, there’s a Linux debugger built into it. That has some key features, advanced features. One of the things that you can do is this: If you’re writing to a cluster application then debugging that cluster application becomes much easier using Intel’s Linux debugger. So here you see that Intel is providing and facilitating a lot of development tools for the Linux community. Moving on, Intel works with the ISB enabling effort. We work in all verticals like the financial community. We work with strategic end users as well as the ISVs, the famous ones that you are all familiar with, like Reuters, Sunguard Thompson. We work with all of these ISVs and practically enable their software to run at its best on the Intel architecture. Why do we do that? We do this because once that application is optimized for the Intel architecture; you as the end user can take advantage of that particular software running at its best. We also work with some of the strategic end users so that their software is also optimized for the Intel architecture.

Now let’s turn our attention to the Intel platform strategy and moving into the multi-core. I’m pretty sure you are all familiar with Moore’s law. Moore’s law basically says that there’s an opportunity for the user value to grow twice by delivering two times the number of transistors every 18 to 24 months. So every 18 to 24 months, we are getting double the number of transistors. Now we as researchers, we need to look at this as an opportunity, and look at what we are going to do with these double transistors. In turn, if we build something that has user
value, users are going to come in and take advantage of that value. So what Intel does is whenever these double transistors come into play, Intel comes up with new technologies such as wireless. These are the technologies that Intel has introduced, and I'll touch on those in the next few slides.

A multi-core is one such technology that we introduced, and we are introducing that technology not as a new one to start with. However, we introduced about a decade ago the SMP concept, the symmetric multiprocessing concept. We then took advantage of some of the applications that were running on our platform. We looked at those applications and found out that a majority of these applications, when they run on Intel architecture, were not utilizing all the resources that were available. So there were a lot of resources that were left out. What Intel then did is create an original resource you could use to take advantage of those hyper-threading resources. In turn, we brought out hyper-threading. Hyper-threading allows you to basically run two threads on the same die. So it allows you to take advantage of parallelism. And this is one of the things that Intel is doing with the future multi-core platforms.

Next we will talk about the multi-core curve. Here you see an example of Moore’s Law, whenever we double the number of transistors, we give additional user value. This doesn’t come without any cost to us. Up until now, every time we use double the number of transistors, we have increased the frequency. Every time we increase the frequency of power, terrible issues arise. So far we have been riding on the frequency curve. We have now reached the point where we are not going to be able to continue on the frequency curve. If you know a little bit of physics, that says that power or wattage = capacitance X voltage^2 X the frequency. The more frequency you increase, the more power you are going to consume. This is going to be a real challenge moving forward beyond what we have reached. We all started making use of parallelism into our processors and with that parallelism, you can now take advantage of multiple cores coming into the same die, giving user value, which is what the Moore’s law states. And this is what we are doing now by adding multiple cores on a single die.
Now I’ll talk about the move to Intel architecture multi-core. Here’s a roadmap that I wanted to give you. On this roadmap, you will see that all the green is basically a dual-core, multi-core and 64-bit. Here we are showing current 2005, 2006 plus and the future. On the Itanium side, currently we just announced the Montecito part. Montecito is a dual-core Itanium part that has 24 mgs of L3 cache, and this one runs at 90 nanometers, and believe it or not, this particular platform has 1.72 billion transistors inside that processor.

Next comes in Monvale; this is another 90 nanometer processor. Moving forward, we go to greater than four cores on the Tukwila. This is coming in the future, sometime around 2007. Then there are dual-core DP processors, DPs servers. Here, Millington is the new part that will be a dual-core, truly 64-bit, running at 90-nanometer core, and this is the part where we have reduced the voltage from 140 watts to 100 watts. We’ll announcement sometime in 2005. Millington will be coming out in 2006, a dual processor Monvale. Monvale is a dual-core, dual processor, 90-nanometer part. And in the future, there will be greater than two cores on the same die, on the part that is called Dimona.

Now we’ll see that we have Xeon parts; there are Xeons with dual-core as well as 64-bit integrated onto these processors. The first one that we are going to come out with is Paxville dual-core. We will have a dual-core part with Tulsa and following that, the Whitefield part is a very interesting proposition that Intel is coming out with. This is the first part that will be shrunk from the previous generation. Up until now, we have been utilizing 90-nanometer technology. Moving forward, we will be using 65-nanometer technology. So here’s where Moore’s law comes into play. We are increasing the number of transistors here. We will have a not just dual-core, greater than two cores, at 65 nanometers, and this will be the first time there will be a common architecture between Itanium and Xeon. So this is the first part that has both the architectures using the same common architecture.
Next there’s a Xeon processor with 2MB cache, the Dempsy part, which is their dual-core, server part with 65 nanometer. This is the first server part with 65 nanometer on the dual-core dual processor. In the future, there will be many more than two cores on the 65-nanometer parts. Recently, we announced Pentium® IV Extreme Edition. As you are aware, just last month we announced this Pentium IV Extreme Edition, the part called Smithfield. This is a 90-nanometer part we renamed as Pentium D. This one has 2MG L2 cache, and following that is a Presler, a 65-nanometer part with 2MG cache on each core. In the future there will be many more parts with multi-cores coming out.

Going down to a mobile platform, you will see that on a single core, there is a mobile dual-core part that is coming up called Yonah. On the Yonah, there are two cores and this is again running at 90 nanometers. So in the future you will see that parts on the mobile part, the Pentium M parts, are going to be 65 nanometers as well. So, in a nutshell, Intel is not just bringing out a dual-core part just for introducing a dual-core. But you will see an extensive roadmap going into server, mobile, desktop and workstation parts as well.

We have greater than 10 multi-core projects spanning all the enterprise, server, desktop, mobile segments. In 2006, greater than 70% of all our desktop parts will be shipping with dual-core parts with EM64T or 64-bit capable parts. In 2006, 85% of the servers will be shipping with dual-core EM64T, 64-bit capable parts. On the mobile side, greater than 70% of the parts will be shipping with dual-core parts.

Now we’re going to start with two complementary 64-bit architectures. Here you will see that the first one is the mainframe architecture where exceptional performance with 64-bit OS and multiple choice of OSs are available. This is the Itanium architecture, a true 64-bit architecture, giving you lots of choices of high performance, reliability, lot of manageability features; a lot of new technologies are being introduced in here. Not all people can directly use 64-bits, so for those who have some projects on 64-bit, they can utilize 32-bit and 64-bit running into the same processor. Those are the EM64T capable I32 and I64 part, EM64T Xeon architecture.
Since the announcement we have shipped greater than 2 million parts of the 64-bit processors. So that’s quite an achievement already from Intel.

Now let’s talk about multi-core. There’s a lot of talk about dual-core and multi-core, so I just want to spend just a quick few minutes on “What is multi-core?” If you look at Intel, whenever you open up your machine, you will see that there is a socket. On each socket there is one processor up until now. From now on, when you open up that box, in each socket there will be two cores. So two processors are physically residing on that same socket. Here are some examples of the dual-core and multi-core platforms. The first two are single die monolithic parts. The second one is called a multi-chip part. Their difference is nothing but manufacturing. It’s much easier to manufacture the monolithic part because you have to take two cores and put them onto the single die. The drawback on that is, if one of the cores is faulty, then the whole die goes to waste, whereas on the multi-chip side, you can have multiple cores taken from anywhere on the wafer. Whenever we manufacture a lot of processors, they are kept on a single wafer. And we can take, on the multi-chip side, the two cores from any part of the wafer. Even if one of them is bad, we can easily replace that from another part from the wafer. That’s the primary difference between these three categories here.

Threading evolution - on the Pentium IV with hyper-threading, you were able to run two threads in the same package, where you had a single processor on the die with hyper-threading enabled. Hyper-threading makes it look like there is a dual processor. So you can run two threads on the single die. Following that came dual Intel Xeon processors. Here, you will see that there are two states, two independent cores, two independent sockets; they are working with two threads but there are two packages. So there are two threads and two packages that are running on it. Then we introduced Smithfield, which is a true dual-core platform. Here you see two threads running on a single package. So we are improving the threading performance and threading to support multiple threads in the single package as we move along.
On the threading, the last example I want to give you is the recently announced Smithfield part, which is the Pentium Extreme Edition part. Here you see on a single package, there are four threads running. Why? Because inside that single die, you have two processors, each processor is hyper-threading enabled. So what's happening is you are able to run four threads in the same package. This is a step in the right direction for going out and utilizing multiple cores. Now, what's Intel future direction for dual-cores? We brought out dual-core products in all segments: desktop, mobile and server. We also want to build a long-term roadmap; there are a lot of dual-core platforms as well as multi-core platforms coming in the future. So it's not just a one-off dual-core platform, but a long-term roadmap that Intel is bringing out. So Intel's multi-core and multi-threading support will deliver the performance of the future.

I want spend a quick few minutes on Intel thread enabling. Multiple cores don't come in easy for your application. Your application needs to take advantage of the available cores. What is Intel doing to make sure that your application takes advantage of the available resources in the processor? Here you will see for developer platforms, Intel has already brought out a dual-core platform with hyper-threading enabled. Intel also gives those platforms to strategic ISVs as software and uses ISVs to test out their application early on, so that they can enable that application before the product is actually announced. Intel also views early access to the new technology that Intel is bringing out. In some cases, you are not able to take advantage of the features by just getting a single system because your environment is such that you need large clusters or a 64-way system. For those customers whose needs are like that, we provide them remote access - in our labs, we build a custom configuration for them so that they can start testing their application for scalability or some proof of concept.

Intel is very much a software company. Intel has more than 2,500 software engineers working all across the world, and Intel brings out software tools. For example, Intel has CC++ compiler for both Linux and Windows; it also has performance libraries that are optimized and threaded for Intel architecture. Intel also has tools for threading that allow you to thread your
application very effectively. If your application is already threaded, it allows you to check for data consistency or any issues that you are running into, like deadlock issues or risk conditions. The thread checker part allows you to check those issues. Intel also has lots of whitepapers on their website. If you are interested, you should go and look at developer.intel.com. There are lots of whitepapers that will help you optimize your applications. In addition, Intel provides extensive service and support. For example, we have started a new program called Thread Immersion Program. Here you will get lots of advantages whether your application is threaded or not. If your application is not threaded, this team comes out and helps you thread your application. If your application is threaded, but it does not scale very well with the number of processors that are in there, this team will come out and help you to identify the issues so that your application is scaling well with the available processors in the system. And in the third case, we also want to make sure that it is running and taking advantage of the optimum features that are available in the processor. We have Solution Centers where you can go in and take your application to test whether the application does scale very well, or if there are some proof-of-concept type arrangements that you want to test out.

Intel also has a Software College, which provides user training either at our site or yours. We have many applications that we looked at and found the hyper-threading now takes advantages of the available resources which were not being used before. You have an extra resource in many applications that we have seen because it takes advantage of hyper-threading. When you enable that, you get at least between a 10% and 30% improvement in performance. With dual-core you have a separate core available for you, and in addition hyper-threading allows you to enhance that feature so you get two full execution cores on a single die. Future multi-cores will have many cores on a single die, allowing increased level of parallelism—greater than two threads can be run on a single core. So Intel is delivering a lot of hardware level threading in volume.
I want to show you a quick chart on software development products. This chart shows the available products like compilers, performance analyzers, performance libraries, threading tools, cluster tools, and the platforms that they are available on. Here you will see that there are Intel compilers available on both Linux and Windows, as well as on Itanium, Xeon and Pentium products. So you can use the same compiler, the same APIs from the threading libraries, and you do not have to record the application differently if you want to deploy it on a different platform. You have the same API at run time when you run the application; libraries get loaded and the application takes advantage of that particular architecture. Intel is beyond processors.

Let’s start from the center of the slide. You will see that Intel has an unparalleled industry reach ecosystem that is going in from handhelds to desktops to mobiles to workstations to servers and the enterprise servers. Multi-way systems going from two ways, to four ways, up to 128 ways are available from many of the OEMs that we work with. Intel invests a lot of money in creating optimized chip sets. Close to 25,000 hours are used for validation before the processor comes out. So you are getting a really robust processor that you can bet your business on. Thirdly, Intel also works on motherboards and server systems so that you can utilize those directly from Intel. Many OEMs these days want to utilize Intel’s reference design and create systems based on Intel’s reference design.

Intel also has lots of software. We have compilers, CC++ compiler, Fortran compiler, and threading tools for thread checking as well as profiling your application. Intel also has cluster tools where you can use MPI. Many end users like VTune, a performance analyzer tool that allows you to analyze your application, how it’s running and what deficiencies to look for. Intel has an Early Access Programs, and it works with the key database vendors and key OS vendors that are listed here. Intel provides solution services so that you can go onsite at Intel solution centers and test your application. Intel also has solution-group rings that give you access to best-known methods. Finally, Intel also has an Intel capital, which invests a lot of money on upcoming technologies that we are always on the look for.
In summary, Intel’s Linux enablement strategy is to create integrated, robust solutions for Linux that take full advantage of Intel’s unique platform features. Intel’s complimentary 64-bit architecture provides a lot of choices to meet deployment needs that you have across the enterprise. Intel’s product line is moving toward multi-core; each product that Intel will bring out will have dual-core or multi-core, and at the same time will be 64-bit capable. Intel’s software development expertise and their tools are ready to assist you. Intel has a lot of resources available to work with your application to get it optimized on Intel architecture. And, as I hope you now see, Intel is beyond processors. Thank you very much.