Federarted Learning

Traditional Energy Management System

- The energy sector has relied on CENTRALISED energy management systems.
- A central authority oversees the generation, distribution, and consumption of energy.
- Examples -
    - Traditional Grid Systems : Electricity is generated in large power plants (e.g., coal, nuclear, hydroelectric) and distributed to consumers via a network of transmission lines
    - Third-Party Management : For example, in the U.S., companies like PJM Interconnection manage wholesale electricity markets where they buy electricity from generators and sell it to utilities

Drawbacks of Centralized Models

- Single Point of Failure : The centralized nature of these models creates a single point of failure. Any disruption, cyber-attack, or failure at the central control can cause widespread outages.
- High Infrastructure Costs : Maintaining centralized grids, involves significant costs, including infrastructure setup, maintenance, and cybersecurity measures.
- Lack of Transparency : Consumers in centralized systems often receive a single electricity bill without clear information on the actual costs or sources of energy.

Alternate Approaches

1) Blockchain-Based Energy Models

- <u>Peer-to-Peer (P2P) Energy Trading</u> : Consumers can trade excess energy resources with neighbors using blockchain technology. This decentralized approach eliminates the need for a central authority, making transactions transparent, tamper-proof, and more efficient.

- <u>Tamper-Proof Transaction Records</u> : Every energy transaction is recorded on a blockchain ledger, which cannot be altered, ensuring transparency and trust between parties.

- <u>Automate Transactions</u> : Smart contracts can be programmed to execute automatically when certain conditions are met. For example, if Bob's battery level drops below 30%, a smart contract triggers a purchase of energy from Alice.

Issues with Blockchain models

- Scalability Issues : As more participants join a blockchain-based energy network, the number of transactions increases, facing issues as transaction times slow down with network congestion.

2) AI-Assisted Energy Systems

- Predictive Energy Management Models : AI and ML to analyze IoT sensor data and predict energy consumption patterns, enabling businesses to optimize their energy use. Eg:- it can predict peak usage hours in an office building and adjust systems accordingly to save energy.

- AI-powered device provides detailed real-time statistics of household appliance energy consumption, allowing users to make informed decisions about their energy use.

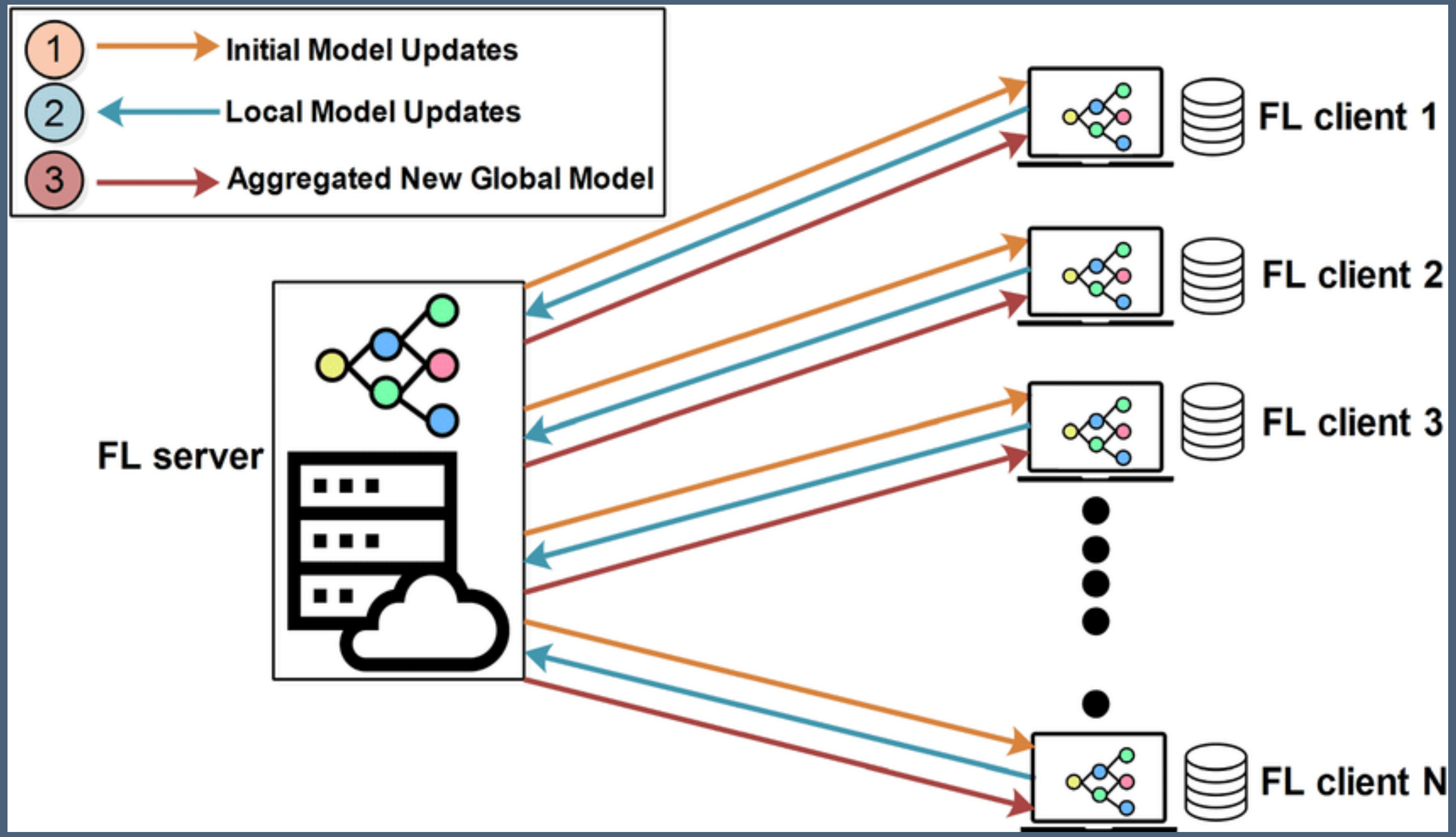
Limitations of AI-Assisted Systems

- Data Privacy Concerns : Centralized AI models require access to large amounts of consumer data. For instance, in smart home systems, sensitive data on daily activities could be exposed to cyber threats.

- Dependence on Centralized Infrastructure : AI models often rely on centralized data storage and processing, which may lead to bottlenecks and potential single points of failure.

Federated Learning

- Federated Learning (FL) is a decentralized machine learning approach where multiple edge devices collaboratively train a model while keeping the data localized.



- Data Privacy and Security: Unlike traditional AI models that require central data storage, FL allows data to remain on local devices while only sharing model updates.

- Improved Fault Tolerance : The decentralized nature of FL reduces the risk of single points of failure. If one or more nodes fail, the rest of the network can continue functioning.

- Enhanced Scalability : FL supports a scalable architecture where new devices and energy sources can easily join the network without requiring significant changes to the core infrastructure