Funnel: is a mutual exclusion (mutex) mechanism that prevents more than one thread from accessing certain kernel resources at the same time. Each thread acquires a funnel when it enters a synchronized portion of the kernel, and releases it when it leaves. If a thread blocks (sleeps) while holding a funnel, the kernel forces the thread to automatically drop the funnel, thereby allowing other threads to enter the synchronized portion of the kernel. **Maze:** CPUs are built to run code that inherently can only run one step after another.

Thread: GPU is more dependent on multi-threaded performance than single-threaded, so you don't need to make each core as fast as possible. Adding cores is easier and requires less power than increasing clock speed.

Amdahl's law: can be formulated as follows: speedup = 1 / (s + p / N), where s is the proportion of execution time spent on the serial part, p is the proportion of execution time spent on the part that can be parallelized, and N is the number of processors. Amdahl's law states that, for a fixed problem, the upper limit of speedup is determined by the serial fraction of the code. This is called strong scaling. **Koomey law:** efficient doubles every 1.57 years. Because of the second law of thermodynamics and Landauer principle, the Landauer bound will be reached in 2048. **Gustafson's law:** is based on the approximations that the parallel part scales linearly with the amount of resources and the serial part does not increase with respect to the size of the problem. It provides the formula for scaled speedup scaled speedup = s + p × N **Moore Law:** roughly every two years, the numbers of transistors on microchips will double. **MTBT:** Mean time between failures is the predicted elapsed time between inherent failures of a mechanical or electronic system, during normal system operation. **Dennard Scaling:** As transistors are reduced in size, their power density stays constant. Meaning, power use stays in proportion with area, as both voltage and current scale (downward) with length. As transistors shrank so did the necessary voltage and current as power is proportional to the area of the transistor. However, Dennard scaling ignored the "leakage current" and "threshold voltage", which establish a baseline of power per transistor. As transistors get smaller, power density increases because these don't scale with size. **FPGAs:** FPGAs offer internal hardware blocks with user-programmable interconnects to customize operations for a specific applications. As the connections between blocks can readily be reprogrammed, changing the internal operation of the hardware, this enables an FPGA to accommodate changes to a design, or even support a new application, during the lifetime of the part. This makes them attractive for changing and evolving technology settings, such as digital television, consumer electronics, cybersecurity systems and wireless communications. **Memory wall:** CPU speeds are exceeding what RAM can keep up with due to natural latency.

clocks: GPUs are clocked no way lower than CPU, if you look back you can see that while CPU have been improving clocks at a really slow pace, GPUs have been improving clocks significantly so the difference is lower. Look also at the die size graph from Intel: GPUs being clocked lower, are much closer to the efficiency point and therefore get more of a clock boost with node shrinks. **CPU frequency/performance scalability:** Most modern processors can operate in several different clock frequency and voltage configurations. As a rule, the higher the clock frequency and the higher the voltage, the more instructions can be retired by the CPU over a unit of time, but also the more energy is consumed over a unit of time. Therefore, there is a natural tradeoff between the CPU capacity and the power drawn by the CPU. **CPU and GPU core:** The central architecture of the CPU is the core where all computation and logic happens. **Cache:** is super-fast memory built either within the CPU or in CPU-specific motherboards to facilitate quick access to data the CPU is currently using. **Memory Management Unit (MMU):** controls data movement between the CPU and RAM during the instruction cycle. **CPU Clock and Control Unit:** every CPU works on synchronizing processing tasks through a clock. So, the higher the CPU clock rate, the faster it will run, and quicker processor-intensive tasks can be completed.

CPU Advantage: 1. **Flexibility:** CPUs are flexible and resilient and can handle a variety of tasks outside of graphics processing. 2. **Precision:** CPUs can work on mid-range mathematical equations with a higher level of precision. 3. **Access to Memory:** CPUs usually contain significant local cache memory, hence, more complex system and computational operations. 4. **Cost and Availability:** CPUs are more readily available, more widely manufactured, and cost-effective for consumer and enterprise use. **CPU disadvantage:** 1. **Parallel Processing:** CPUs cannot handle parallel processing like a GPU. 2. **Slow Evolution:** in line with Moore Law, developing more powerful CPUs will eventually slow. 3. **Compatibility:** not every system or software is compatible with every processor. **GPU advantage:** 1. **high data throughput:** a GPU consist of hundreds of cores performing the same operation on multiple data items in parallel. So, it can push vast volumes of processed data. 2. **Massive Parallel Computing:** GPUs excel in extensive calculations with numerous similar operations, such as computing matrices or modeling complex systems, **Bitcoin Mining, Machine Learning, Analytics, and data Science. GPU disadvantage:** 1. **Multitasking:** GPUs aren't built for multitasking. Cost: While the price of GPUs has fallen somewhat over the years, they are still significantly more expensive than CPUs. 2. **Power and complexity:** While a GPU can handle large amounts of parallel computing and data throughput, they struggle when the processing requirements become more chaotic. **GPU:** GPU has small caches, simple control, energy efficient ALUs. Each ALUs have an arithmetic operation that can be executing every one stage of the ALUs so we can fully utilize the large number of ALUs to produce results in a very high throughput, which is suitable for hash cracking. Because hash cracking is used by Brute force, dictionary attack and look-up table. Each method requires a lot of computation. **IoT Security:** Data encryption, access control, monitoring every layer, network partners are safe.

OpenCL: 1. Discover and initialize the platforms and devices. 2. Create a context. 3. Create a command queue. 4. Create device buffers. 5. Write host data to device buffers. 6. Create and compile the program. 7. Create the kernel. 8. Set the kernel arguments. 9. Configure the work-item structure. 10. Enqueue the kernel for execution. 11. Read the output buffer back to the host. 12. Release OpenCL resources. **Cloud Automation:** Use process automation to simplify cloud management, simplify configuration management in the cloud, collect inventory and track changes, save time and reduce costs, integrate with services users rely on. **The cost of the cloud:** The unified management of resources in the virtual resource pool optimizes the physical resources to a certain extent. **Cloud disaster protection:** The backup is as follows: **CSBS:** Cloud Server Backup Service, which provides the whole machine backup function for cloud servers, supports local backup based on the consistent snapshot technology of multi-cloud hard disks, and remote replication of backup data, and supports the use of backup data Restore cloud server data, maximize the security and correctness of user data, and ensure business security. **VBS:** Backup service for cloud disks. Users can create backups for cloud disks, and use the backup data to roll back the cloud disks to maximize the correctness and security of user data.

SLA: A contract between an ISP and a customer that defines terms such as type of service, quality of service, and customer payment.

Cloud computing in the Industrial Internet of Things: The industry's requirements for network latency, stability, security and other indicators have been further improved, showing a trend of refinement, flexibility and intelligence, requiring the overall operation of cloud computing.

Edge computing: It refers to providing the nearest end service on the side close to the source of the object or data. Its applications are initiated on the edge side to generate faster network service responses and meet the basic needs of the industry in real-time business, application intelligence, security and privacy protection.

ASIC: It is designed specifically for its intended application. It has only the blocks required for optimum operation. It's best-suited for high-volume applications. The Tensor Processing Unit (TPU) by Google, for example, is an accelerator specifically for neural-network machine learning.

DSRC(Dedicated Short Range Communications) is wireless both-direction radiocommunication technology.

Duty Cycle: the time occupied by the cycle of operation of a machine or other device, especially as a percentage of available time.

DERC: dedicated short range communication is a wireless communication protocol most commonly encounter in vehicular networking context.

GPU offer a performance advantage in hash cracking: A GPU has hundreds of cores that can be used to compute mathematical function in parallel, hash cracking is one of the functions that can be done in parallel very easily.

Cluster, Grid, Cloud: 1. **Cloud:** Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services. 2. **Grid** is defined as a large collection as machines connected by a private network and offers a set of services to users, it acts as a sort of supercomputer by sharing processing power across the machines. 3. **Clusters** are two or more computers who share a network connection that acts as a heartbeat. Clusters can share some resources through configuration.

Industry 4.0: The combination of new technologies and organization of labor to push manufacturing into a new realm of optimization. It is a trend that focuses on creating smart factories through innovative communication and design between machines and humans. **Big data, analytics and IoT:** There are so many sensors in the factory and data collect into a big data, then analysis those data. **RUL:** remaining useful life. **TTF:** time to failure.

Cloud: Iaas: (Infrastructure-as-a-service) cloud infrastructure services are made of highly scalable and automated compute resources. IaaS is fully self-service for accessing and monitoring computers, networking, storage, and other services. IaaS allows businesses to purchase resources on-demand and as-needed instead of having to buy hardware outright. **Iaas drawbacks** are the possibilities of provider security issues, multi-tenant systems where the provider must share infrastructure resources with multiple clients, and service reliability. **PaaS:** (Platform-as-a-service) is another step further from full, on-premise infrastructure management. It is where a provider hosts the hardware and software on its own infrastructure and delivers this platform to the user as an integrated solution, solution stack, or service through an internet connection. **Paas advantage:** simple, cost-effective development, scalable, highly available, reduction in the amount of coding needed. **Paas disadvantage:** data security, customization of legacy systems, runtime issues, operational limitation. **SaaS:** (Software-as-a-service) also known as cloud application services, is the most comprehensive form of cloud computing services, delivering an entire application that is managed by a provider, via a web browser. **Saas advantages:** reducing the time and money spent on tedious tasks such as installing, managing, and upgrading software. **SaaS disadvantages:** interoperability, lack of integration support, data security. **OwnCloud** is a suite of client–server software for creating and using file hosting services. The Server Edition of ownCloud is free and open-source, allowing anyone to install and operate it without charge on their own private server. **Private Clouds** are cloud environments solely dedicated to the end user, usually within the user's firewall. Although private clouds traditionally ran on-premise, organizations are now building private clouds on rented, vendor-owned data centers located off-premise. **Public clouds** are a type of computing in which a service provider makes resources available to the public via the internet. Resources vary by provider but may include storage capabilities, applications, or virtual machines. **Edge Cloud** as an interchangeable cloud ecosystem encompassing storage and compute assets located at the edge and interconnected by a scalable, application-aware network that can sense and adapt to changing needs, securely and in real-time. **Hybrid cloud:** Hybrid cloud refers to a mixed computing, storage, and services environment made up of on-premises infrastructure, private cloud services, and a public cloud with orchestration among the various platforms. **Multi-cloud** is a company's use of multiple cloud computing and storage services from different vendors in a single heterogeneous architecture to improve cloud infrastructure capabilities and cost. It also refers to the distribution of cloud assets, software, applications, etc. across several cloud-hosting environments.

Cloud Automation: Use process automation to simplify cloud management, simplify configuration management in the cloud, collect inventory and track changes, save time, and reduce costs, integrate with services users rely on. The cost of the cloud: The unified management of resources in the virtual resource pool optimizes the physical resources to a certain extent. **Cloud disaster protection**: The backup is as follows: **CSBS**: Cloud Server Backup Service, which provides the whole machine backup function for cloud servers, supports local backup based on the consistent snapshot technology of multi-cloud hard disks, and remote replication of backup data, and supports the use of backup data Restore cloud server data, maximize the security

and correctness of user data, and ensure business security. **VBS**: Backup service for cloud disks. Users can create backups for cloud disks and use the backup data to roll back the cloud disks to maximize the correctness and security of user data. **SLA**: A contract between an ISP and a customer that defines terms such as type of service, quality of service, and customer payment. **Cloud computing in the Industrial Internet of Things**: The industry's requirements for network latency, stability, security, and other indicators have been further improved, showing a trend of refinement, flexibility, and intelligence, requiring the overall operation of cloud computing. **Edge computing**: It refers to providing the nearest end service on the side close to the source of the object or data. Its applications are initiated on the edge side to generate faster network service responses and meet the basic needs of the industry in real-time business, application intelligence, security, and privacy protection. **Service-Level Agreement**: It stands for Service Level Agreement. A contract between an Internet SERVICE PROVIDER and a customer that defines terms such as type OF service, quality of service, and payment to the customer. Cloud computing in the Industrial Internet of Things: the requirements of industry on network delay, stability, security, and other indicators have been further improved, showing the trend of refinement, flexibility, and intelligent development, which requires the overall operation of cloud computing. **CPA**：consistency, availability, partition tolerance. **Storage**: Large amounts of data can be stored remotely and accessed easily. Clients only must pay for storage that they use. **Workload resilience**. CSPs often implement redundant resources to ensure resilient storage and to keep users' important workloads running -- often across multiple global regions. **Cloud performance**. Performance -- such as **latency** -- is largely beyond the control of the organization contracting cloud services with a provider. Network and provider outages can interfere with productivity and disrupt business processes if organizations are not prepared with contingency plans. **Disaster proofing** with cloud-based services, organizations can quickly recover their data in the event of emergencies, such as natural disasters or power outages. This benefits BCDR and helps ensure that workloads and data are available even if the business suffers damage or disruption. **Fog** is an architecture that distributes computation, communication, control, and storage closer to the end users along the cloud-to-things continuum. Sometimes the term "fog" is used interchangeably with the term "edge," although fog is broader than the typical notion of edge. The relevance of fog/edge is rooted in both the inadequacy of the traditional cloud and the emergence of new opportunities for the Internet of Things, 5G and embedded artificial intelligence. **IoT Security**: Data encryption, access control, monitoring every layer, network partners are safe. **Coin mining**: Cryptocurrency mining was initially performed using cpus. However, its limited processing speed and high-power consumption lead to limited output, which makes CPU-based mining process inefficient. Because the mining process needs to be more efficient when performing similar double calculations. The mining device repeatedly tries to decode different hash values, with only one digit changing in the hashed data in each attempt. **Keras** is an open-source artificial neural network library written in Python, which can be used as a high-level application interface for **Tensorflow**, Microsoft-CNTK and Theano to design, debug, evaluate, apply, and visualize deep learning models. **TensorFlow** is an end-to-end open-source machine learning platform. **Distributed Ledger Technologies: 1. Blockchains: A. Key features:** traceability, decentralization and security. **B. Limitations:** scalability. **C. Future development** -> **1st layer:** Sharding, **2nd layer:** off-chain solutions, State channels, sidechains. **D. Interledger approaches:** Sidechains, Ledger-of-ledgers approaches > **NDL:** interoperability, scalability, decentralization, safety / **NDL Retis:** a single blockchain network / **NDL Integra:** connection with different blockchain networks. **2. Directed Acyclic Graphs: A. Key features:** scalable and efficient. **B. Limitations:** be vulnerable to attacks, centralized validators. **C. Future development:** No central coordinators for decentralization. **Ledger:** proof-of-work, proof-of-stake. **P2P:** A peer-to-peer sevice, the status of all communication nodes is equal, each node plays the dual role of client and server, and the nodes realize file information and processor computing power through direct communication. storage space and other resources are shared.

Block Chain: 1. Advantages: 1. Collective maintenance 2. Decentralization 3. No need to trust the system 4. Information cannot be tampered with. **2. Disadvantages:** 1. No privacy 2. Supervision 3. Security issues 4. Delay in data confirmation