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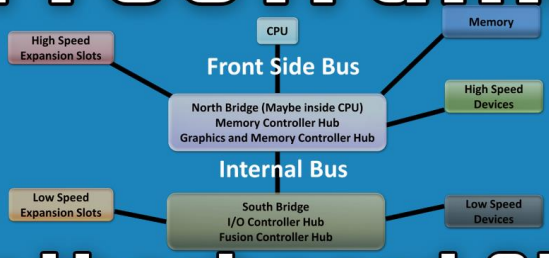

Motherboard Chips and Components

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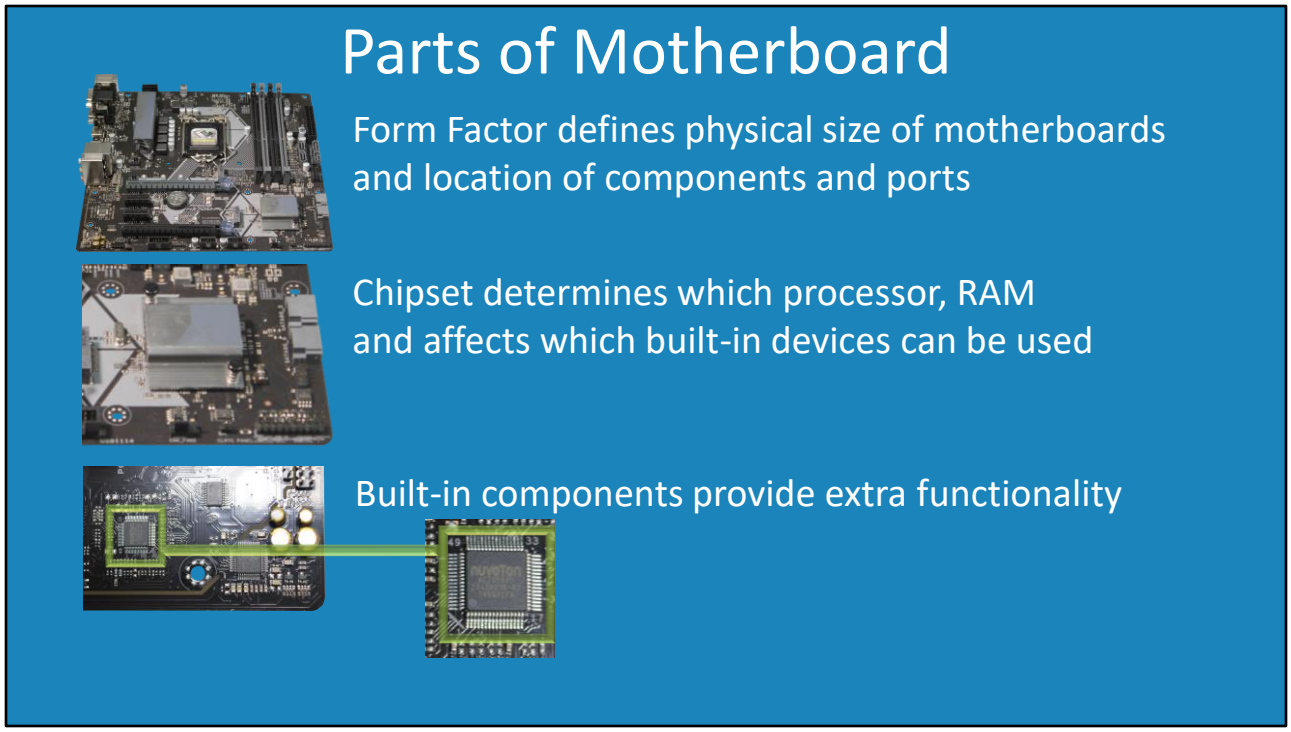
In this video from ITFreeTraining I will look at the different chips and components that make up a motherboard. Understanding these chips and components will give you a better understanding of what motherboard to buy.



0:12 To start with, I will first look at the different parts that make up a motherboard. The size and shape of motherboards are defined by what is called the form factor. The form factor defines the size of the motherboard, its shape and where different components can be put on the motherboard.

Since the form factor defines the size, shape and layout of the motherboard, it is the form factor that makes it possible for different motherboards from different manufacturers to be used in the same computer case. As long as the computer case supports the form factor, it will be able to be used in that case.

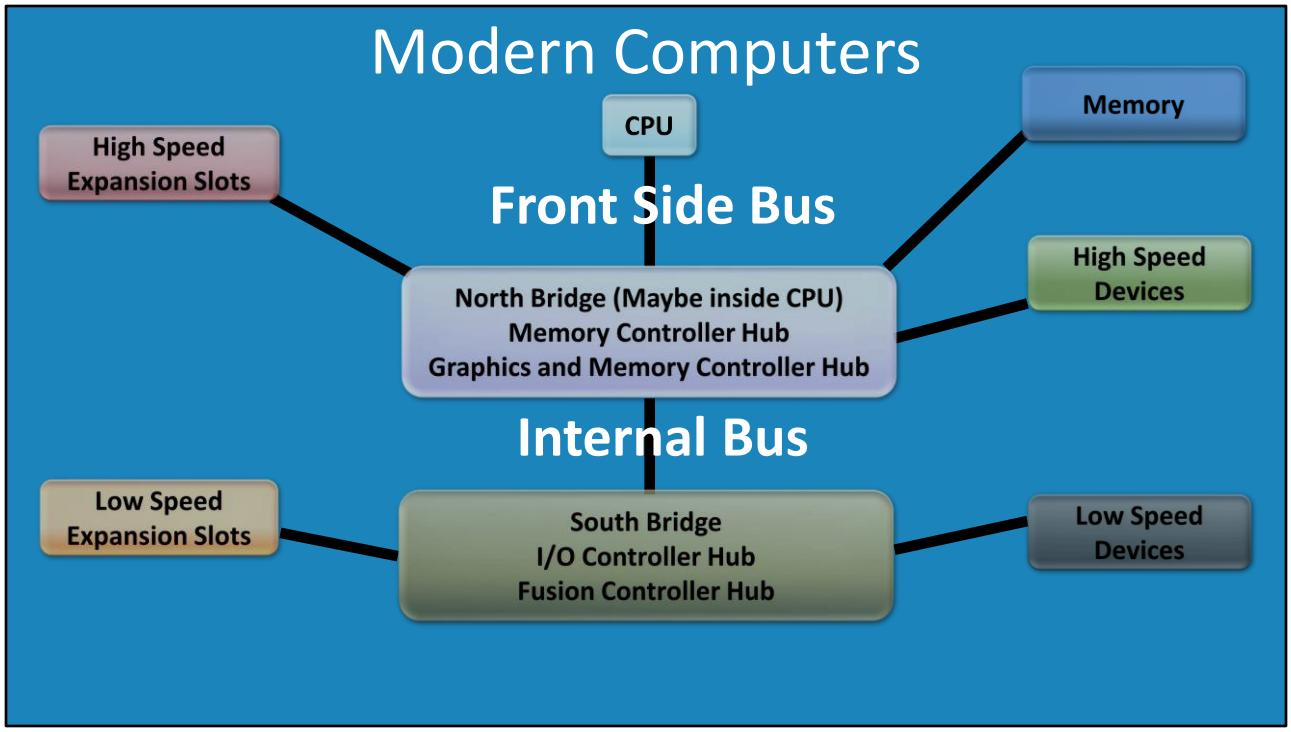
The next part of the motherboard is the chipset. The chipset determines which components (like processor and RAM) can be used. On this motherboard there is a single chip that provides these features. On some motherboards there will be two. Later in the video I will go into more detail about how the chipset works.

The chipset has an impact on which devices can be used with that motherboard. For example, it determines how many USB ports and hard disks the motherboard supports. I say has an impact, as the motherboard manufacturer is able to add more devices if they wish. The manufacturer is also free not to use all the features provided by the chipset if they don't wish to. Basically, the chipset provides the basic functions the manufacturer can use or add on if they wish to. They can use as little or as many of the chipset functions as they wish.

The last parts of the motherboard are the built-in components. On the motherboard you will

find a lot of additional chips. These chips provide additional functionality that are not included in the chipset. In these examples there are three chips that can be seen. This chip, for example, provides ethernet functionality.

In this example, the chipset provides the data channel for networking. However, the chip is required to provide all the functionality of a network card. Let's have a closer look at how it all works.



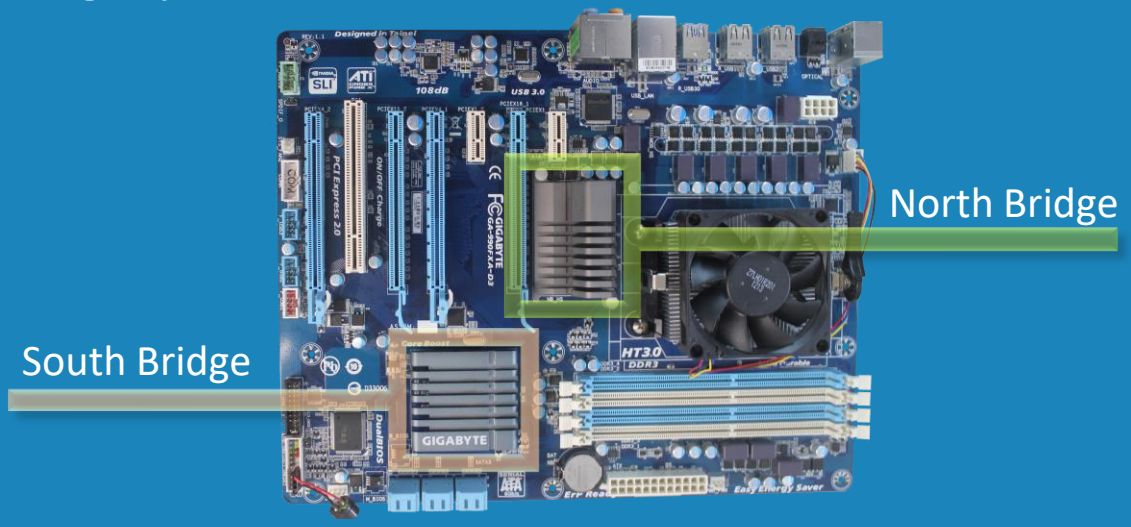
2:14 Modern computers, although they may look different, are designed in a similar way. To start with, you have the CPU. The CPU is connected to the North Bridge via a bus. This bus is known by a number of different names. One of the more commonly used names is the Front Side Bus by Intel.

The North Bridge may be a chip on your motherboard or it may be part of the CPU. It may also be referred to as the memory controller hub or graphics and memory controller hub. Regardless if there is a separate chip or if it is inside the CPU, its purpose is the same. The North Bridge connects high-speed expansion slots, memory and high-speed devices.

The North Bridge is connected to the South Bridge via an internal bus. The South Bridge is connected to the low-speed expansion slots and low-speed devices. Not all motherboards will have both a North Bridge and a South Bridge chip. However, all modern motherboards will follow this basic design.

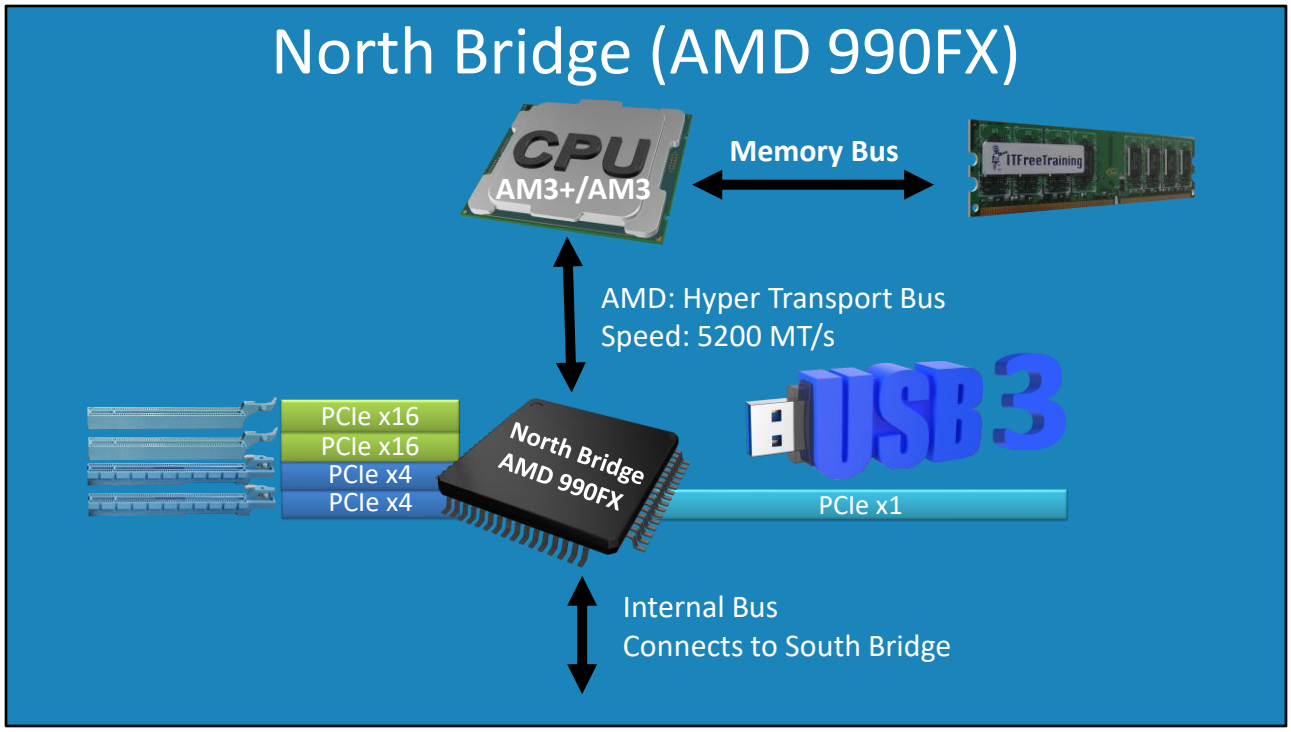
North Bridge/South Bridge MB

- Gigabyte GA-990FXA-D3



3:16 I will first look at a motherboard that has a North and a South Bridge chip. I will use a Gigabyte motherboard for this example. On this motherboard you can see the North Bridge chip near the CPU and the South Bridge chip next to the memory slots.

The CPU connects directly to the North Bridge and the South Bridge connects directly to the North Bridge. I will first have a closer look at the North Bridge.



3:40 So, using my Gigabyte motherboard as an example, this motherboard supports an AMD CPU. On this motherboard there is a memory bus that connects the memory directly to the CPU. In older motherboards you may find that the memory is connected to the North Bridge rather than the CPU. As technology improves, we are seeing a trend that more and more features are being put in the CPU rather than in the North Bridge. As we will see later in the video, a chip for the North Bridge may not even be present on the motherboard.

On this motherboard, the CPU is connected to the North Bridge chip by a high-speed bus. For AMD, the high-speed bus is called Hyper Transport Bus. In the case of Intel, it is called the Front Side Bus. The bus is a high-speed bi-directional bus. In the case of AMD, this is measured as Mega Transfers per second or MT per second. This effectively is a measurement of the actual data speed of the bus rather than the clock speed of the computer. It is done this way because data transmission has overhead and also it is possible to send multiple pieces of data in the same clock cycle. Mega Transfers is a measure of the actual data transfers that happen each second, removing overhead and accounting for multiple transfers per clock cycle. This gives a realistic indication of its speed.

Think of it this way, if you have two cars that travel at the same speed, if one car has two seats and the second car has four seats, the second car will carry more passengers because it has more seats. Using Mega Transfers per second, this gives an idea of how much data is transferred per second rather than how fast it runs. Mega Transfers makes it easy to compare motherboards to see which is faster. For example, if the car with two seats went 20% faster than the car with four seats, you could compare the two by comparing the number of people

transferred per second to see which performs better. You don't need to do the math of how long a car trip is, how many people are in each car and account for overhead such as how many times the car needs to stop during the trip. The same is true with Mega Transfers, it is one simple figure that can be used to compare different motherboards giving you a realistic measure taking into account all the other factors.

The North Bridge will also connect directly to high-speed devices. In the case of this motherboard, there are two PCI Express by 16 slots. The 'by' in the name refers to how many data paths there are from the North Bridge to the PCI Express slot. These physical data paths are called lanes. Each lane requires eight physical electrical paths on the motherboard. These electrical paths are referred to as traces. So essentially, each PCI Express by 16 slot requires 128 traces.

With two PCI Express slots, we are already up to 256 traces. So, you can start to understand why every device is not connected directly to the North Bridge. The number of pins the chip would need would be way to high.

On this motherboard there are also two PCI Express by 4 slots. This essentially means there are four lanes going to these PCI Express slots. It should be noted that these slots are the same size as the by 16 slots. So, when you put cards into a motherboard, make sure you are putting cards that can utilize 16 lanes in a by 16 slot. If for example, you are installing a high performing video card in a by 4 slot rather than a by 16 slot, this will affect the performance of the video card.

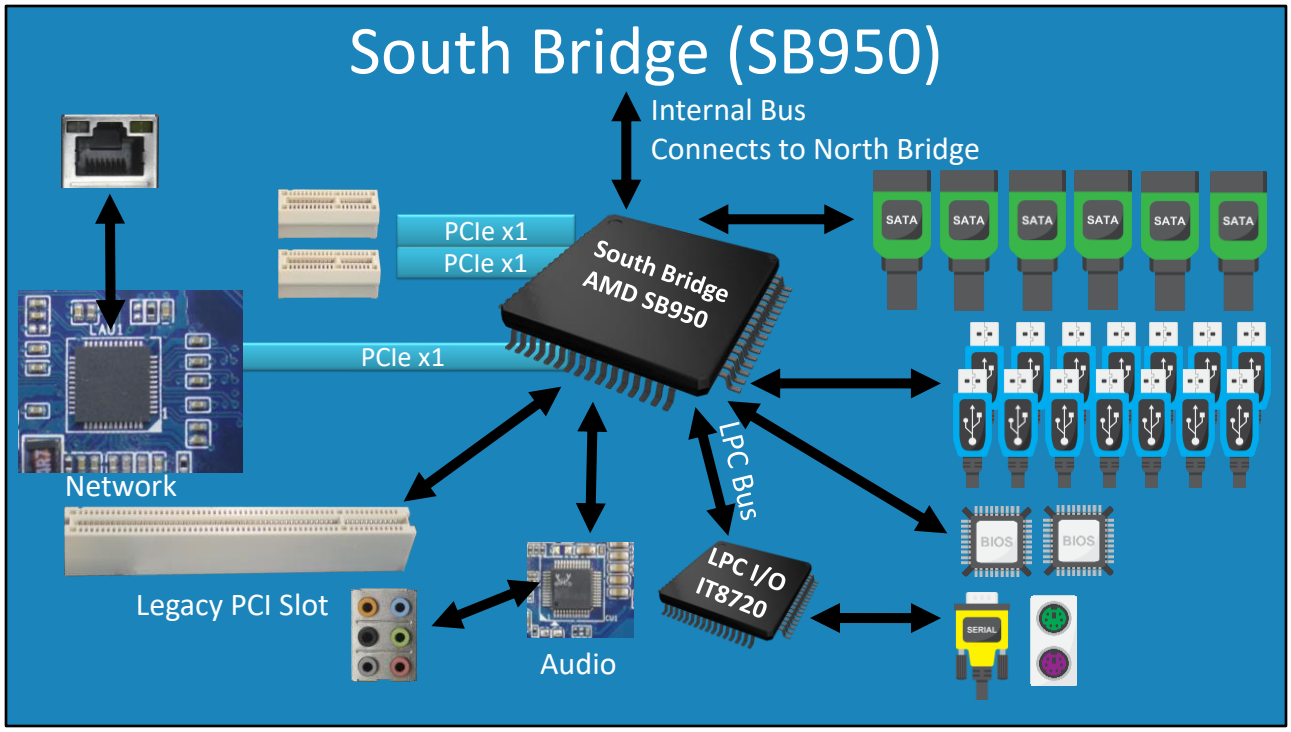
In this example, the four slots utilize a total of 40 lanes. Each lane requires eight traces. To connect all these slots directly to the North Bridge requires 320 pins. That's a lot of pins! You may find that on some motherboards when you put multiple expansion cards in the computer this may affect how many lanes are used in each slot. For example, the first slot may be a by 16, but when you use the second slot it may change both slots to eight lanes. Essentially, to limit the number of pins on the chip there is also a limited number of lanes. To improve performance, the North Bridge attempts to use the lanes as efficiently as possible.

This is not the case with this motherboard as it has dedicated lanes. Generally, if the motherboard has a lot of expansion slots there is more chance of this occurring. You will find that cheaper motherboards will have less available lanes and thus will allocate what lanes it has across multiple expansion slots.

The North Bridge also connects to some high-speed devices. In the case of this motherboard, it connects to two USB 3 ports. Also, in the case of this motherboard, this is done with one lane from the North Bridge. Depending on the motherboard, you may also have SATA 3 drives connected to the North Bridge. However, as

motherboards have become faster so has the South Bridge and some high-speed devices have been moved from the North Bridge to the South Bridge. Essentially, only the fastest devices in the computer will be found connected to the North Bridge. As motherboards get faster, the speed of older devices relative to everything else gets slower. Since the older devices are now considered slower devices compared with everything else, they get moved to the South Bridge. For example, USB 3 is connected to the North Bridge in this example, but if computers keep increasing in speed, USB 4 is likely to be connected to the North Bridge and USB 3, being the slower device, would be connected to the South Bridge.

The last connection is a connection from the North Bridge to the South Bridge. This is called the internal bus. This is still a relatively high-speed connection. In the case of this motherboard there are four lanes connecting the North Bridge to the South Bridge. So, you can see that there is still a lot of data that can be transferred to the South Bridge at one time.



9:56 I will now have a closer look at the South Bridge. The South Bridge connects to the slower devices on the computer. On this particular South Bridge, the two PCI Express by 1 slots are connected to the South Bridge. Since there is only one lane going to these slots, these slots don't have a huge need for data transfer and thus can be on the South Bridge.

The South Bridge connects to other components that are included on the motherboard. On this motherboard, there is a lane from the South Bridge to the network chip on the motherboard. This chip is connected to a plug which allows the computer to be plugged into a network. On most motherboards the chip will have writing on it to identify the chip. In this case, the writing has come off, but you can always look at the motherboard diagram in the motherboard manual to locate the chip.

It is up to the manufacturer of the motherboard to decide which components they add to the motherboard. For example, in the case of server motherboards, you may find that there are two network adapters on the motherboard.

The South Bridge will also connect to legacy slots and on this motherboard, there is one legacy PCI slot. Since these slots run very slowly compared to modern PCI Express slots, a large number of these legacy slots can be connected to the South Bridge as required. You will generally find that if you have legacy PCI slots on your motherboard you will also have a second crystal oscillator on the motherboard. The second crystal will provide a different clock cycle for the legacy PCI slot.

On this motherboard, there is a chip for audio. This chip is connected to the external connectors for the audio plugs. When you start looking at motherboards you will start noticing these chips. The Realtek audio chip has a logo on it which makes it easy to recognize. Keep in mind that Realtek also makes network adapters, so don't assume if it has the Realtek logo on it that it is an audio chip.

This motherboard has six SATA 3 connectors. The number of SATA connectors will be determined by how many the South Bridge supports and how many SATA plugs the manufacturer wants to put on the motherboard. You will find motherboards on the market with chipsets that support more features; however, the manufacturer has not implemented all the features available. For example, it might support 20 SATA connections, but only connects ten of them. It costs more money to implement every feature, so to make the motherboard cheaper to manufacture, not every feature may be implemented.

You may find that on older motherboards the SATA 3 connectors are on the North Bridge and the SATA 2 connectors are on the South Bridge. In the case of this motherboard, the South Bridge is fast enough to support SATA 3 connectors.

Next, this motherboard supports 14 USB 2 ports. Remember that two USB 3 ports are connected to the North Bridge. USB 2 is significantly slower than USB 3 so you can afford to have more of them connected to the South Bridge.

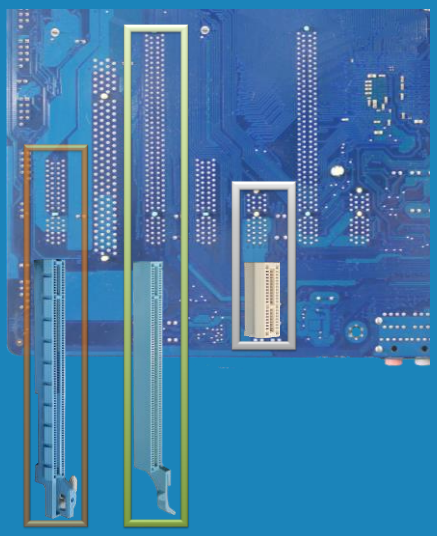
Next, this motherboard has two BIOS connections to the South Bridge. BIOS and UEFI will connect directly to the South Bridge. Since they don't need to run too quickly and are generally only used to start the computer up, they can be connected on a slow connection.

The last connection that I will look at is the LPC bus or Low Pin Count bus. The LPC bus is a slow connection to a chip that provides slow IO functions. On this motherboard it is referred to as the LPC I/O chip; on older motherboards it may be referred to as the Super IO chip.

The chip provides connections to low speed devices. On this motherboard, this is the serial and PS/2 mouse and keyboard. In the old days, devices like the serial port had their own chips. As time when on, these chips were combined together. With modern motherboards, these devices are considered legacy devices and are very slow compared to the rest of the computer. As time passes, less and less legacy devices will be supported until there is no need for this chip at all. In the case of the serial port for example, such a port is no longer provided in the IO area of this motherboard. If you want to use a serial port, a header on the motherboard is provided to plug a serial adapter in.

Before I look at a motherboard without a dedicated North Bridge chip, I will have a quick look at the back of the motherboard.

PCIe Slot Connectors



14:28 On the back of the motherboard, you can see the number of pins that each slot has. The first PCI slot is the PCI Express by 4 slot. Looking at the motherboard, you can see the numbers of pins on the motherboard.

If I compare that to a PCI Express by 16 slot, you can see it has a lot more pins. Lastly, if I look at the PCI Express by 1 slot, you will notice that it has the least number of pins. If you are not sure how many lanes the PCI Express slot supports, flip the motherboard over and have a look at how many pins there are. Just keep in mind, that if you have multiple cards in the same computer, your motherboard may reduce the number of lanes that go to each PCI Express slot.

MB Without North Bridge Chip

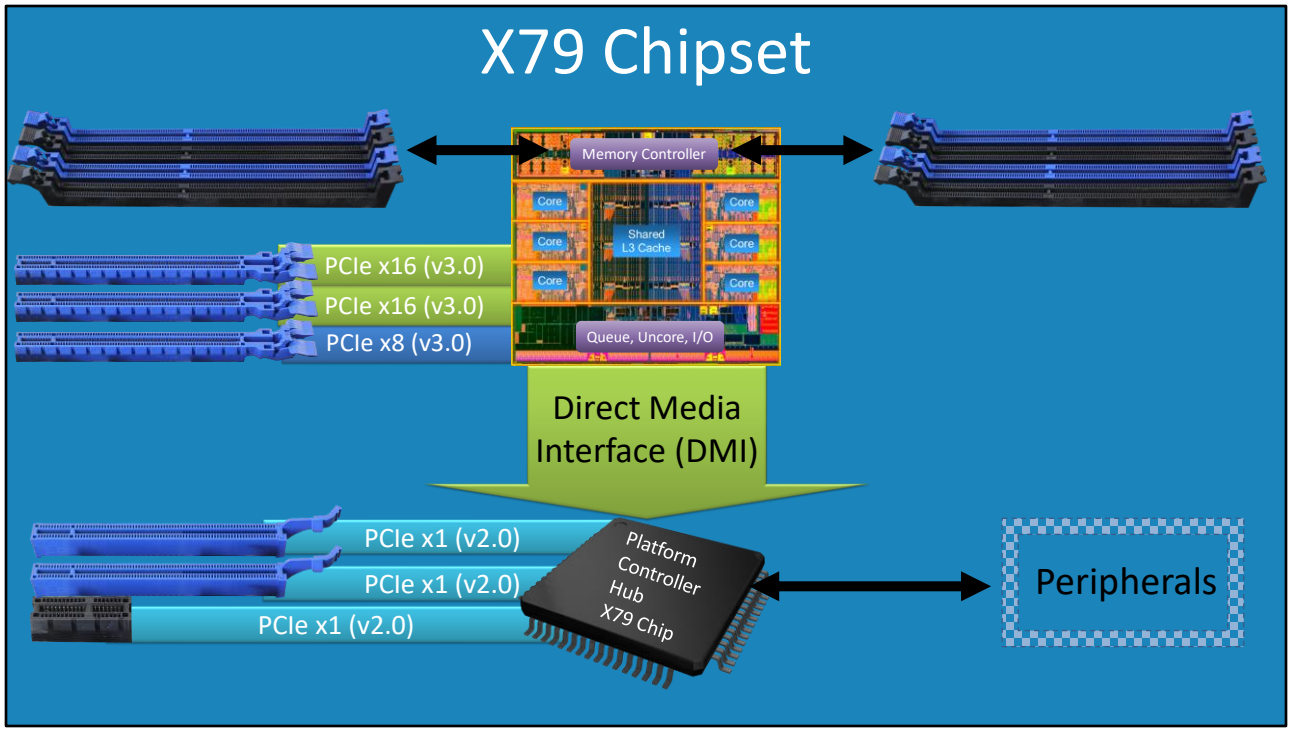
- Gigabyte X79A-GD45 (8D)

15:14 The next motherboard that I will look at is a Gigabyte motherboard that does not have a dedicated North Bridge chip. When looking at the specifications for a motherboard like this, you will not see in the specifications of a North Bridge and South Bridge chip, instead you will see it listed as a single chipset. On this motherboard, you will see the chipset is essentially one chip on the motherboard.

The question you may have, is why is it called a chipset if there is only one chip? Consider that you purchase a suit. The pants of the suit match the jacket. The suit is essentially a set. If you purchase a black suit, you most likely would purchase black shoes to match the suit. The shoes themselves are not part of the suit but you need to make sure they match the suit.

A chipset is the same idea. The chips need to be compatible with the other components on the motherboard. So, the chip will only work with certain CPUs and other components. Therefore, like the suit, everything needs to match. Thus, even though there is only one chip, the chip and the other components make a set. One cannot work without the other and they all need to be compatible.

I will now have a look at how a motherboard without a dedicated North Bridge chip works. I won't go into the same level of detail as with the previous example as it works much the same. I will focus more on the differences.



16:40 To start with, consider the CPU die of a processor. This is essentially a photo of the inside of a CPU. In this case the i7 4960. On older motherboards, the memory controller was found in the North Bridge. Here you can see, the memory controller is at the top of the CPU.

Since the memory controller is in the CPU, the CPU connects directly to the memory slots. For this reason, you need to be careful when purchasing a CPU for a motherboard, with what features and memory the CPU will support. For example, on this motherboard there are eight memory slots. This CPU will support eight memory slots; however, it is possible to purchase a CPU that will work in this motherboard that will only support four memory slots. If you want to use all eight memory slots on the motherboard, make sure the CPU supports it. The CPU will also determine the maximum amount of RAM the motherboard will support.

With these chipsets, you will also generally find that a select number of PCI Express slots will be connected directly to the CPU. These will generally be used for graphics cards, but you are free to put whatever expansion card in that you want. The number of lanes is determined by the CPU. In this case, this CPU has 40 lanes. It supports a number of different allocations of these 40 lanes; in this case the manufacturer has divided these up into 16, 16, and eight. In the case of this motherboard, all these PCI Express lanes are version 3.0.

Generally, the manufacturer of the motherboard will put the faster PCI Express slots closer to the CPU. However, don't assume the closest PCI Express slot is the fastest. In some cases, the motherboard manufacturer may put a full-sized slower PCI Express slot as the first expansion slot. This is generally done as there may be something on the motherboard that may get in the

way of the expansion card – most likely the memory modules. When this occurs, the motherboard manufacturer will generally not use the first expansion slot for the fastest slot due to the fact that the faster expansion cards are generally the larger ones.

In order to connect to the rest of the motherboard, the CPU has part of it dedicated to communicating with the motherboard. This is shown at the bottom. With Intel CPUs, the I/O part connects to the South Bridge via the Direct Media Interface or DMI.

In this example, since it is an Intel chipset, the South Bridge is called the Platform Controller Hub. In the case of AMD, the South Bridge is called Fusion Controller Hub. CompTIA will refer to this as the South Bridge so don't worry if you can't remember which is which.

Also, since this is an Intel example, the internal bus is called DMI, while on AMD it will be called Unified Media Interface or UMI. If you don't remember which is which, just refer to it as the internal bus.

As before, the South Bridge connects to the remaining devices. The first point to notice, on this example motherboard, is that there are three additional PCI Express expansion slots. Notice that each of these expansion slots are by one, meaning there is only one lane going to each expansion slot. Also notice that each expansion slot is also PCI Express version 2.0.

This shows the importance of making sure high-speed cards like video cards are put in the correct slot. In this example, putting a card like a high-speed video card in the wrong slot will reduce the video card from 16 lanes to one lane. The video card communication will be going via the South Bridge rather than directly to the CPU. This is much slower since it is going over a longer distance and with more overhead. The video card will be using PCI Express version 2 rather than 3. Version 3 of PCI Express can transfer about twice as fast as version 2 due to protocol and electrical improvements. You can understand why, when a video card is placed in the wrong slot, performance will be significantly reduced.

The last point to consider is that the remaining peripherals are also connected to the South Bridge. I won't worry about going through them because it is the same as with the previous example. Essentially the remaining devices will be connected to the South Bridge directly or the South Bridge will connect to another chip that will connect to these devices.

Summary

- Chipset. Collection of items that function as a unit
  - Chipset named after North/South Bridge
  - Not all motherboards will have a North Bridge
- Chipset will determine core features supported
  - CPU will determine some features
  - Additional features added with extra chips

21:09 Before finishing this video, I will do a quick summary of the major points. A chipset is a collection of items that function as a unit. The main component of the chipset are the North and South Bridges and thus the chipset is named after these chips.

A chipset will only work with certain other components. For example, a particular chipset will only support certain CPUs and memory types. The chipset is like the spinal cord that connects all the other components together, but just like a fruit salad, you have limited choices of what you can use. If you want to use vegetables, well that would require the salad chipset! An example of this would be that a certain chipset may support particular memory modules and CPUs while another supports different ones. Your needs will determine which chipset you will need.

Not all motherboards will have a North Bridge chip. In order to improve performance North Bridge functions may be moved into the CPU. This will make the CPU bigger and thus cost more, but performance is much better than having a separate North Bridge chip.

Ultimately, the chipset will determine all the core functions the motherboard will support. This includes how many expansion slots, USB ports and SATA connections the motherboard can have. In some cases, the CPU will also determine some of the features the motherboard will support. If the North Bridge is included in the CPU this will improve performance, but will also limit options on the motherboard. For example, if there is a memory controller on the motherboard, the manufacturer can use whatever memory modules they wish. If the memory controller is in the CPU, they are limited to what that CPU supports. Some CPUs may not

support all the memory slots on the motherboard, so check this before you purchase it.

Even if the chipset does not directly support a feature, additional features can be added using additional chips. Generally, network adapters and audio adapters will be included as extra chips. The manufacturer is free to add what chips they like. The speed of these devices will be limited by the whether they are connected to either the North or South Bridge.

That concludes this video on motherboards and chips. I hope you found this video informative. Until the next video from us, I would like to thank you for watching.

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