SEC-205: Distributed Ledger and Blockchain

Lecture 3: Decentralization

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Today's Agenda

- In today's lecture, we will explore and learn about:
  - Centralized vs. Distributed vs. Decentralized
  - Methods of Decentralization
  - Full-Ecosystem of Decentralization
  - Decentralization in Practice

Can you think of a centralized system?

In a small or medium food court in a department store, there will be a cash card counter that every customer should exchange their money to a cash card.

Bottleneck!

A long queue?

Out of Resources!

Out of cash cards?

The staff at counter cannot go to the toilet?

Availability!

Can you think of a centralized system?

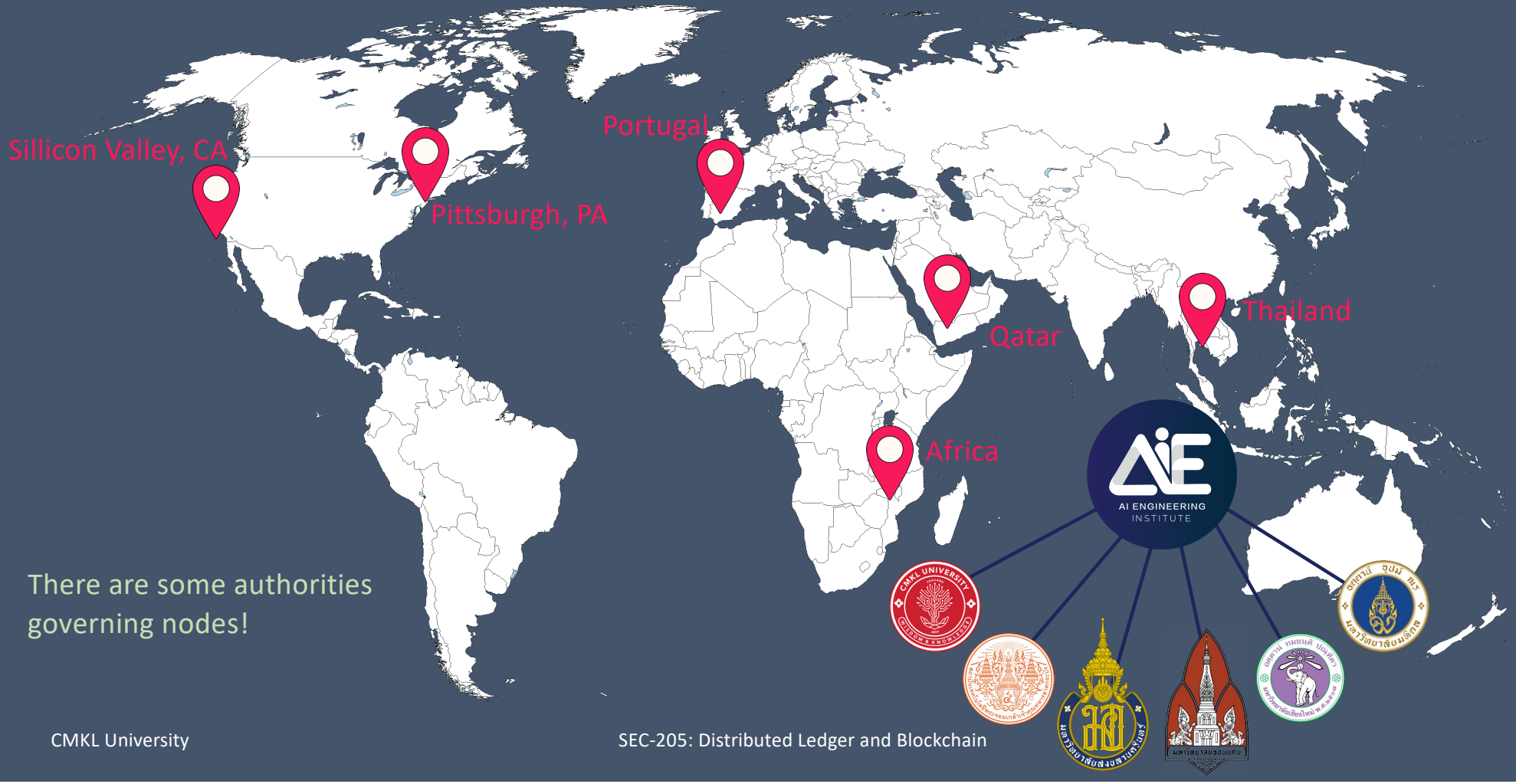
Food Court

Can you think of a centralized system?

Governance Issues?

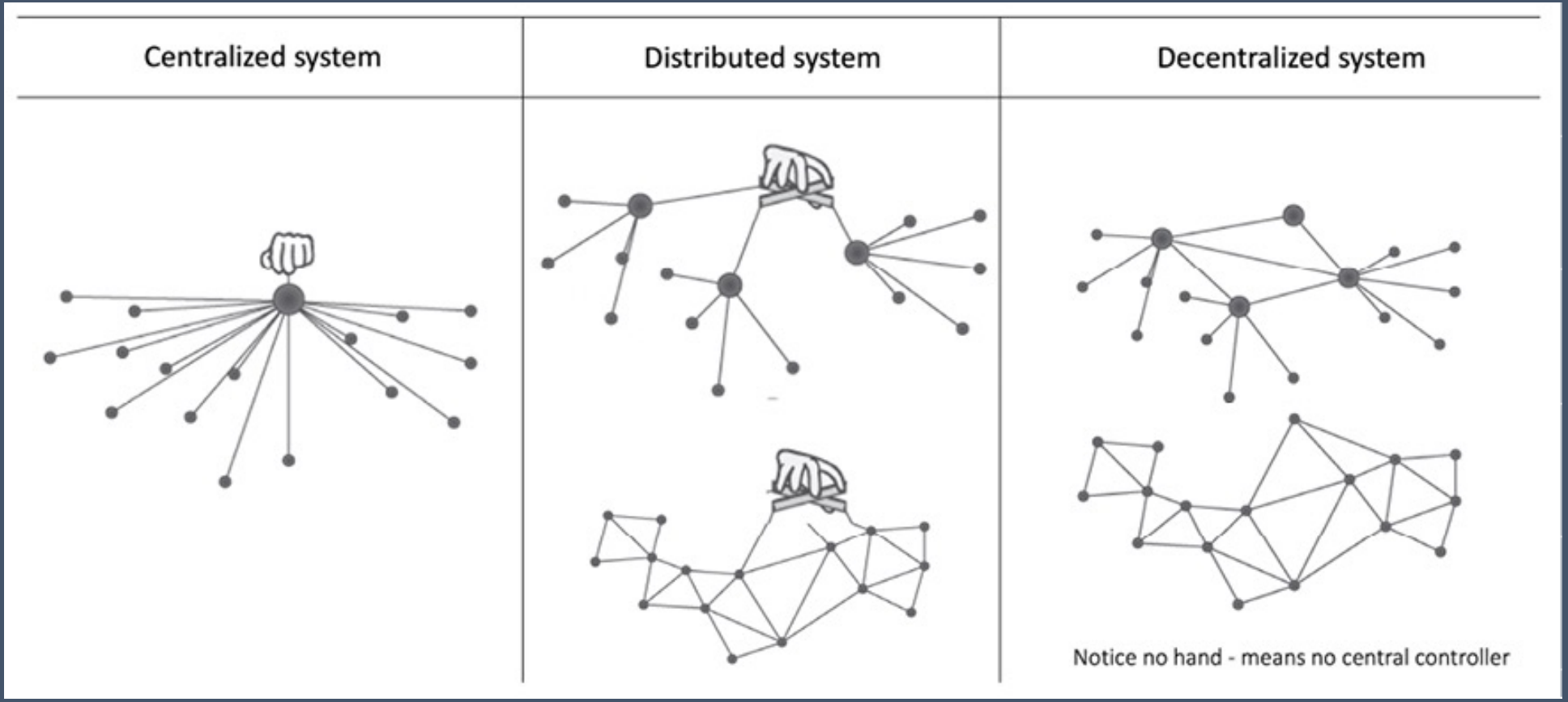
Manager of the food court

Can you think of a distributed system?

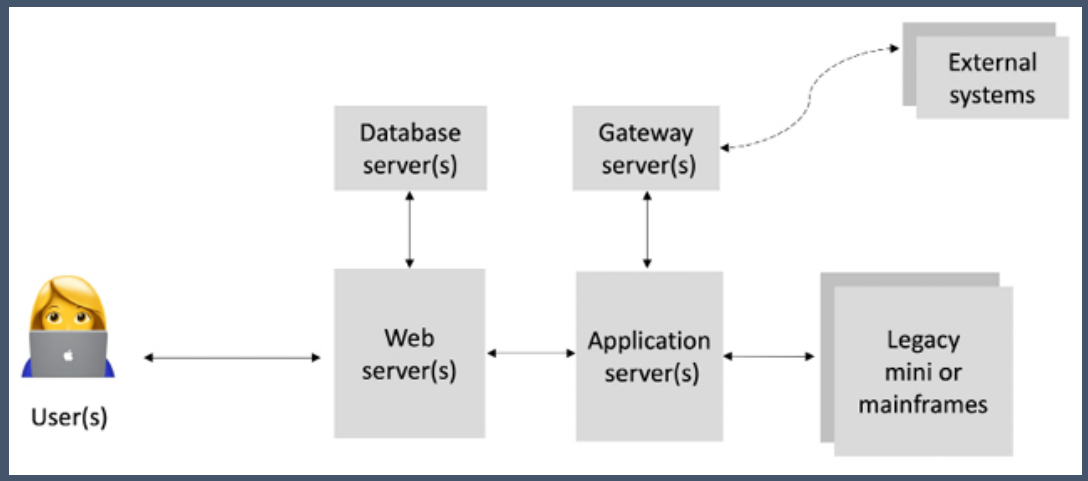


There are some authorities governing nodes!

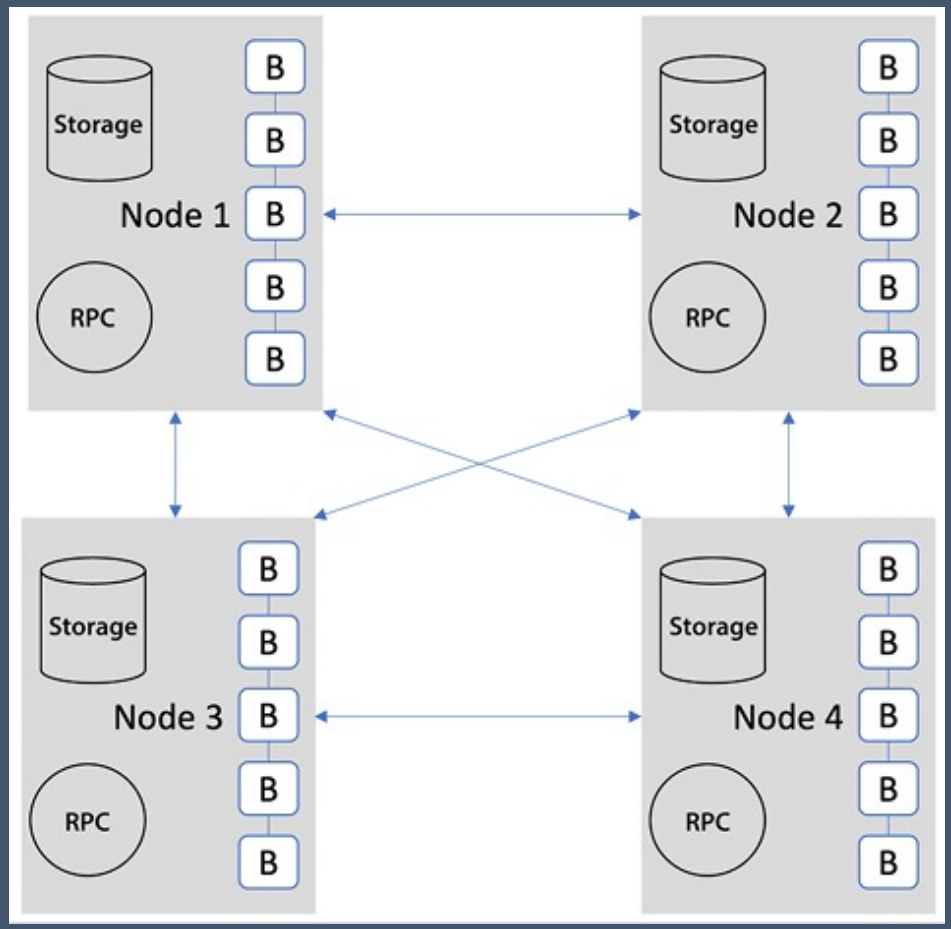
Centralized vs. Distributed vs. Decentralized



Distributed vs. Decentralized Systems



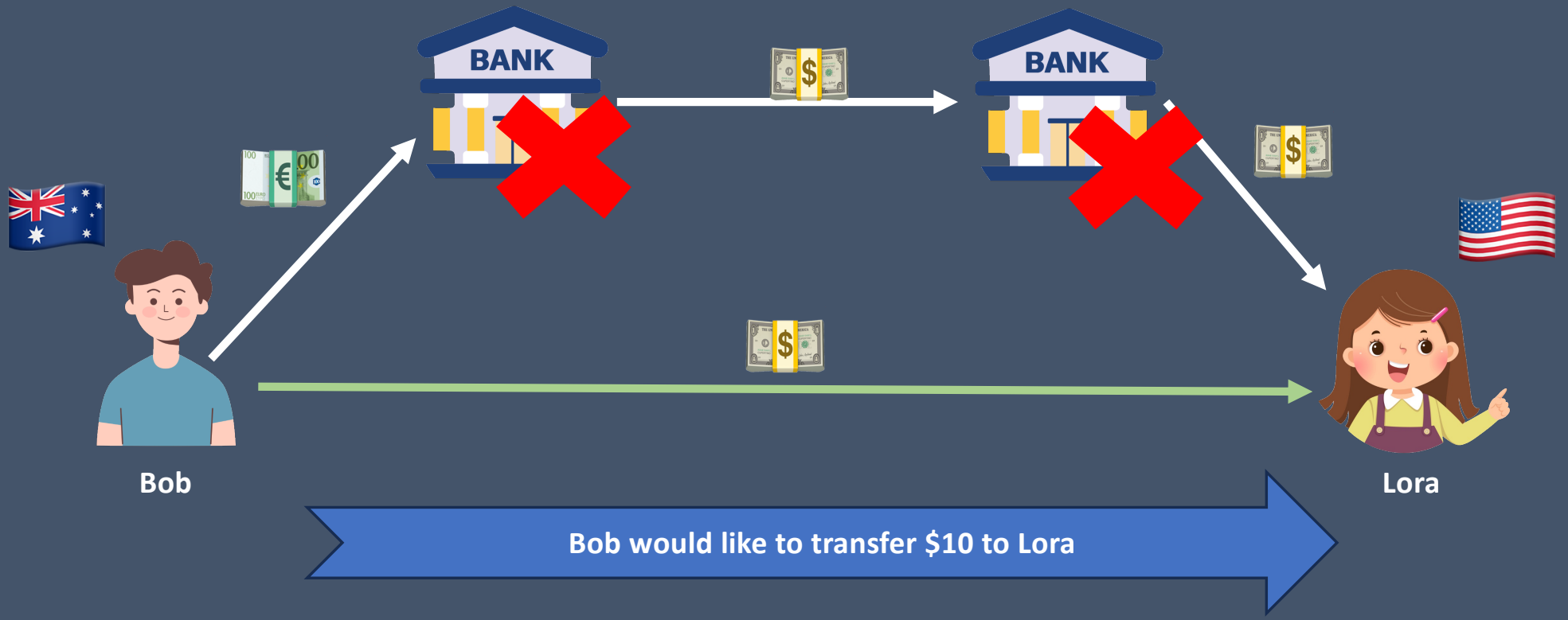
A traditional distributed system comprises many servers performing different roles.



A blockchain-based decentralized system (notice the direct P2P connections and the exact replicas of blocks (data))

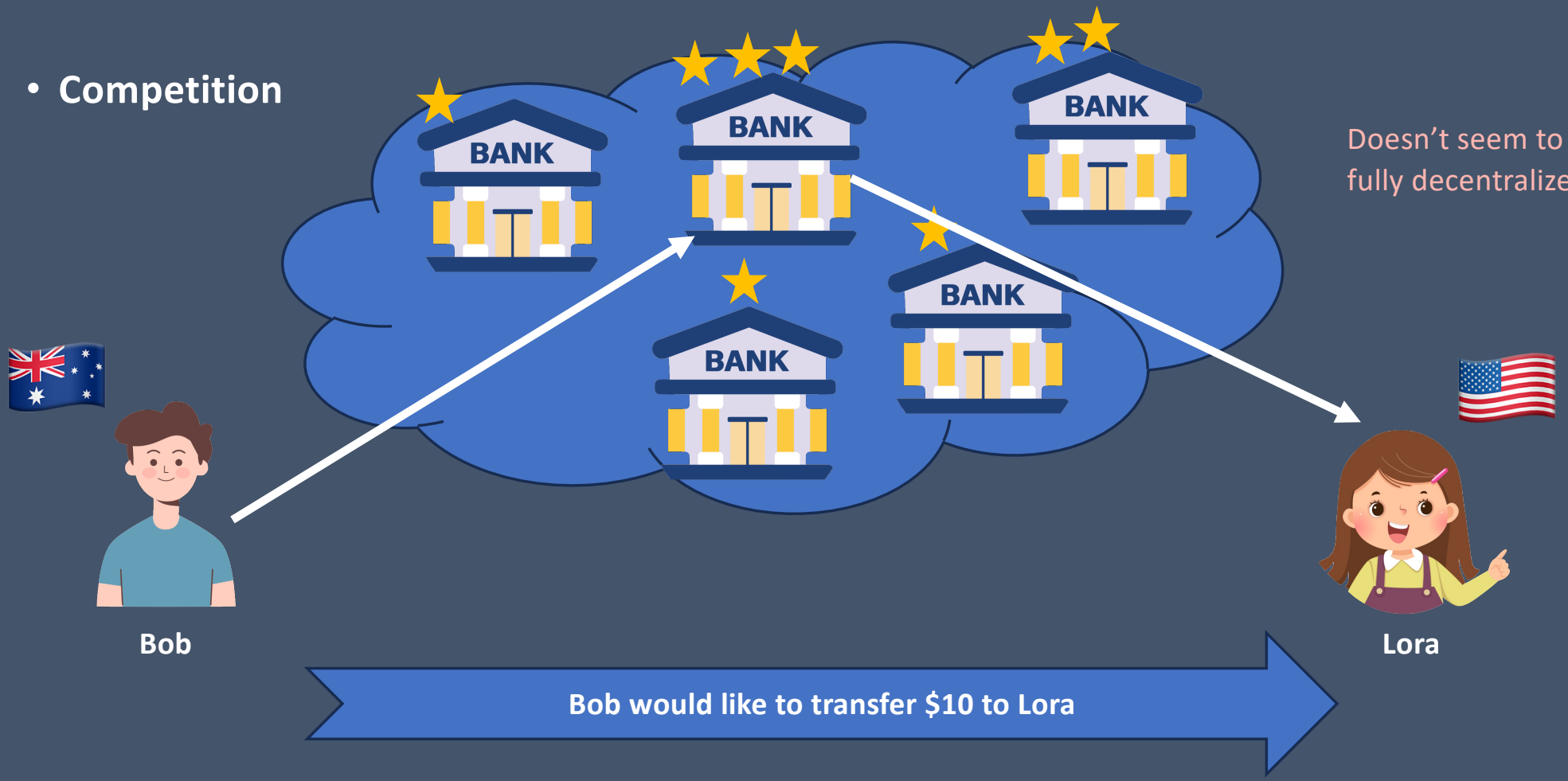
Methods of Decentralization

- **Disintermediation**



Methods of Decentralization

- **Competition**



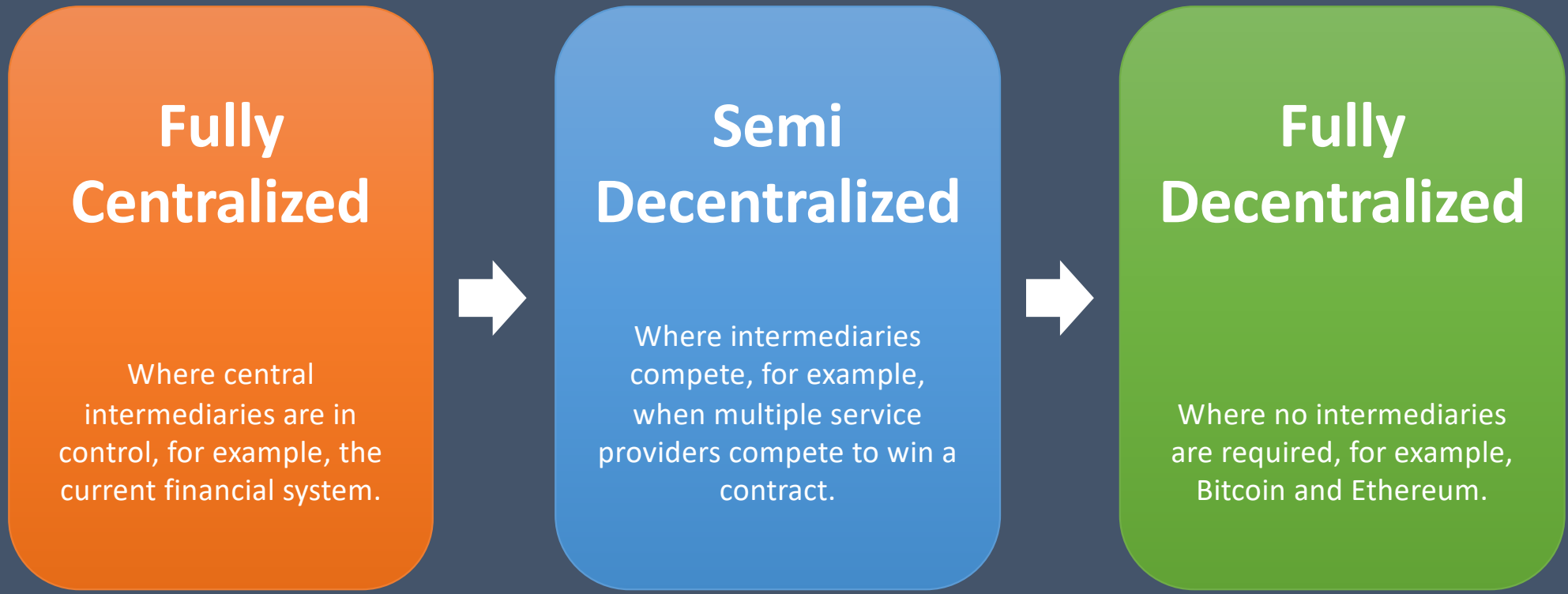
Doesn't seem to be fully decentralized!

Methods of Decentralization

- **Competition – Real World?**

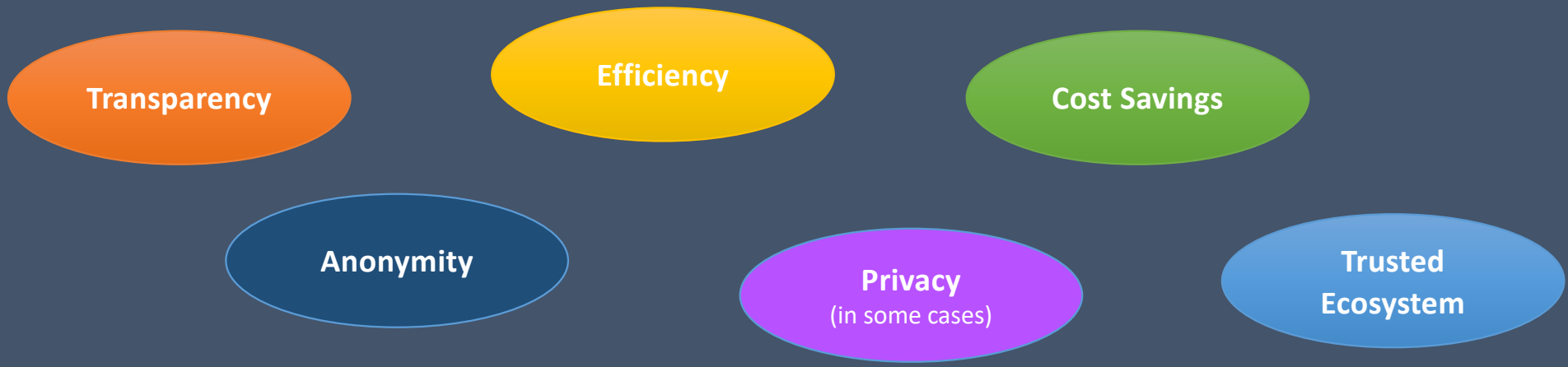
Quantifying Decentralization

- It is possible that there will not be always fully decentralized in some senses.



Benefits of Decentralization

- There are many benefits of decentralization, including:



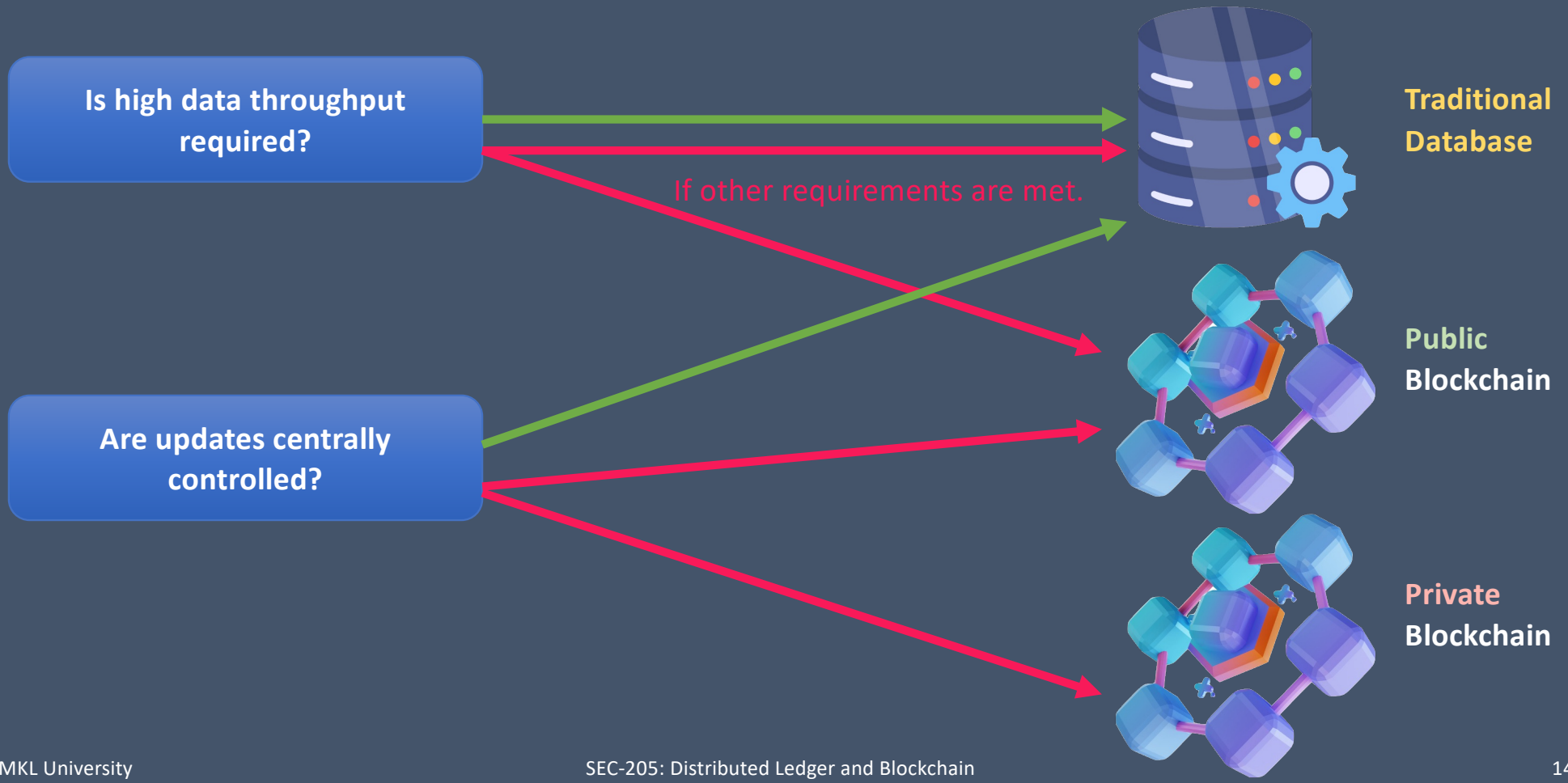
However, we cannot decentralize everything! You can think of a system that required high throughput in data processing, but it has to wait for consensus mechanisms in Bitcoin.

Is a blockchain really needed?

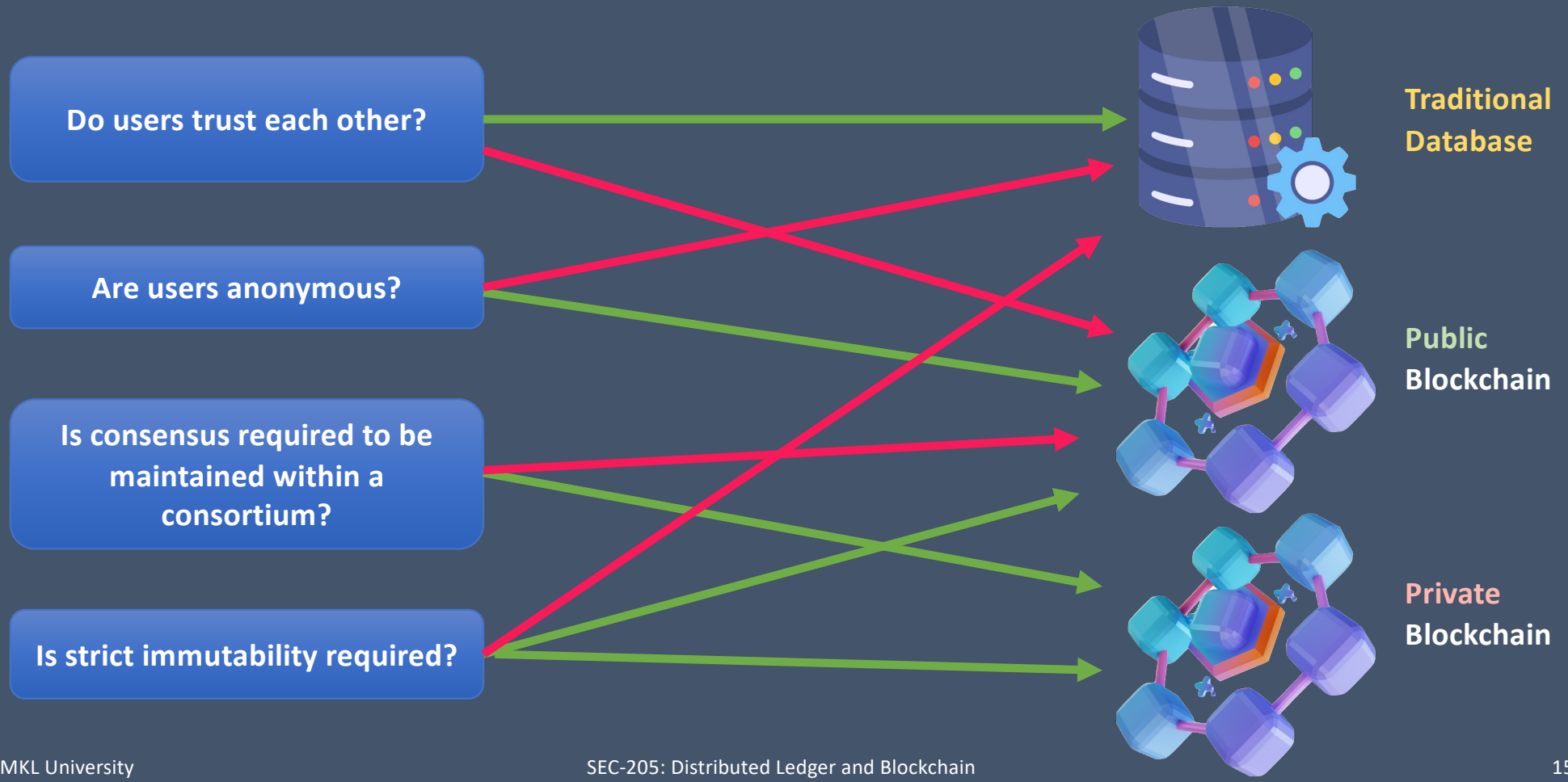
When is a blockchain required?

In what circumstances is preferable to traditional databases?

When do we need a blockchain or decentralized system?



When do we need a blockchain or decentralized system?



Evaluating Requirements for Decentralization

- Arvind Narayanan et al. have proposed a framework that can be used to evaluate the decentralization requirements of a variety of issues in the context of blockchain.

What is being decentralized?:

This can be any system, such as an identity system or a trading system.

What level of decentralization is required?:

This can be full disintermediation or partial disintermediation.

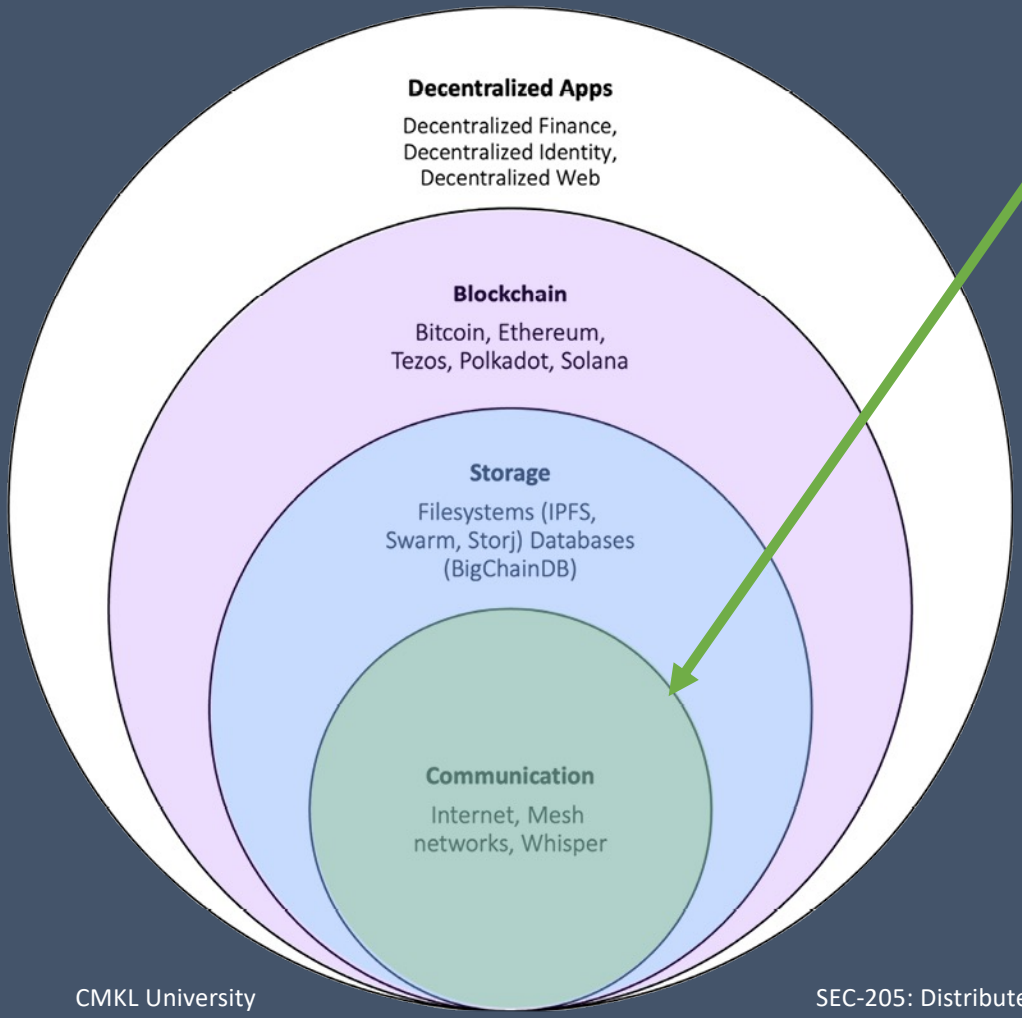
What blockchain is used?:

It can be the **Bitcoin** blockchain, **Ethereum** blockchain, or any other blockchain that is deemed fit for the specific application.

What security mechanism is used?:

For example, the security mechanism can be atomicity-based, where either the transaction executes in full or does not execute at all. This deterministic approach ensures the integrity of the system. Other mechanisms include those based on reputation, which allows for varying degrees of trust in a system.

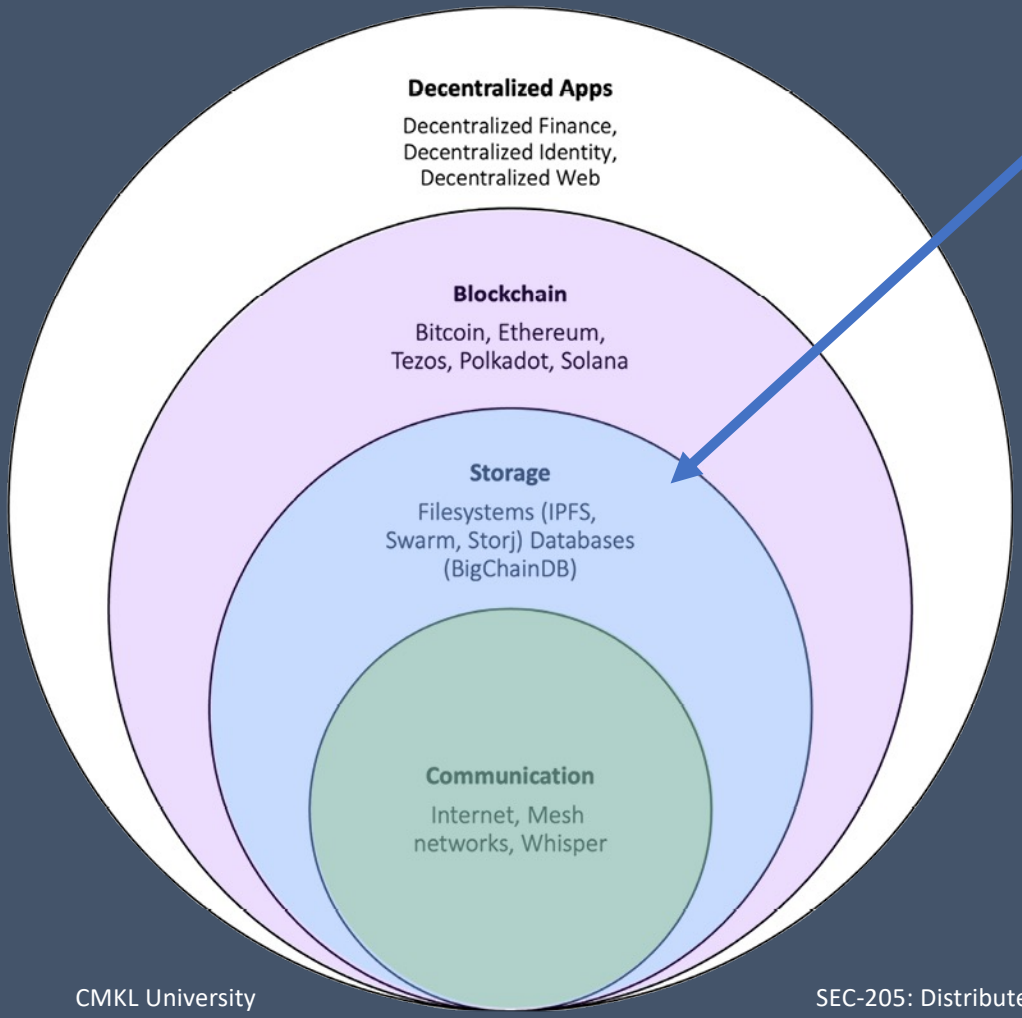
Full-Ecosystem Decentralization



Communication

- **Internet** appears to be decentralized to some extent.
- Access to the internet is controlled by **Internet Service Providers (ISPs)**.
- An alternative is to use **mesh networks**, e.g., Bluetooth Low Energy (BLE), where nodes in relative proximity can *talk directly to each other* without the need of the internet.

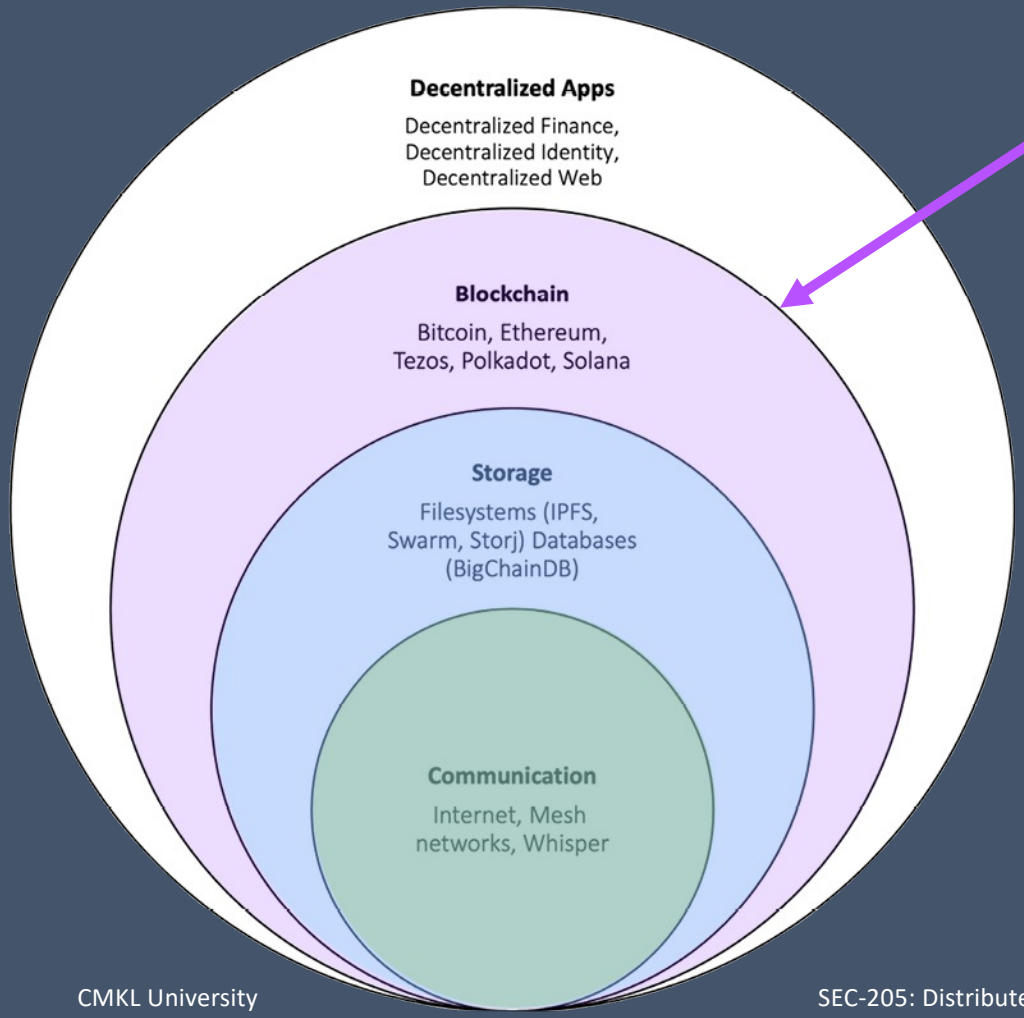
Full-Ecosystem Decentralization



Storage

- Data can be stored directly on blockchain.
- However, blockchain is not suitable for storing large amounts of data by design.
- **Distributred Hash Table (DHT)** is very famous for P2P file-sharig system, such as BitTorrent.
  - It requires node availability.
- Storage must be:
  - High Availability
  - Stable for links to nodes.
- A solution for decentralized storage is **Inter-Planetary File System (IPFS)**.

Full-Ecosystem Decentralization



Computing Power

- The decentralization of computing power is achieved by a blockchain, such as Ethereum, where smart contracts with embedded business logic can run on the blockchain network.

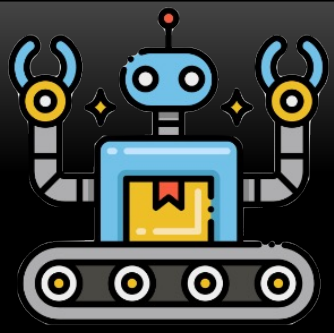
Decentralization in Practice

Smart Contracts:

- A smart contract is a software program that is usually run on blockchain.
- A smart contract contains some business logic and a limited amount of data.
- The business logic is executed if specific criteria are met.
- Actors or participants use these smart contracts, or they run autonomously on behalf of the participants.

Autonomous Agents:

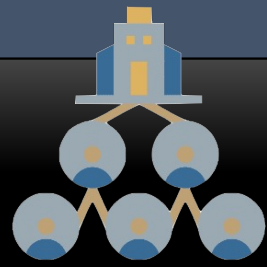
- An Autonomous Agent (AA) is a software entity (artificially intelligent or traditionally programmed) that acts on the behalf of its owner to achieve some desirable goals without requiring any or minimal intervention from its owner.



Decentralization in Practice

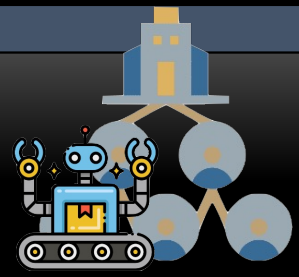
Decentralized Organizations (DOs):

- DOs are software programs that run on a blockchain and are based on the model of real-life organizations with people and protocols.



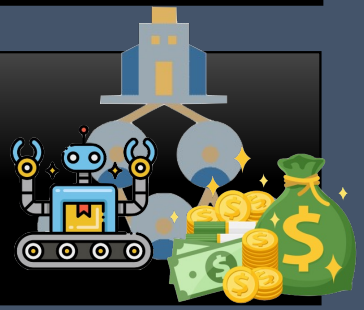
Decentralized Autonomous Organizations (DAOs):

- DOs and DAOs are fundamentally the same thing, except DAOs are autonomous.
- DAOs are fully automated and contain artificial intelligent logic.



Decentralized Autonomous Corporations (DACs):

- DACs are like DAOs in concept.
- DAOs are usually considered to be nonprofit, whereas DACs can earn a profit via shares offered to the participants and to whom they can pay dividends



Decentralization in Practice

Decentralized Applications (DApps):

- DAOs, DACs, and DOs come under the broader umbrella of decentralized applications, abbreviated to DApps (Pronounced Dee-App).
- DApps are used to refer to applications that run on top of a blockchain in a peer-to-peer network.
- DApps can be run with different methods (categorized into three types):

Type 1: These applications run on their own dedicated blockchain, e.g., Ethereum Smart Contract.

Type 2: These applications use an existing established blockchain but bear custom protocols and tokens.

Type 3: These applications use the protocols of Type 2 DApps. USDT can be considered a Type 3 DApp, where the OMNI layer protocol (a Type 2 DApp) is used, which is itself built on Bitcoin (a Type 1 DApp).

Decentralization in Practice

- The following comparison table highlights the key properties of and differences between these different types of decentralized entities:

Entity	Autonomous?	Software?	Owned?	Capital?	Legal Status?	Cost
DO	No	No	Yes	Yes	Yes	High
DAO	Yes	Yes	No	Yes	Some work has initiated	Low
DAC	Yes	Yes	Yes	Yes	Unsettled	Low
DApp	Yes	Yes	Yes	Optional	Unsettled	Use Case Dependent

Decentralized Web

- Decentralized web is a term that's used to describe a vision of the web where no central authority or set of authorities will be in control.
- Once intended and developed as decentralized, open and free protocols are now being dominated by powerful commercial entities around the world, which has resulted in major concerns around privacy and data protection.

Web 1.0

This is the original World Wide Web, which was the era when static web pages were hosted on servers and usually only allowed read actions from a user's point of view.

Web 2.0

This is the era when more service-oriented and web-hosted applications started to emerge around 2003. E-commerce websites, social networking, social media, blogs, multimedia sharing, mashups, and web applications are the main features of this period.

Web 3.0

This is the era that will be fully user-centric and decentralized without any single authority, large organization, or internet company in control. Other fast-growing and exciting applications include decentralized identity and decentralized finance (DeFi).

Today's Agenda

- At this point of today's lecture, you have already learned about:
  - Centralized vs. Distributed vs. Decentralized, which are different depending on the network topology and the governance power.
  - Methods of Decentralization, including disintermediation, and competition.
  - Full-Ecosystem of Decentralization that covers communication, storage, and computing power on blockchain.
  - Decentralization in Practice, e.g., DOs, DAOs, DACs, DApps, and the vision of decentralized web, including Web 1.0, Web 2.0, and Web 3.0.

End of the lecture! 

Please feel free to ask any questions.

If you need further discussion, please contact me:

- Email me at charnon@cmkl.ac.th
- Appoint me for 1-on-1 discussion during the office hours.