Cloud Computing (CS60118)

(Spring 2020-2021)

Fog Computing

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Cloud Computing

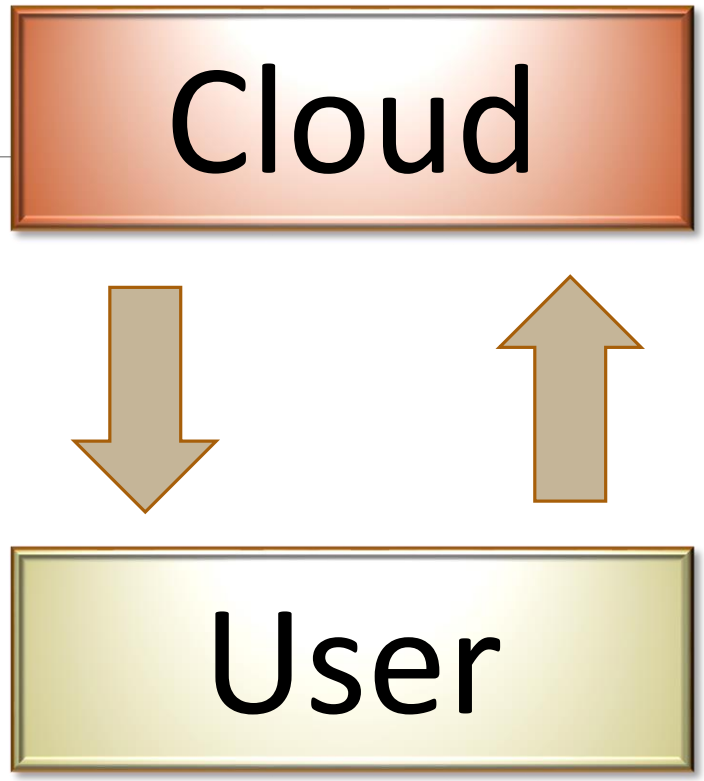
Remote access of applications and data

Device Independent

Virtual services

Scalable computing resources

Reduced capital and maintenance overheads

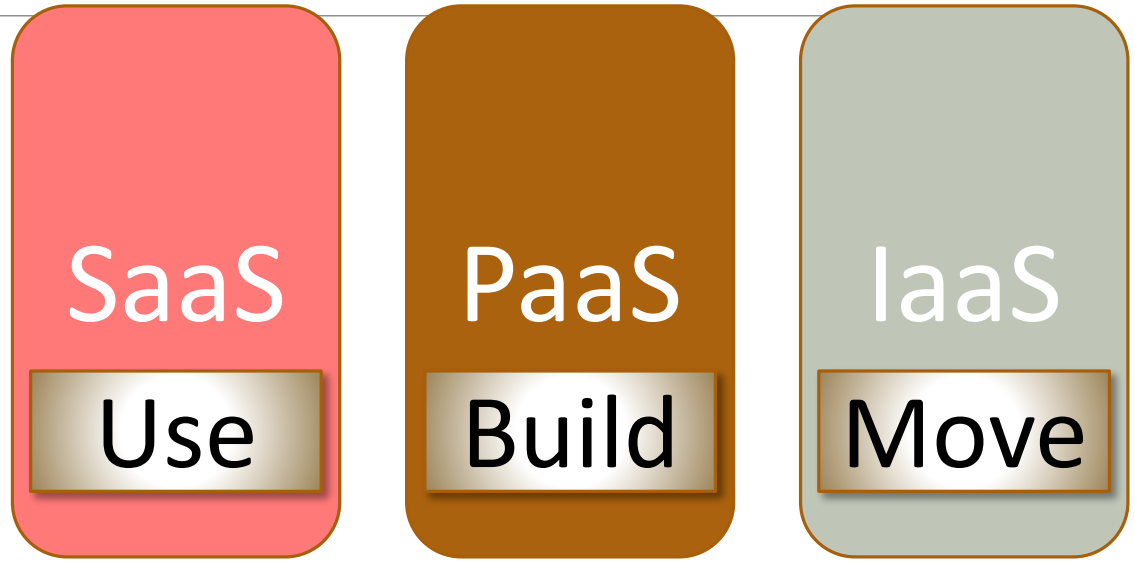


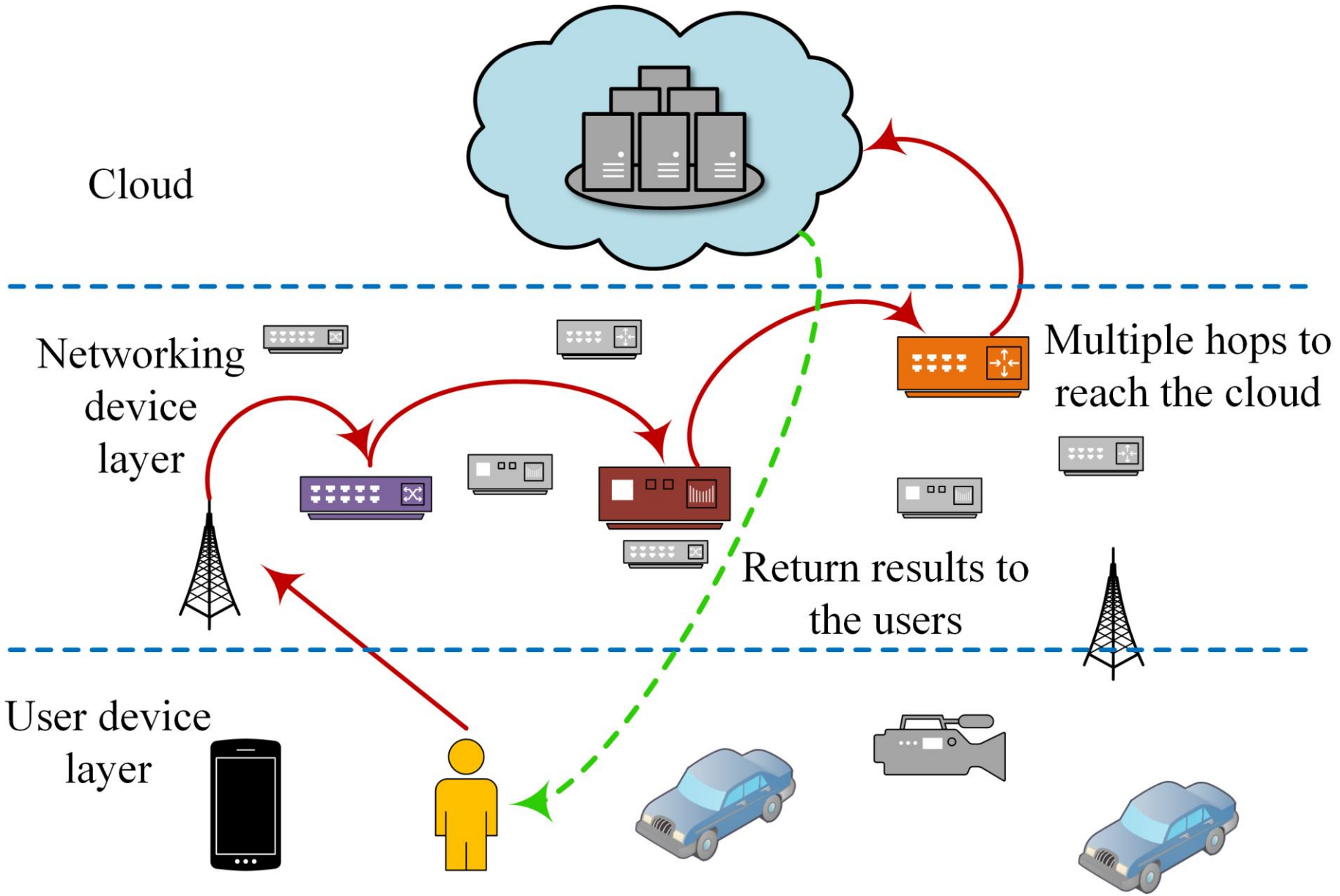
Cloud Computing Services

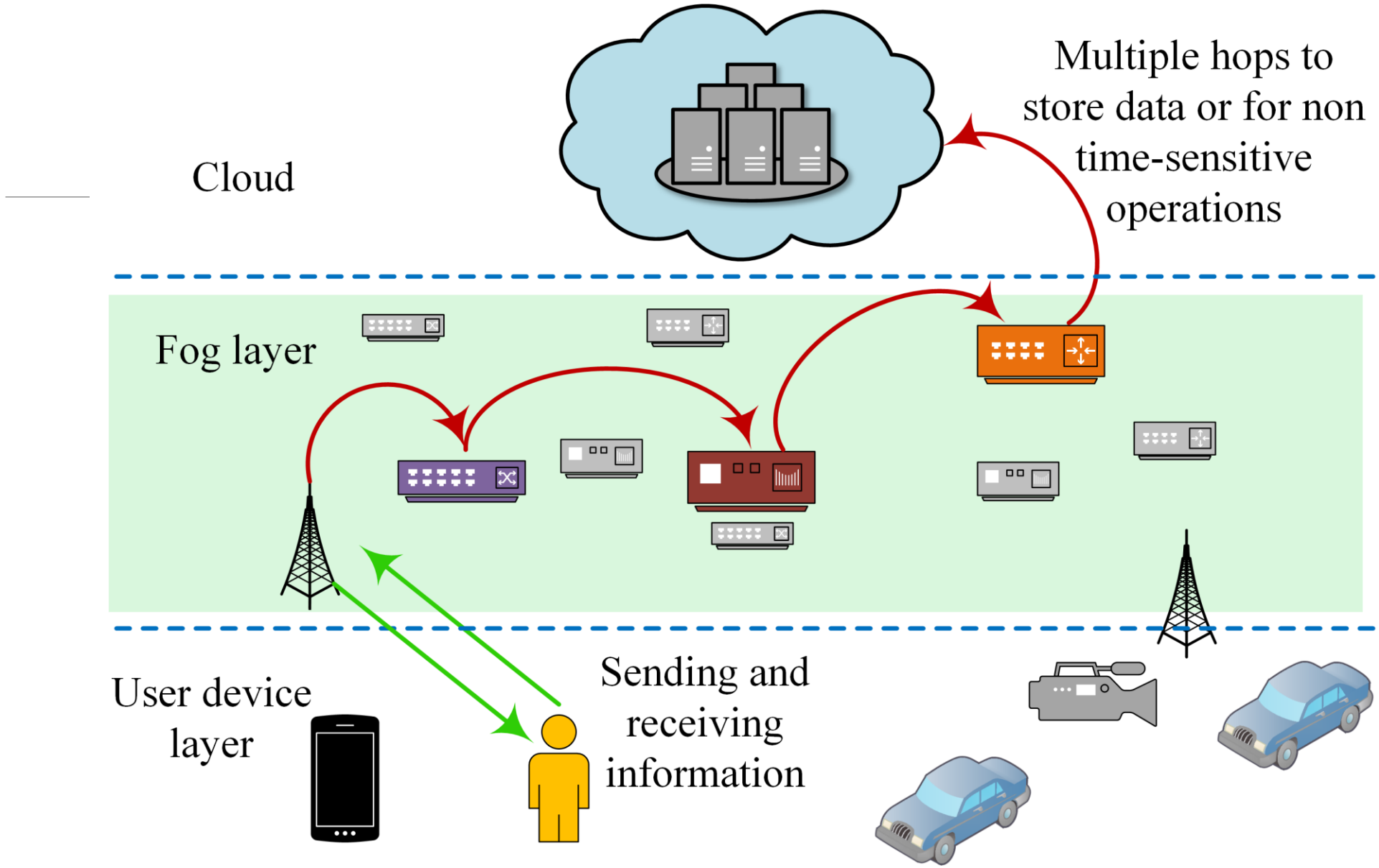
Software as a Service (SaaS)
- Ready-made softwares
- Hosted on remote servers
- Example: Google's Gmail, Docs, and Sheets

Platform as a Service (PaaS)
- Framework for developing applications
- Most web hosting solutions
- Example: Google App Engine

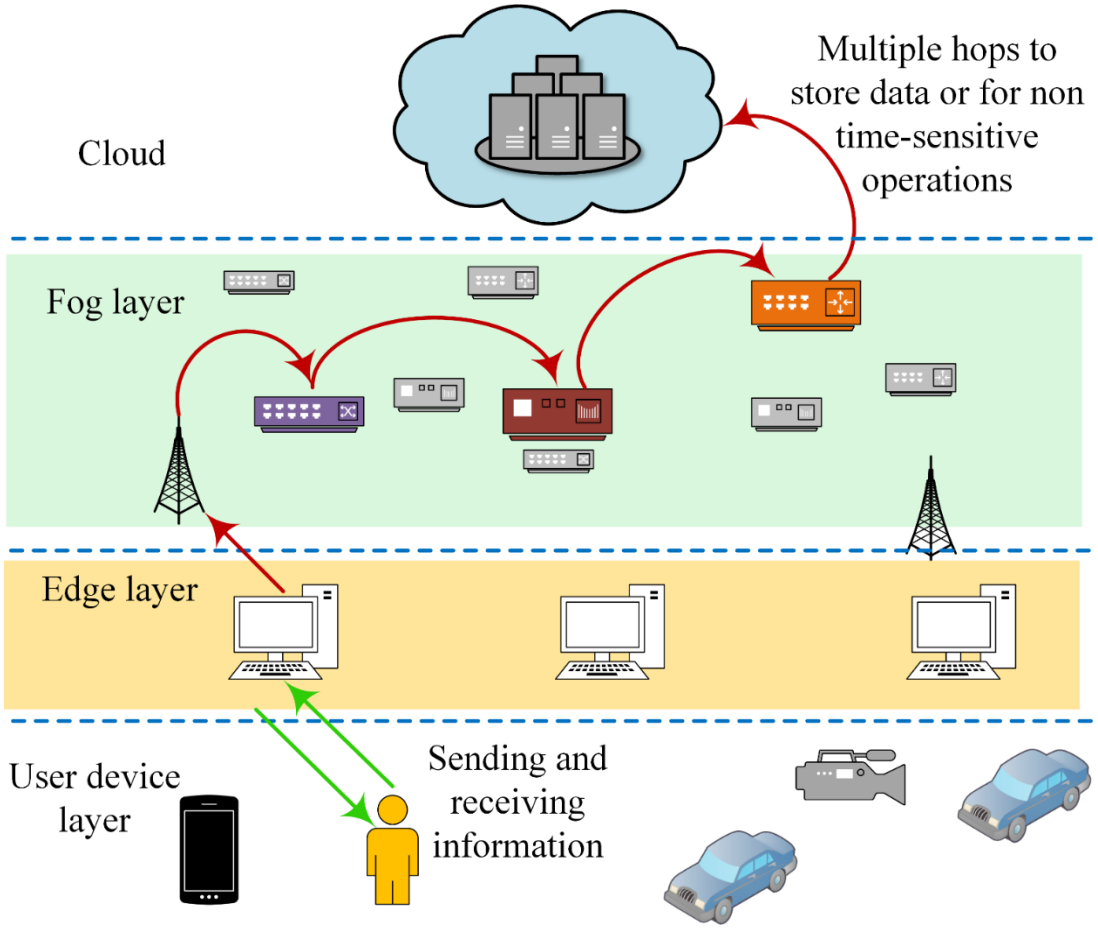
Infrastructure as a Service (IaaS)
- Outsource for storages, servers, data center space, and cloud networking
- Illusion of on-premises infrastructure
- Example: Microsoft Azure, GoGrid




Cloud
Networking device layer
Multiple hops to reach the cloud
Return results to the users
User device layer


Cloud
Multiple hops to store data or for non time-sensitive operations
Fog layer
User device layer
Sending and receiving information

Fog vs Edge Computing



Fog vs Edge Computing

Both bring data and intelligence to the edge of the network

Edge computing is limited to embedded systems and close to the data sources

Edge computing does not transmit data to the network (issue with cloud communication)

Edge provides results in real-time

Fog computing operates on the LAN level for generalized applications

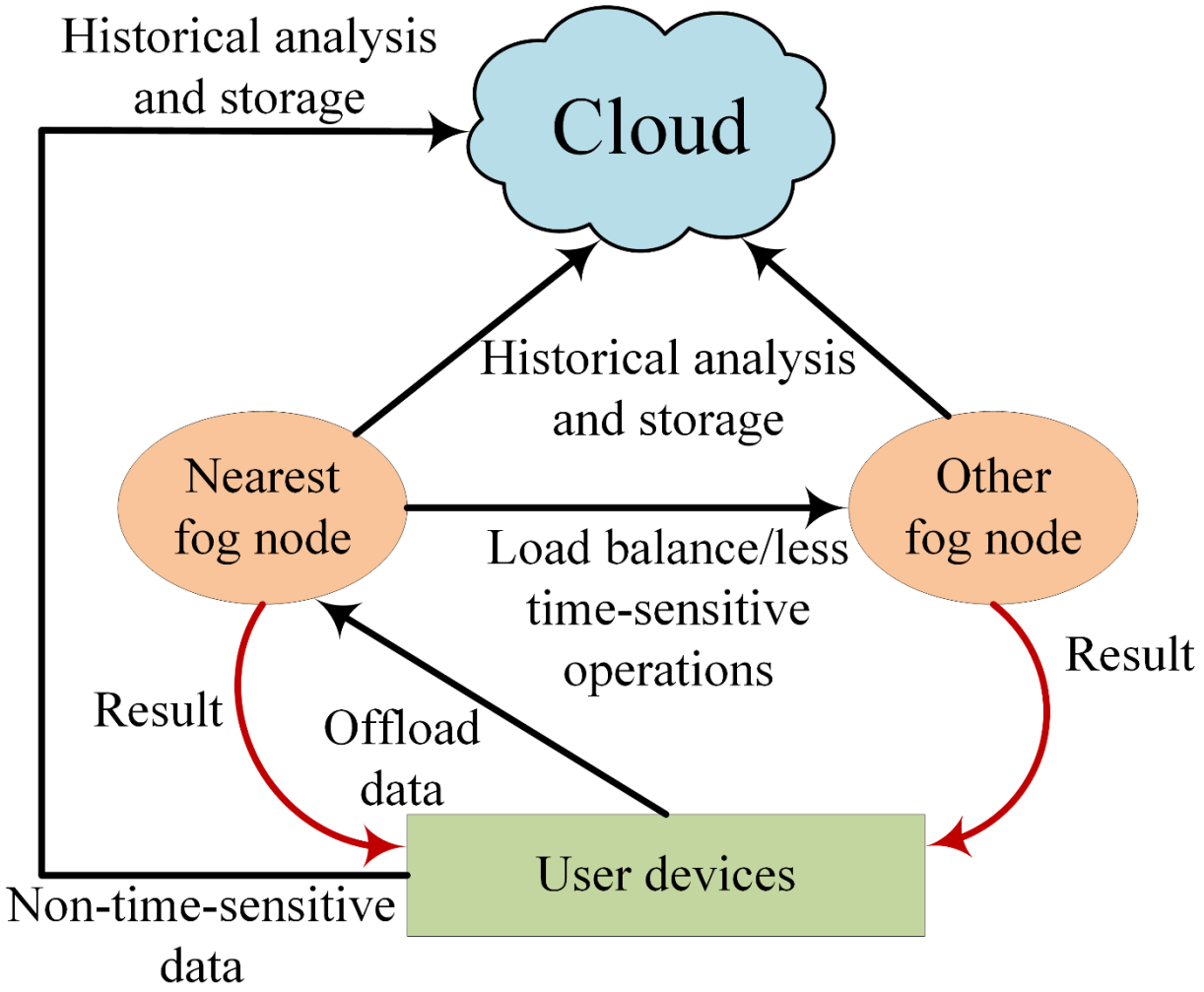
Fog computing provides results in near real-time

Fog Computing

The fog extends the cloud to be closer to the things that produce and act on IoT data. These devices, called fog nodes, can be deployed anywhere with a network connection: on a factory floor, on top of a power pole, alongside a railway track, in a vehicle, or on an oil rig. Any device with computing, storage, and network connectivity can be a fog node. Examples include industrial controllers, switches, routers, embedded servers, and video surveillance cameras.

-Cisco

Cisco white paper:
https://www.cisco.com/c/dam/en_us/solutions/trends/iot/docs/computing-overview.pdf


Historical analysis
and storage
Cloud
Historical analysis
and storage
Nearest
fog node
Other
fog node
Load balance/less
time-sensitive
operations
Result
Result
Offload
data
User devices
Non-time-sensitive
data

Advantages

Minimize latency

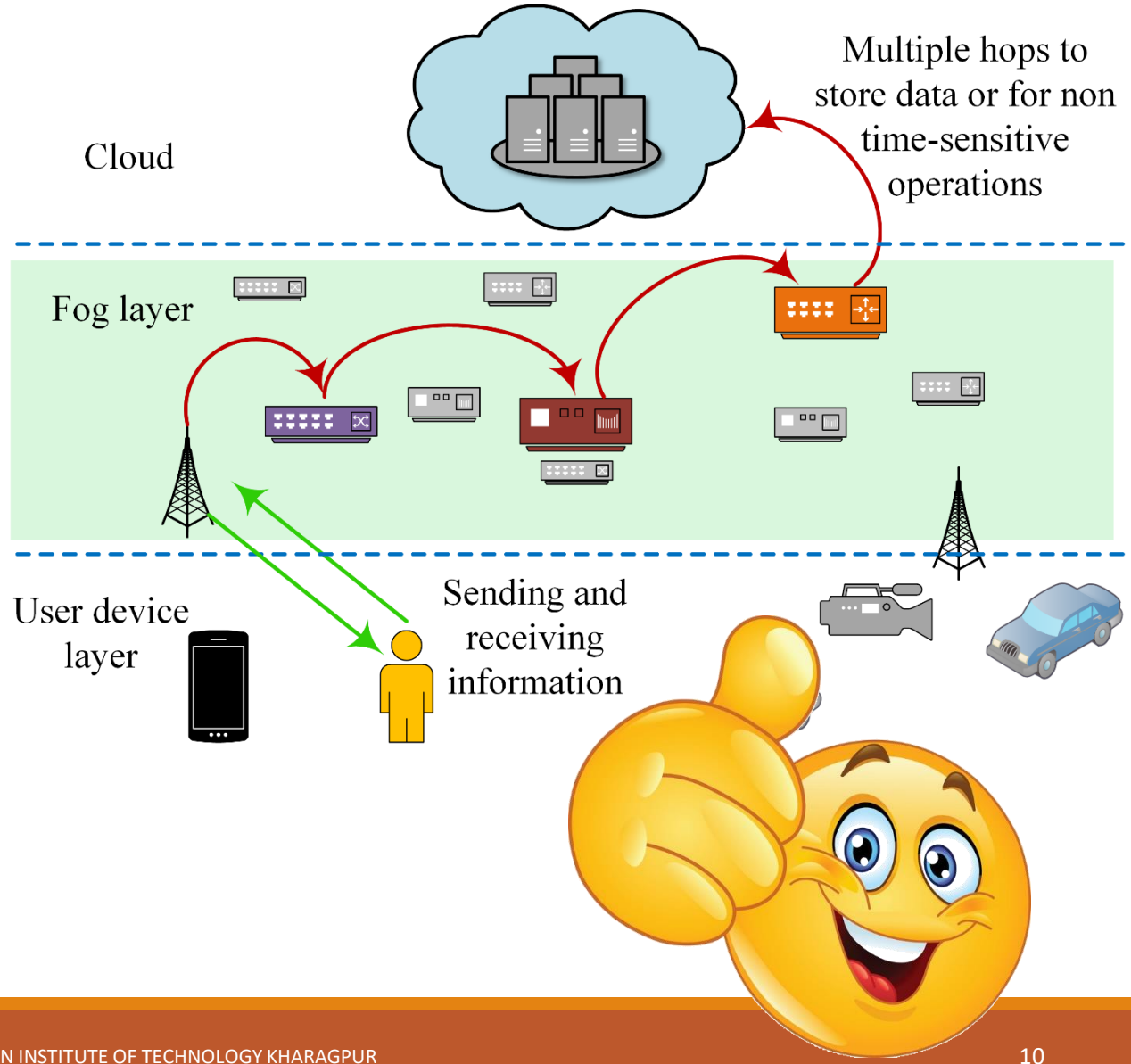
Bandwidth conservation

Enhanced security

Reliable operations

Spatially aware data

Optimized movement of data



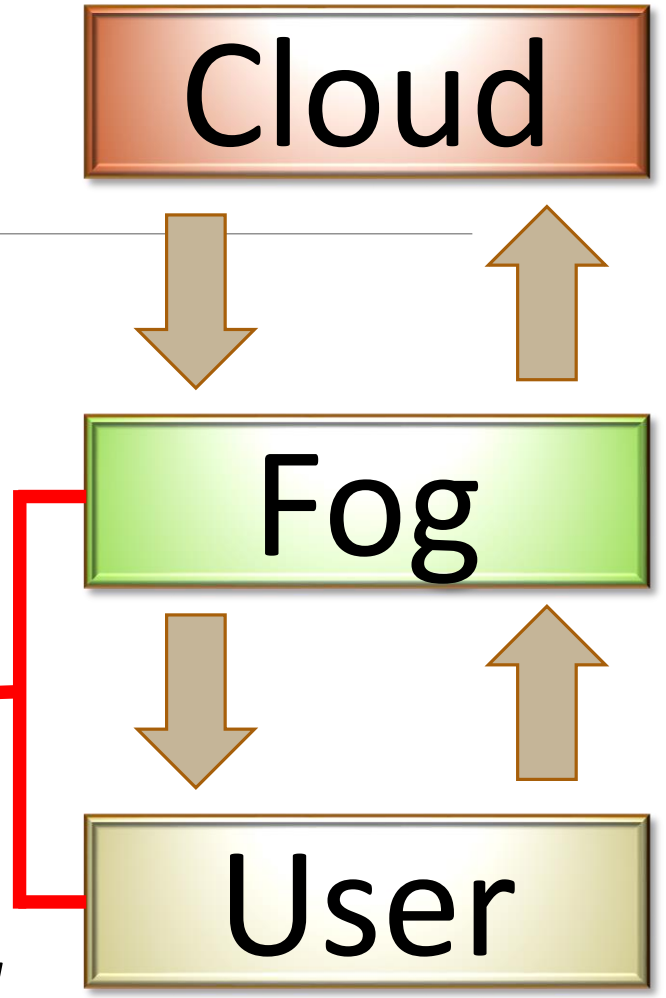
Minimize Latency

Time-sensitive operations

Operation on sensor data closer to end devices

Reduced transmission time

Tradeoff between execution speed of cloud and fog



"Analyzing data close to the device that collected the data can make the difference between averting disaster and a cascading system failure."

-Cisco

Bandwidth Conservation

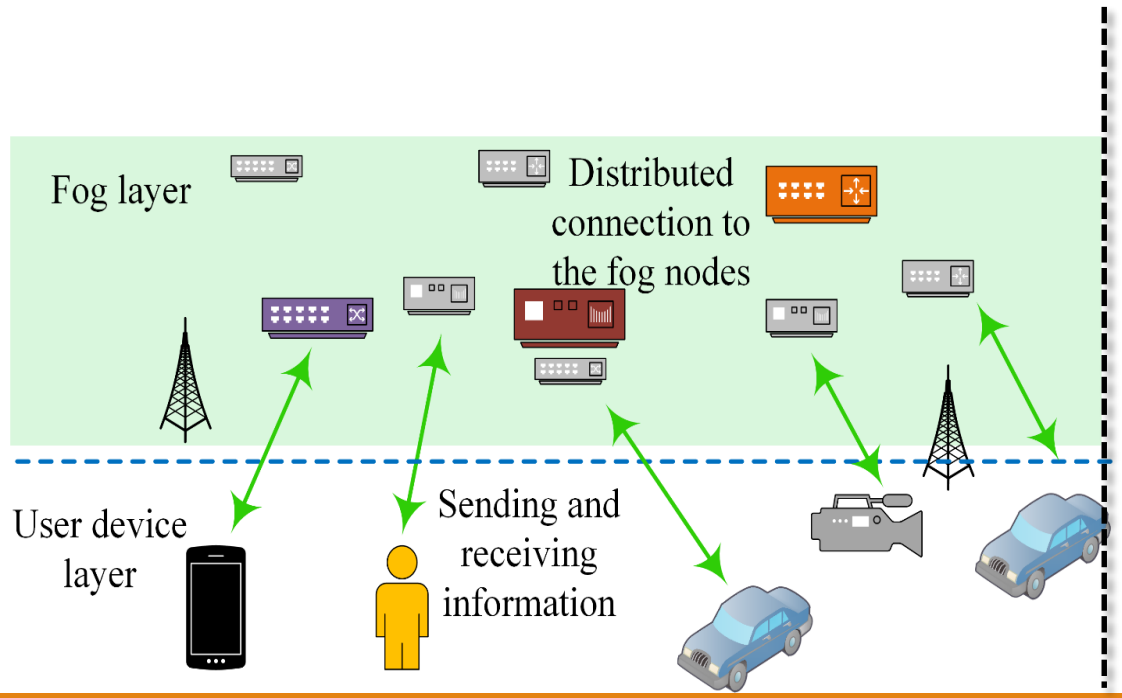
IoT devices generate huge amount of data

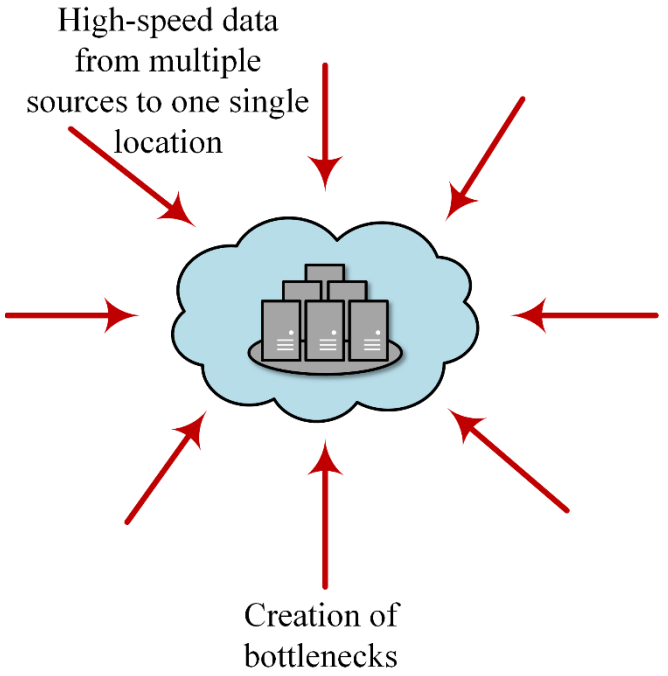
Not practical to send everything to the cloud

Not all applications need cloud level processing/storage

Possibility of bottlenecks

Reject/postpone services





Enhanced Security

Data travels through multiple networks to reach the cloud

Spatially, data travels long distances

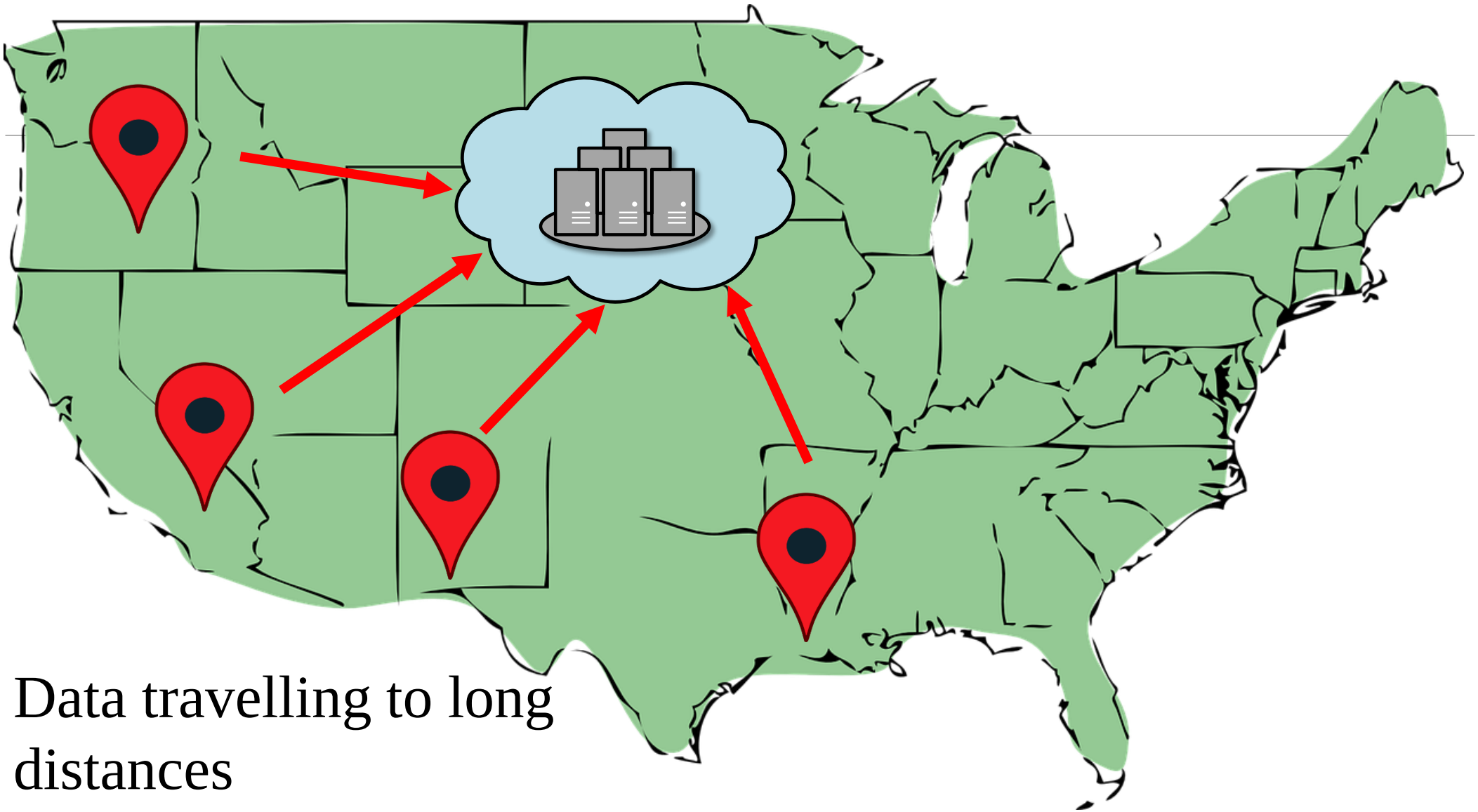
Fog allows local processing

Data does not need to travel far

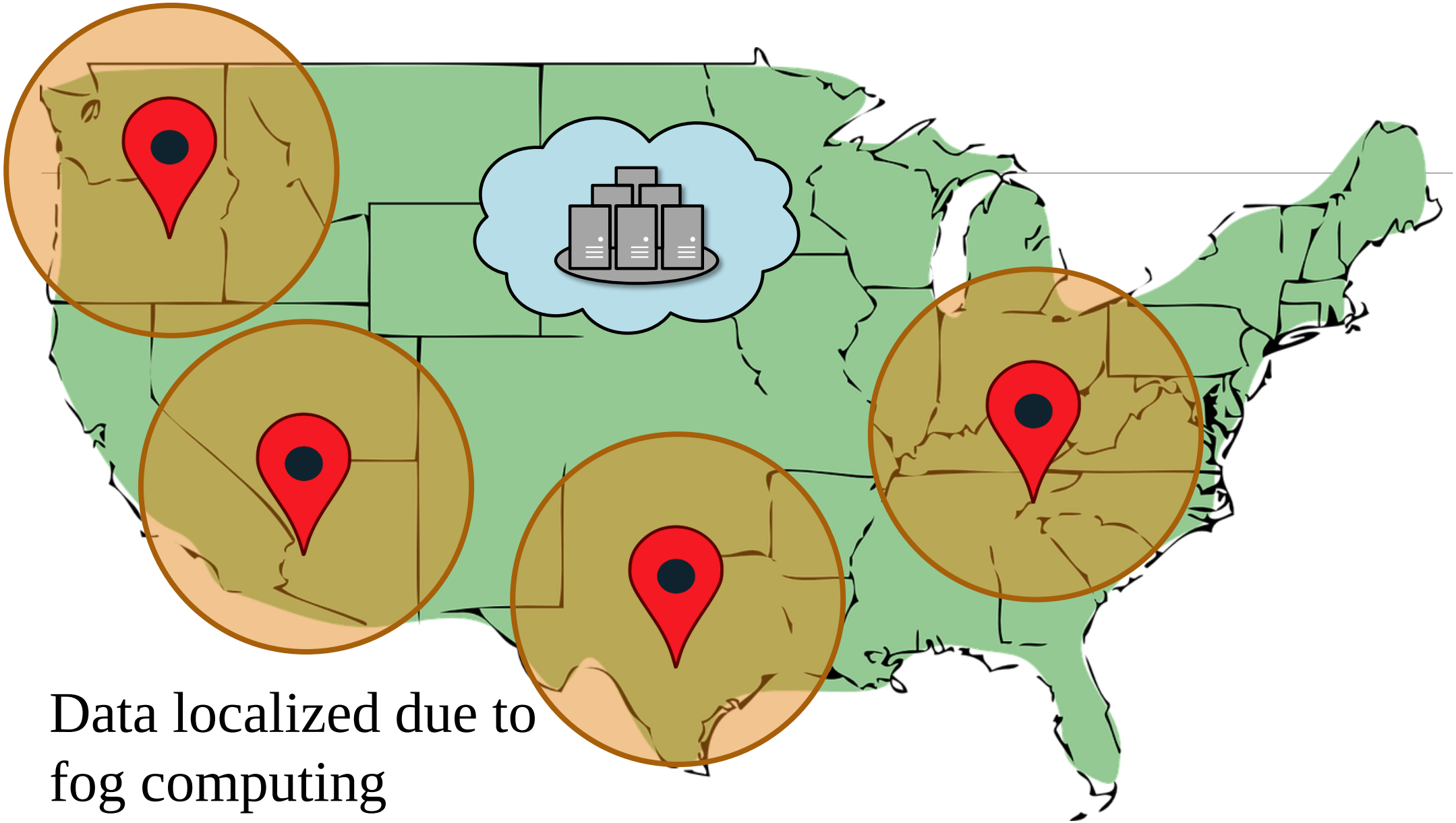
Remains closer to data generating sensor modules

Reduces the possibility of attacks

Limited to local network



Data travelling to long distances



Data localized due to fog computing

Other Advantages..

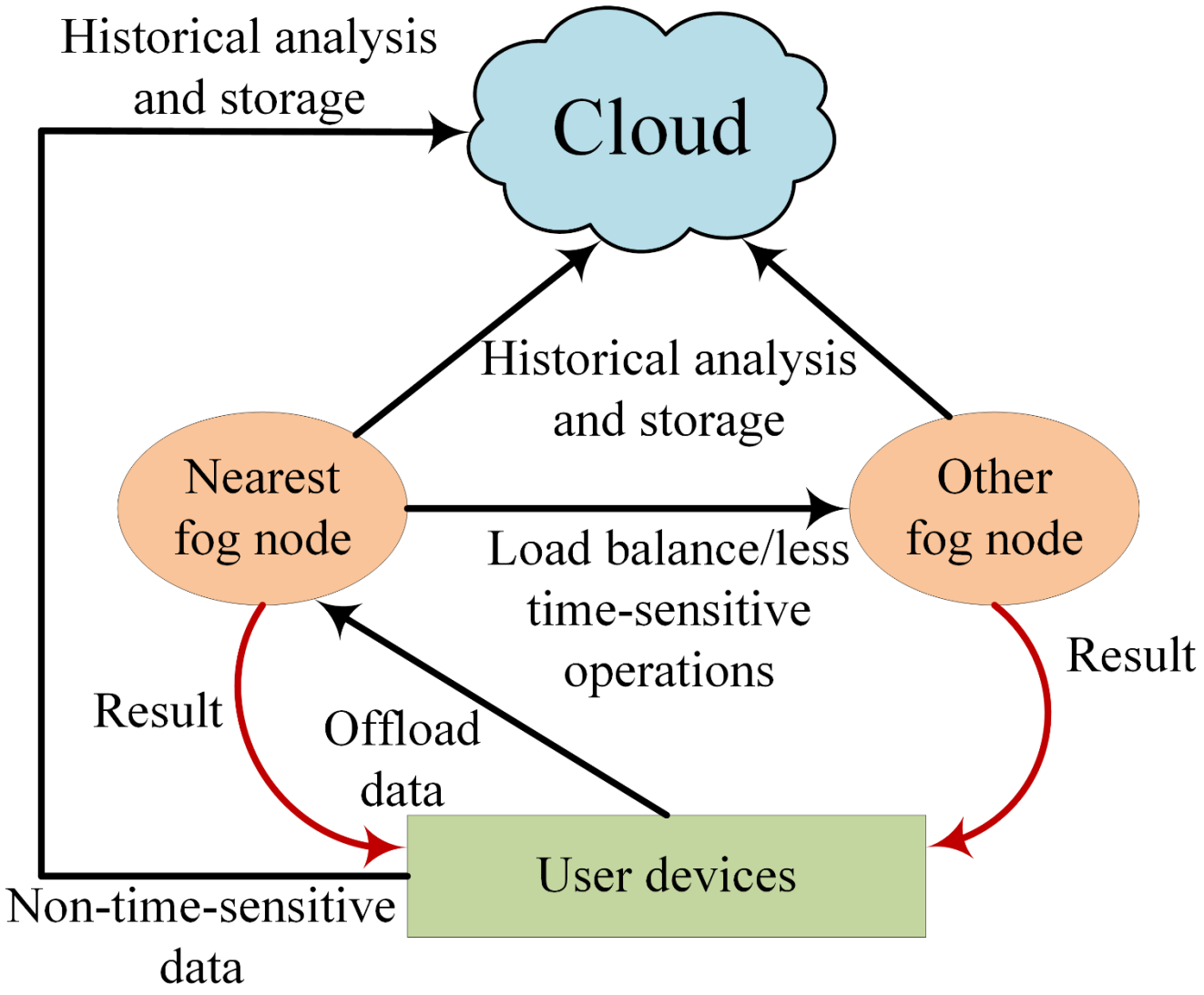
Reliable operations

Spatially aware data

Optimized movement of data

Reduce load from the cloud

Support mobility



Applications

Real-time health analysis

Intelligent power efficient system

Real-time rail monitoring

Pipeline optimization

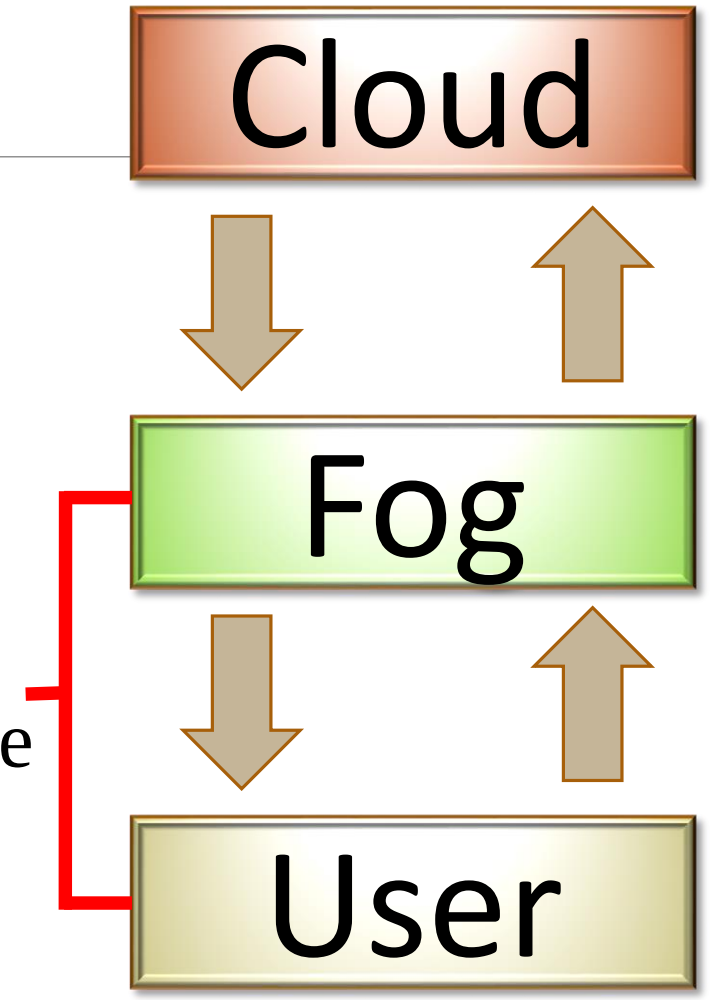
Real-time monitoring

Reduced network latency

Close proximity

Reduced operational cost

And others…



Challenges

Power consumption

Data security

Reliability

Fault tolerance

Real-time analysis

Architecture

Upcoming 5G technology

Millimeter waves

Small cells

Massive MIMO

Beamforming

Full Duplex

Upcoming 5G technology

Millimeter waves

Small cells

Massive MIMO

Beamforming

Full Duplex

- Wavelength decreases as the frequency increases
- narrow wavelengths
- Vulnerable against gases, rain and humidity
- Absorption
- Range limited to few kilometers

Upcoming 5G technology

Millimeter waves

Small cells

Massive MIMO

Beamforming

Full Duplex

- Reliable coverage
- Spectral efficiency
- Improved capacity
- Improved overall performance
- High speed

Upcoming 5G technology

Millimeter waves

Small cells

Massive MIMO

Beamforming

Full Duplex

- Increase in number of devices/users
- Diverse services
- Need for efficient task scheduling
- Processing near the data generating devices
- Need for preventing bottlenecks

Upcoming 5G technology

Millimeter waves

Small cells

Massive MIMO

Beamforming

Full Duplex

- Directional signal transmission
- Enhance LoS transmission
- Avoid blockage due to buildings/trees
- Faster
- Reliable

Upcoming 5G technology

Millimeter waves

Small cells

Massive MIMO

Beamforming

Full Duplex

- Typically, MAC schemes used
- TDMA/FDMA/CDMA
- 2-way communication in same channel
- Increased capacity
- Spectral efficiency

Conclusion

Reduces load from the cloud

Brings processing closer to the users/sensors

Increases security

Real-time analysis and monitoring

Complements the services of the cloud

Perfect for upcoming technologies

Thank You