Improving Quality of Service in Edge Computing Networks

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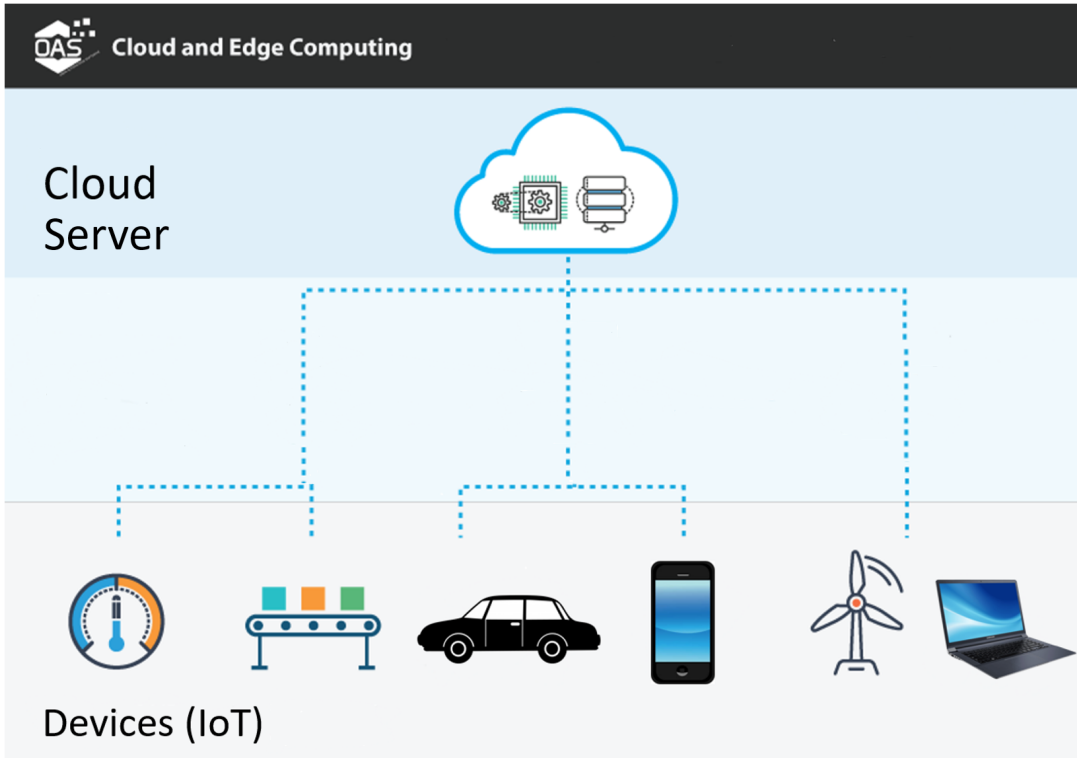
What is Edge Computing?

- Fills same role as cloud computing



Open Automation Software [5]

What is Edge Computing?

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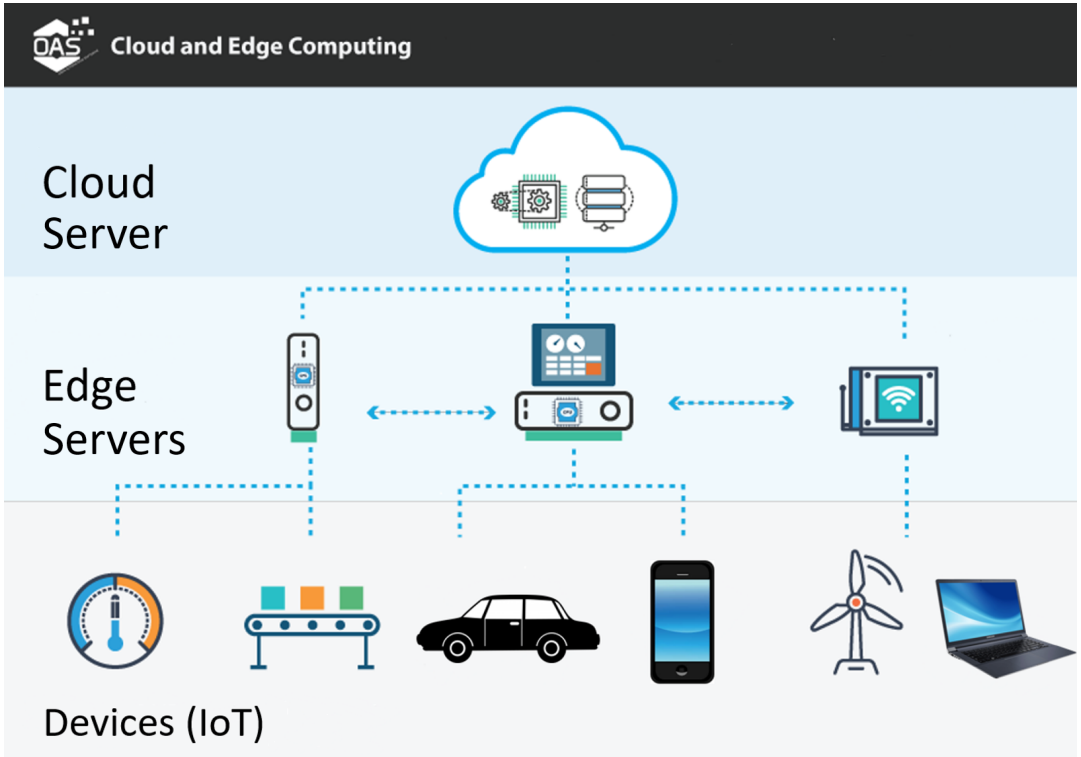
- Processes and stores data near devices



Open Automation Software [5]

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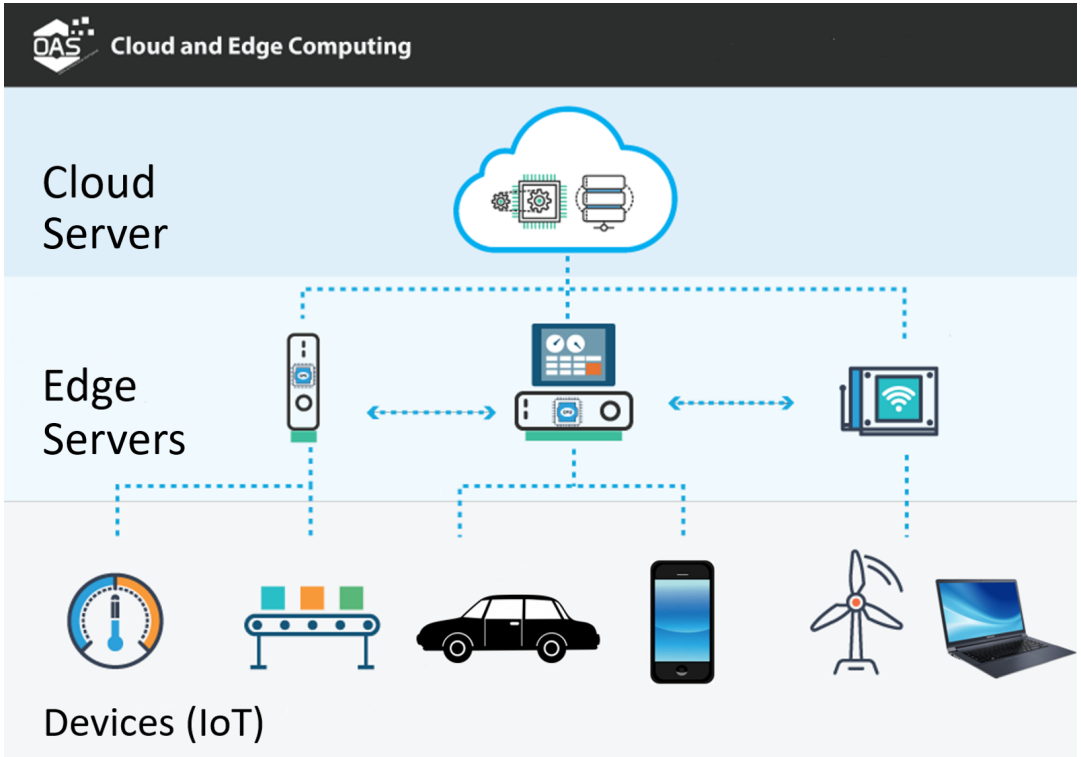
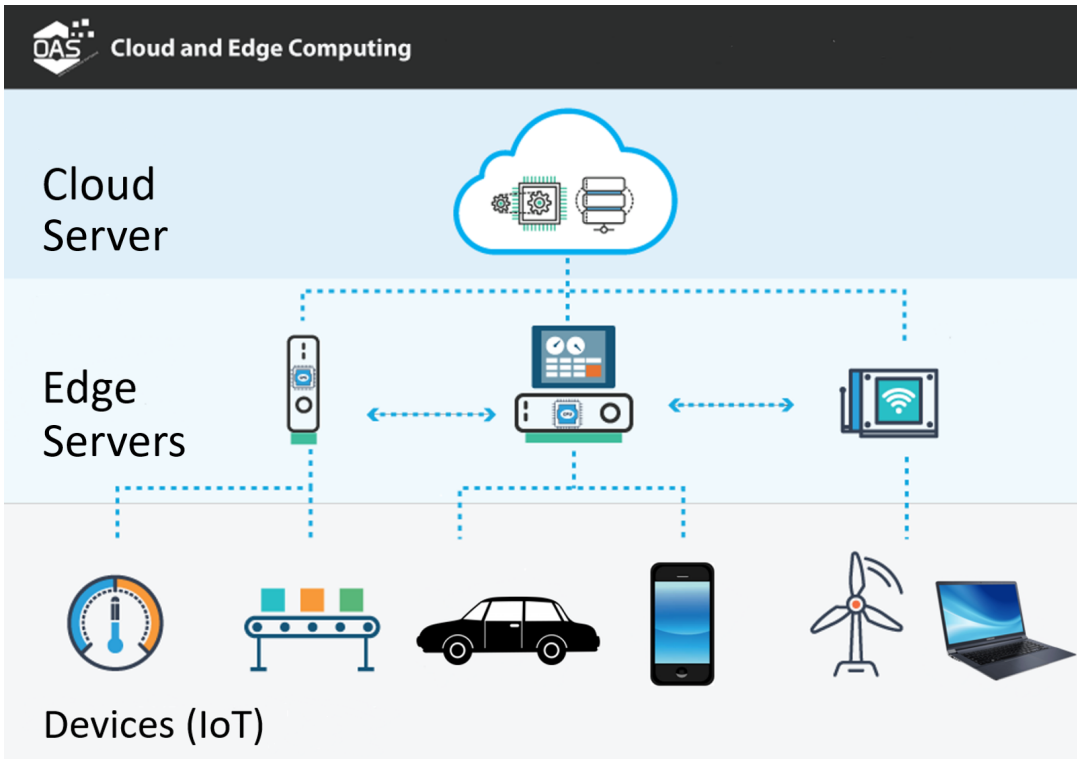
- Processes and stores data near devices
- Edge servers can be heterogeneous



Open Automation Software [5]

What is Edge Computing?

- Fills same role as cloud computing
- Processes and stores data near devices
- Edge servers can be heterogeneous
- Devices can be part of the Internet of Things (IoT)



Open Automation Software [5]

Why is it important?

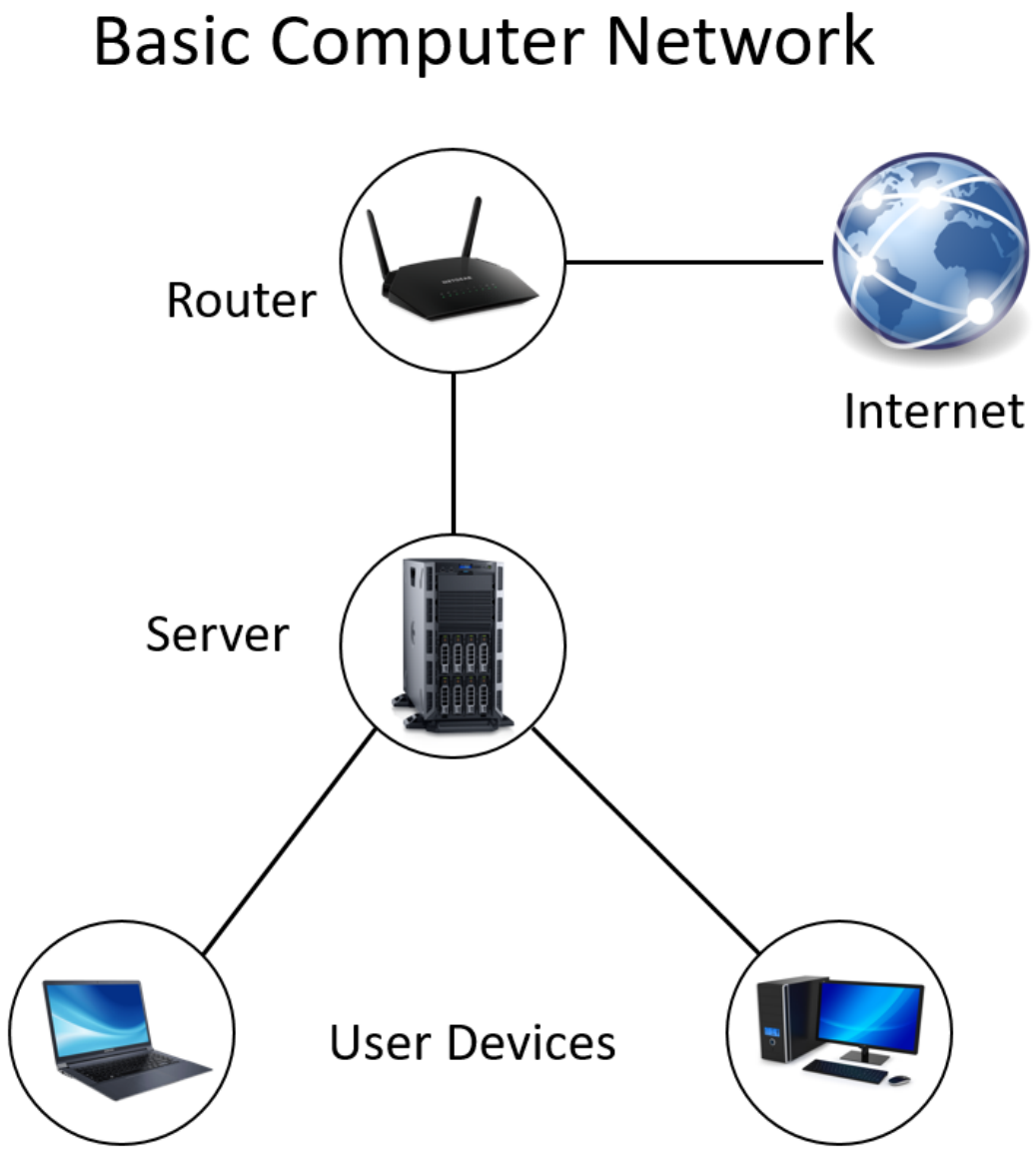
- Much faster response times
- Reduces bandwidth strain
- Security of data is improved
- Applicable for autonomous vehicles, augmented reality, and the Internet of Things
- Can increase productivity in business, medical, and industrial environments

Outline

Outline

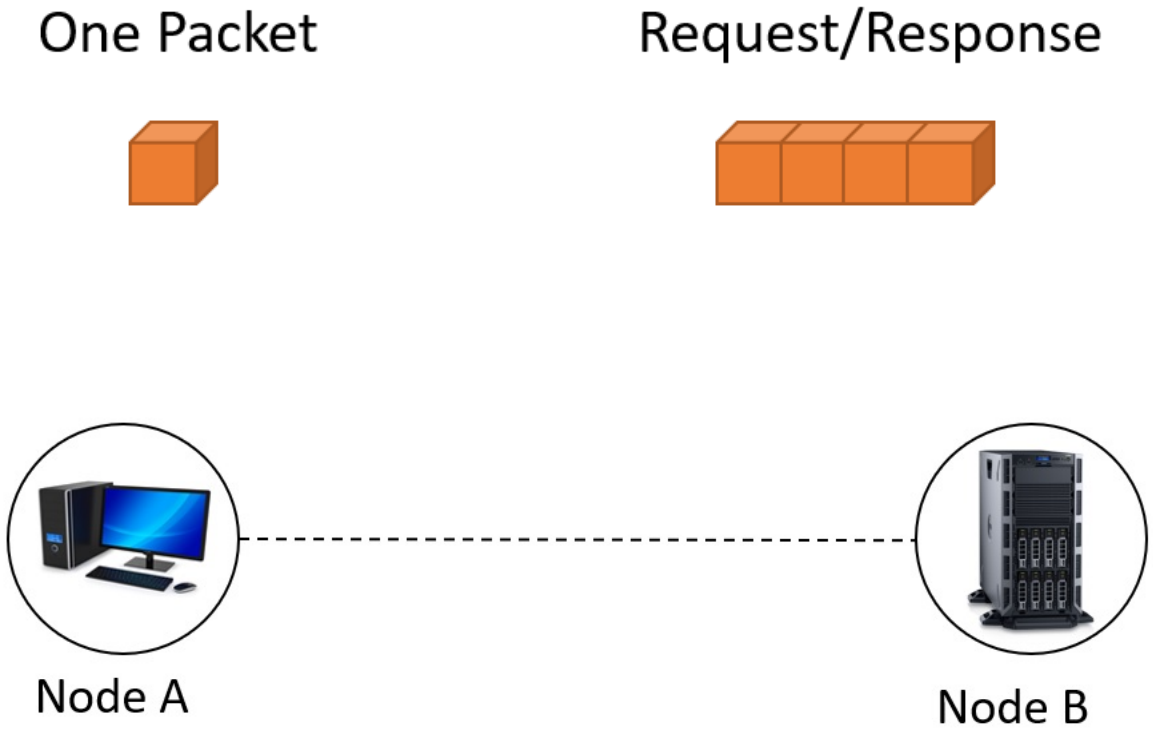
Networks

- Networks consist of connected computers that can share data
- They can be considered graphs with nodes and edges



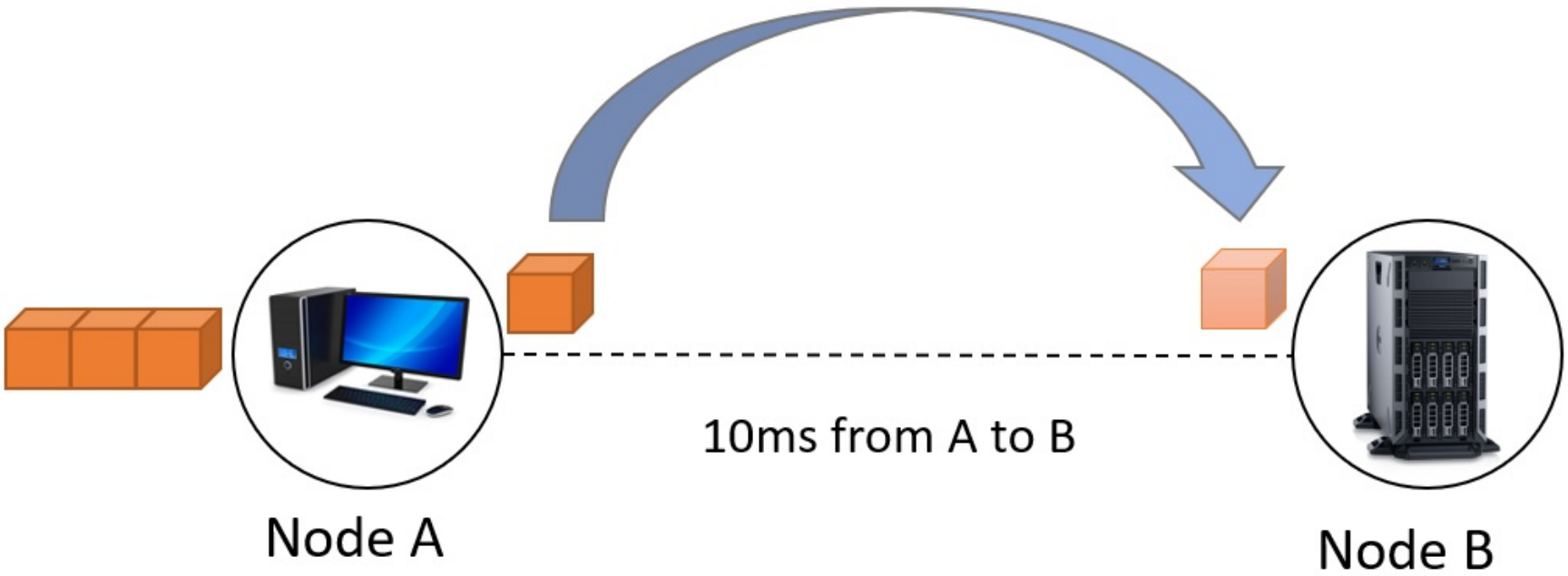
Networks cont.

- Packets are units of data that are sent over the network
- Nodes can make requests and receive responses made of packets



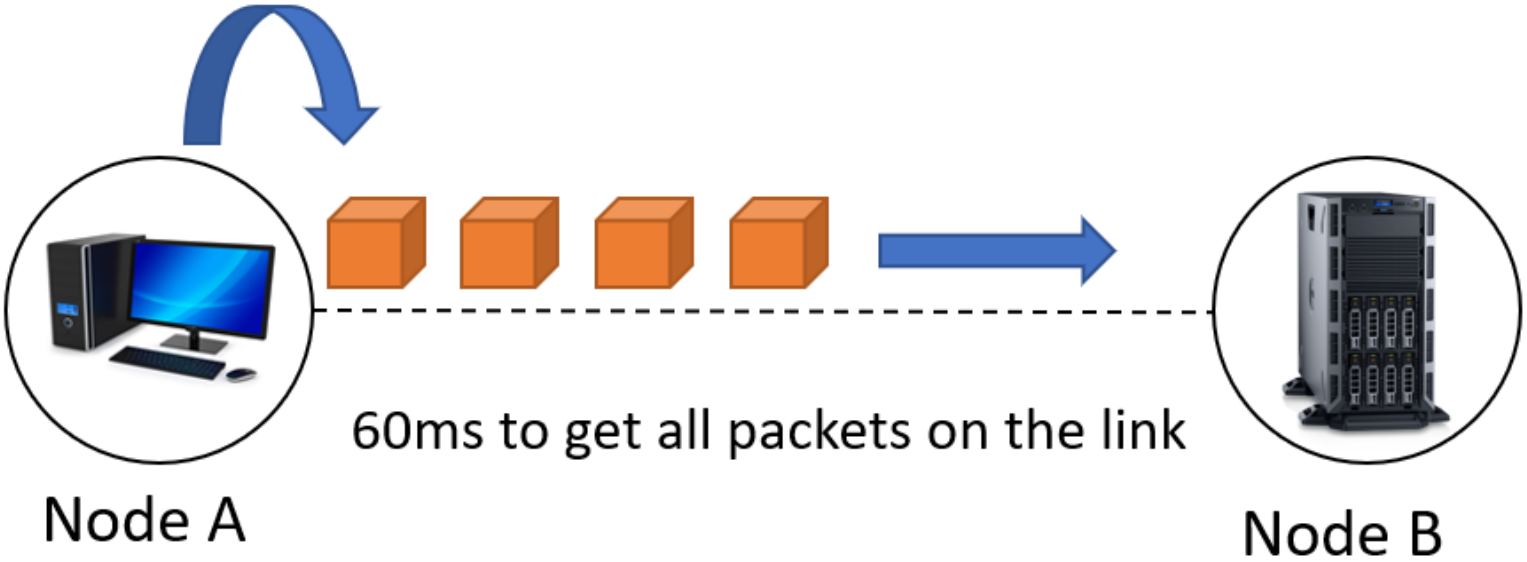
Networks cont.

- Propagation delay is the amount of time it takes for the first packet in a request or response to reach a node

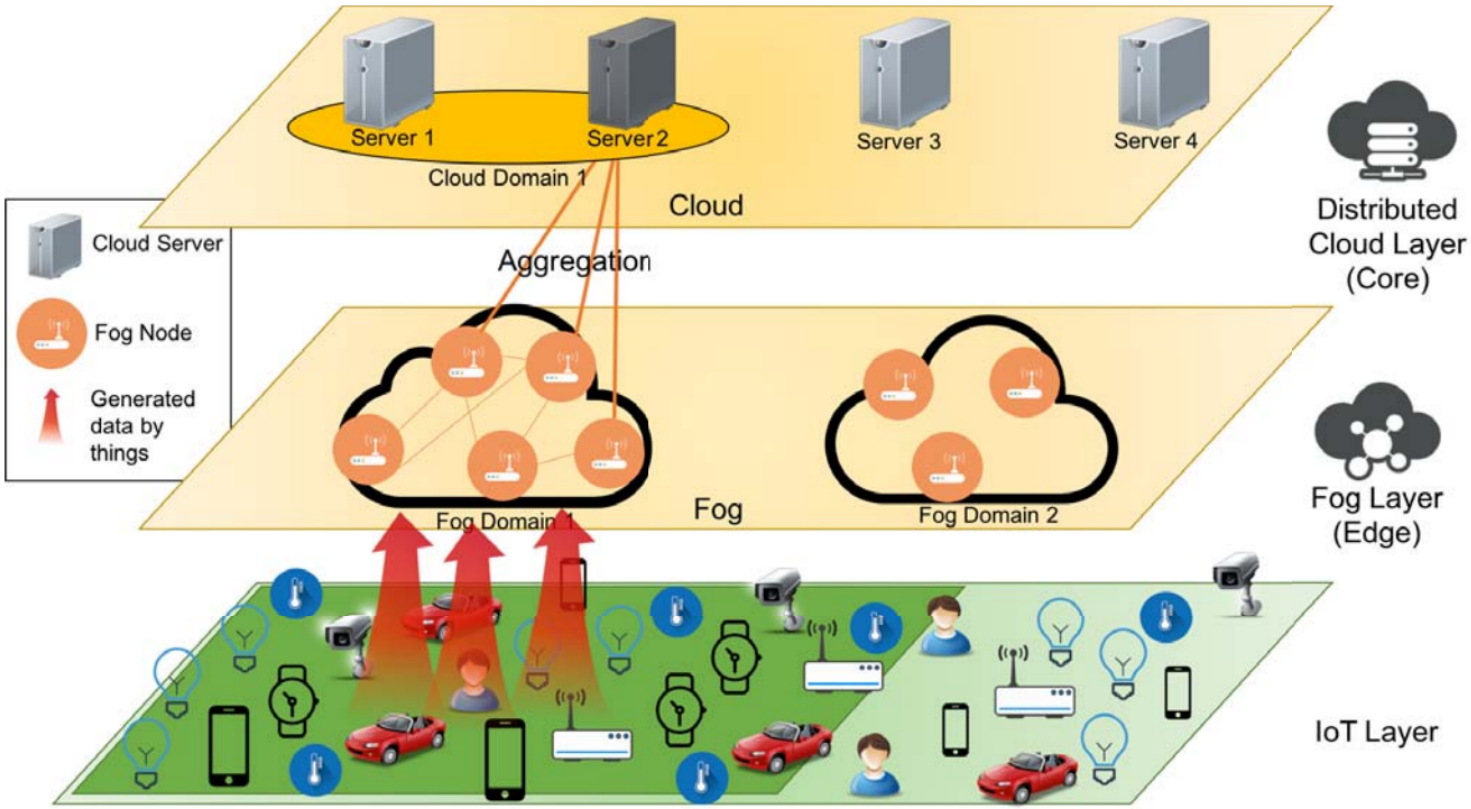


Networks cont.

- Transmission delay is the amount of time it takes for a node to get all of the packets into the data link



Fog Computing



- Composed of three layers
- Fog and cloud layers contain domains
- Fog nodes process tasks using queues

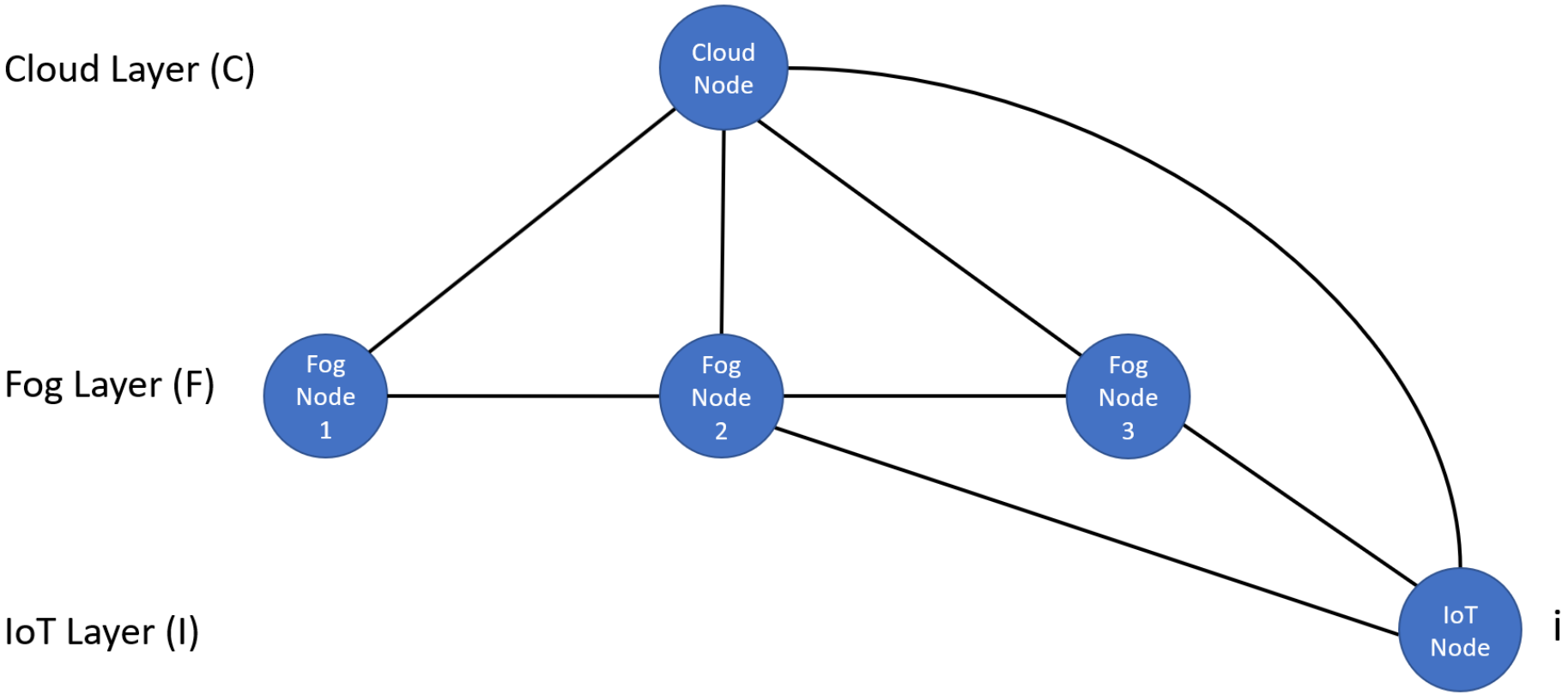
Yousefpour et. al. [1]

Outline

Task Offloading Overview

- The goal of task offloading is to reduce service delay
- If a fog node receives a task and its queue is full, it sends the task to a neighboring fog node, or the cloud
- Light and heavy tasks can be distinguished between each other

Service Delay



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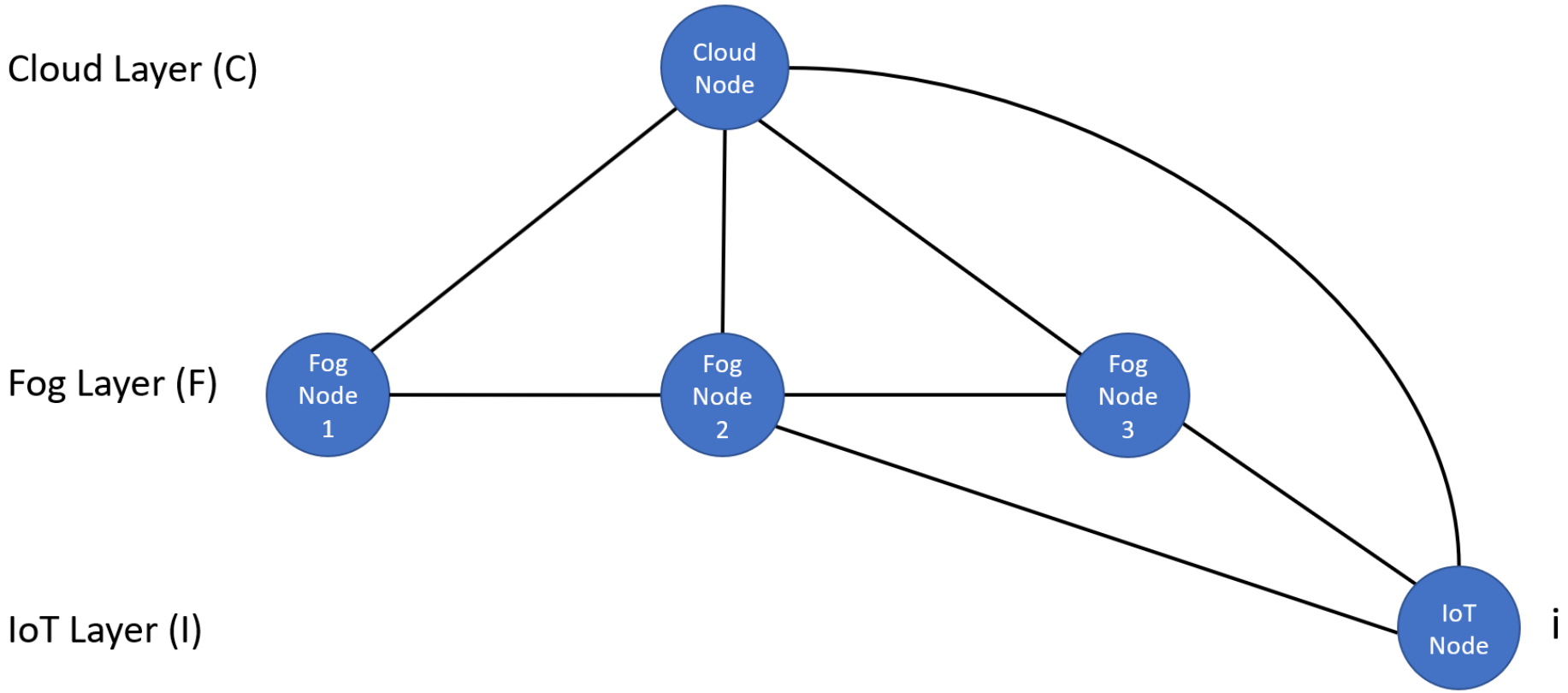

Equation for Average Service Delay

$$d_i = p_i^I \cdot (A_i) + p_i^F \cdot (X_{ij}^{IF} + Y_{ij}^{IF} + L_{ij}) + p_i^C \cdot (X_{ik}^{IC} + Y_{ik}^{IC} + \overline{H}_k + X_{ki}^{CI} + Y_{ki}^{CI})$$

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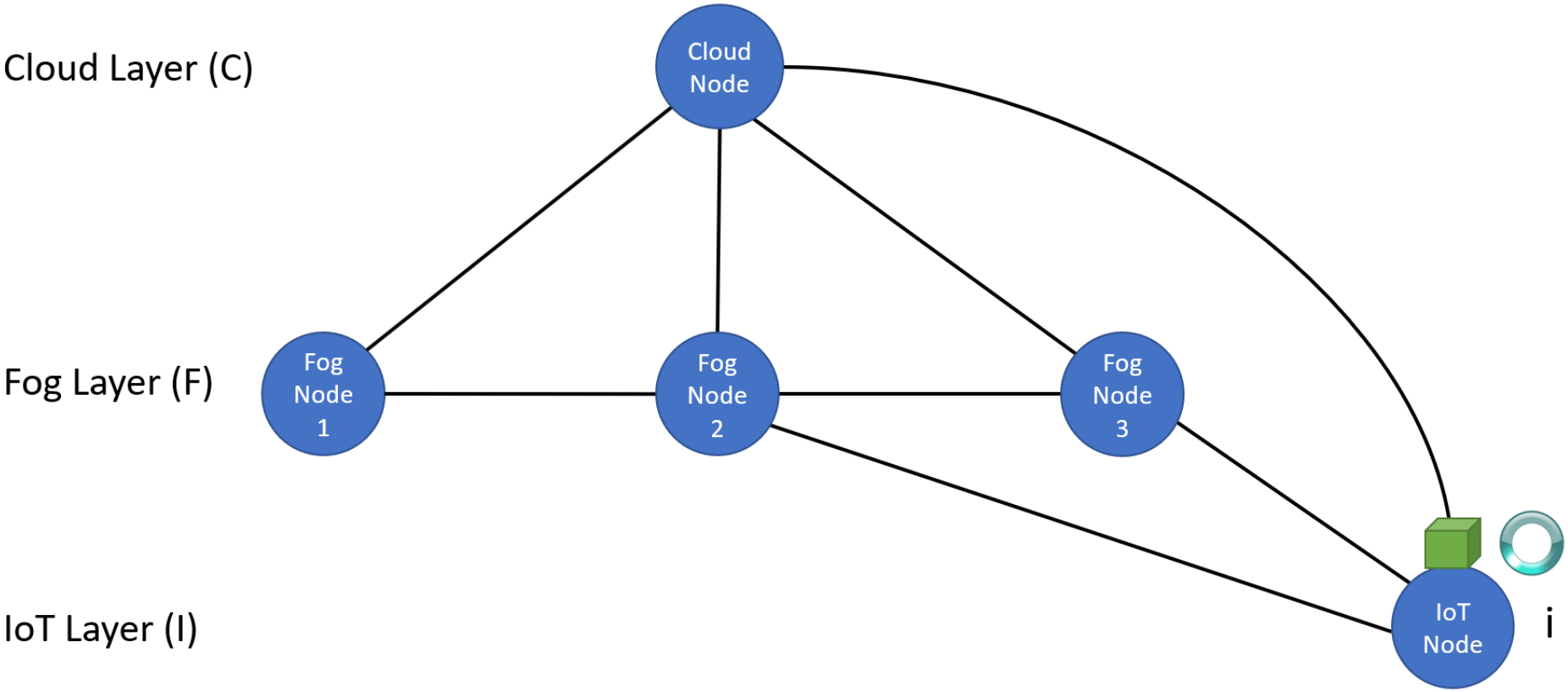

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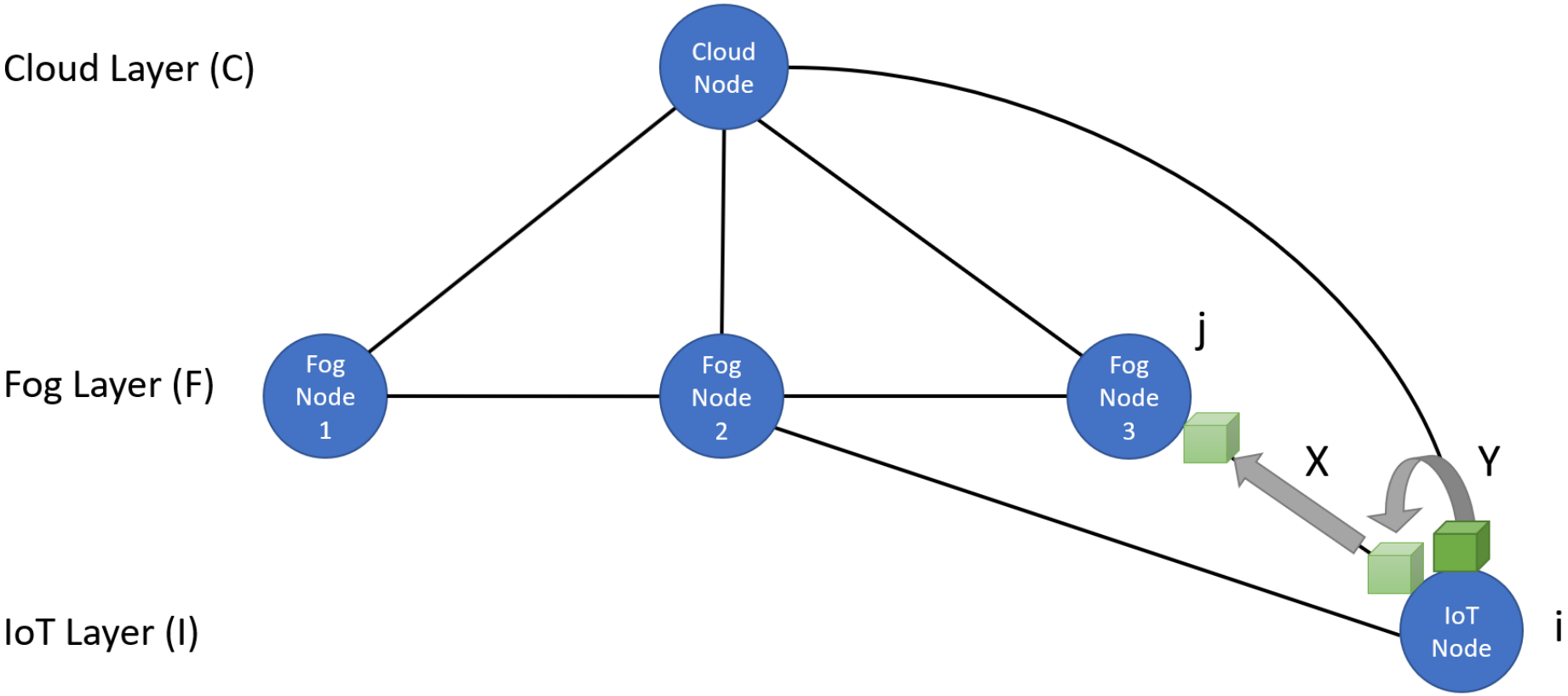

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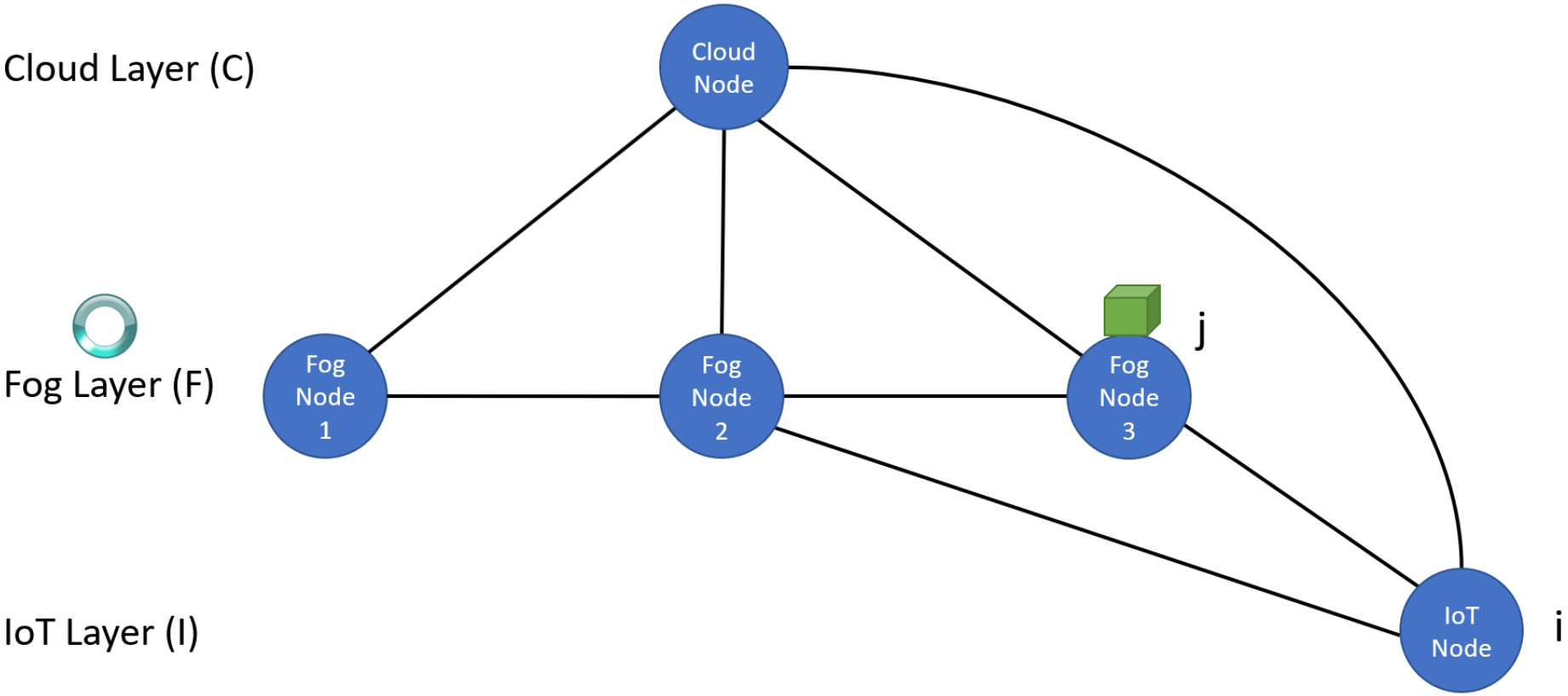

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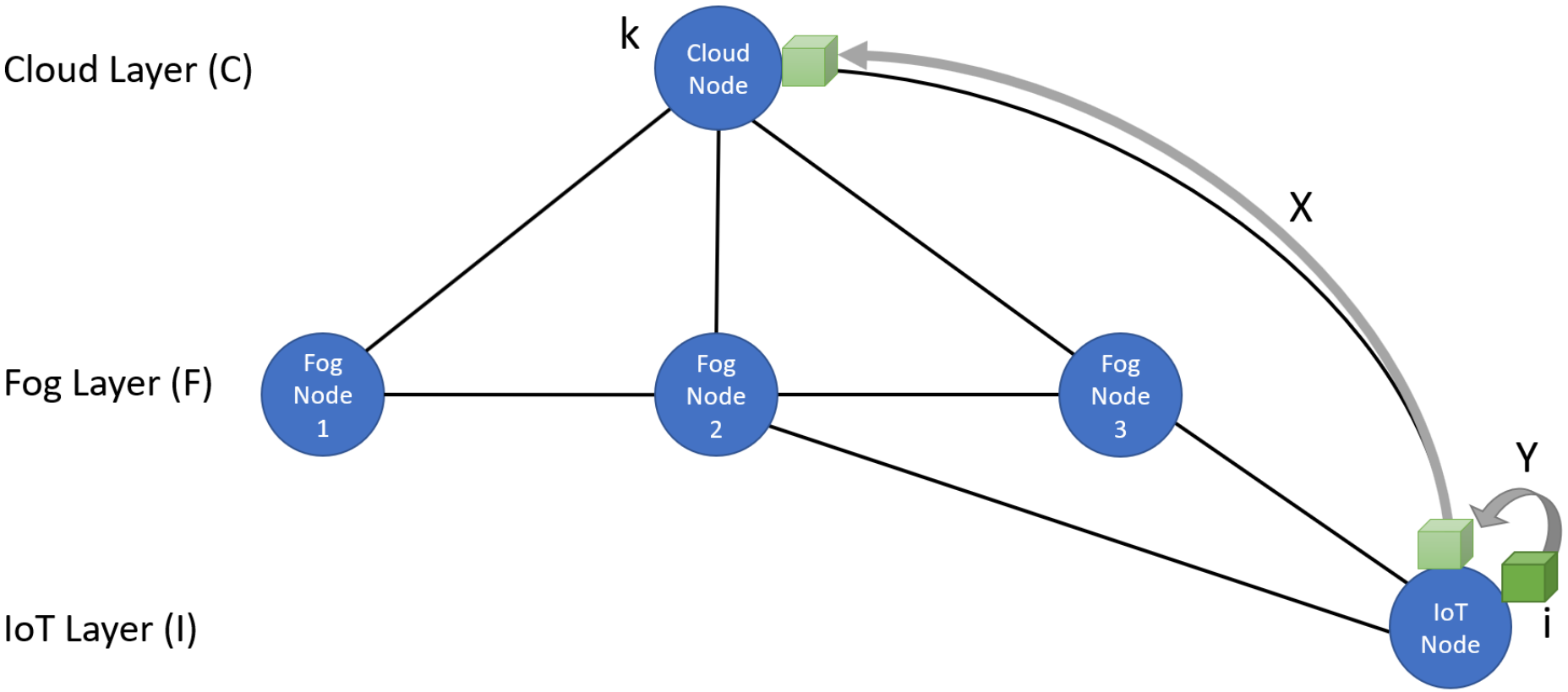

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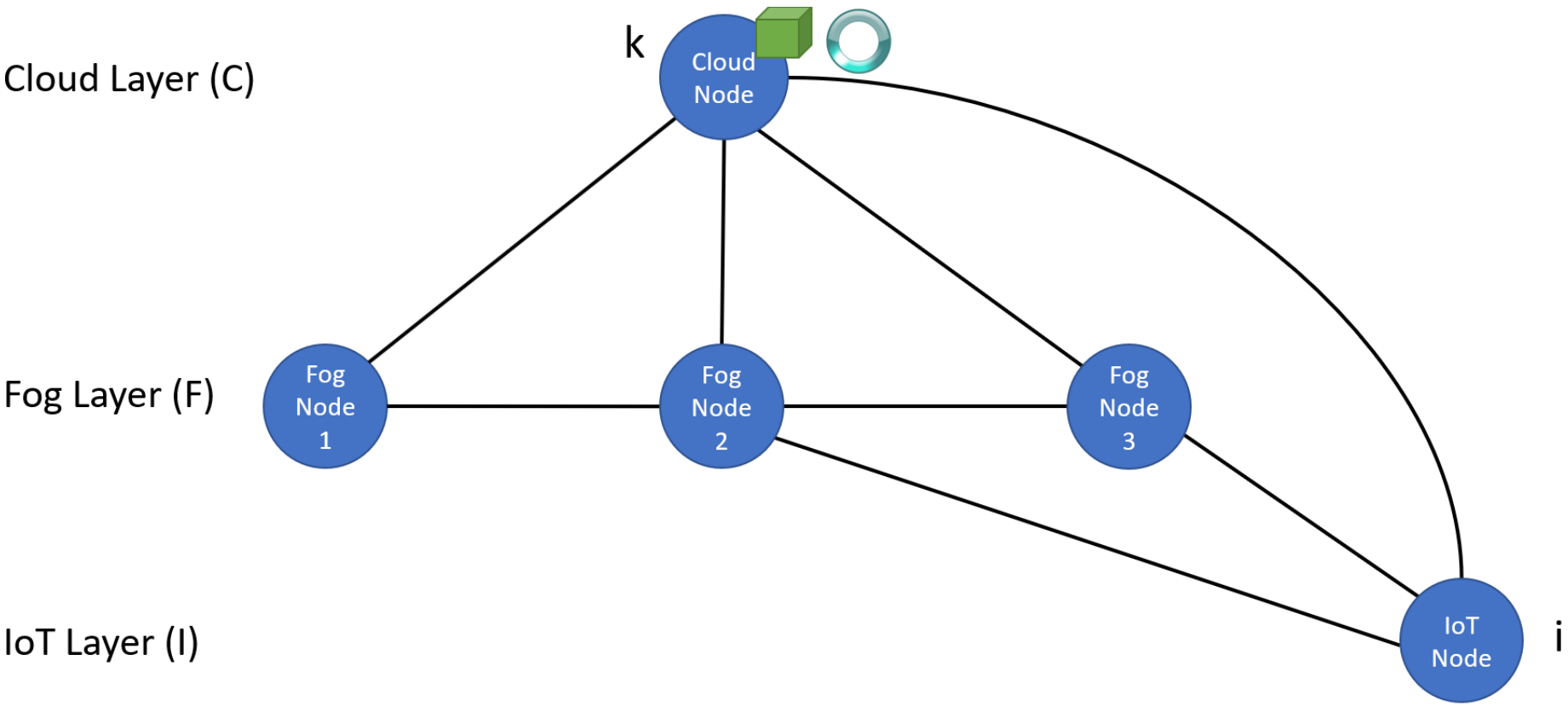

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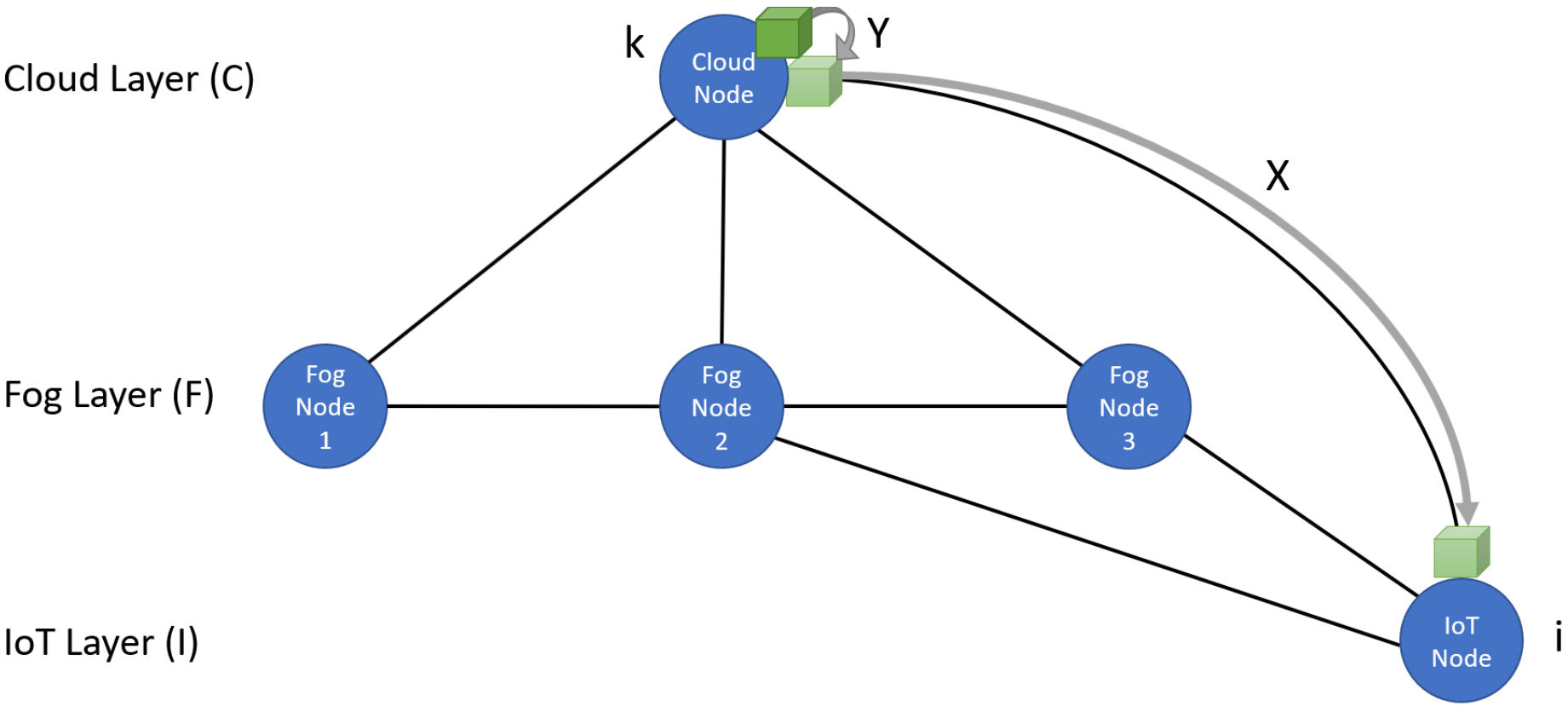

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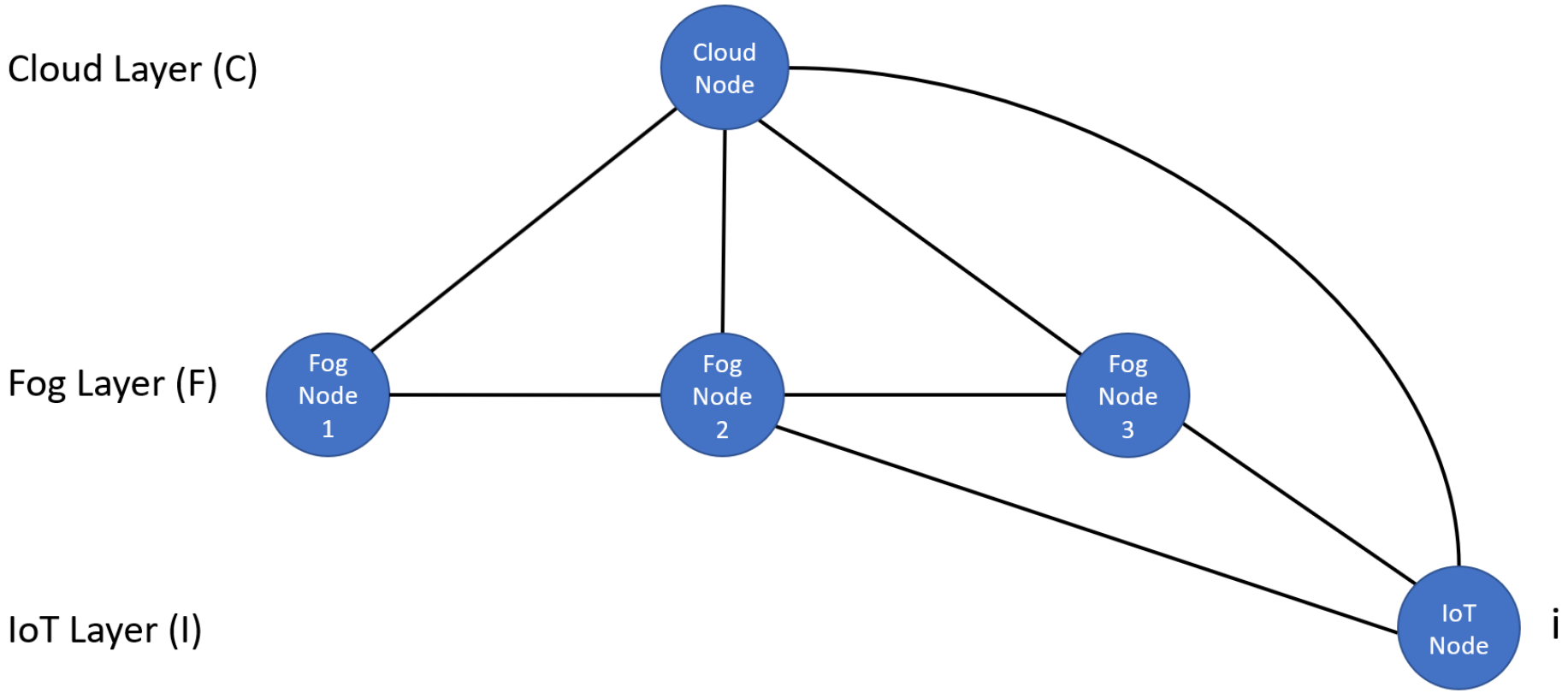

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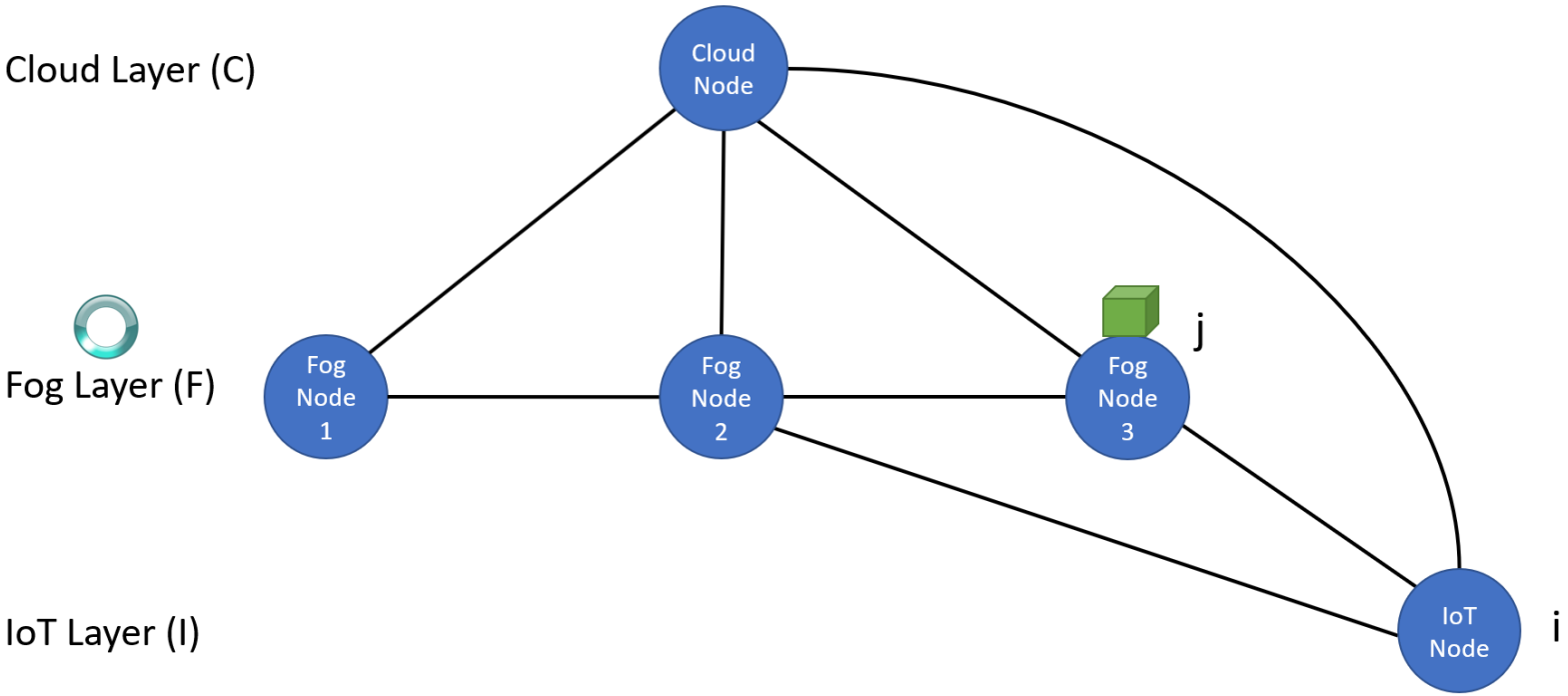
Offload Limit

- The maximum number of times a request can be offloaded in the fog layer is called the offload limit, $e_{\mathcal{M}}$
- If the offload limit is reached, tasks are sent to the cloud

The offloading function is displayed below:

$$\phi(x) = \begin{cases} 0 & x < e_{\mathcal{M}}, \\ 1 & x = e_{\mathcal{M}}. \end{cases}$$

Fog Layer Delay



Equation for Average Fog Delay

$$L_{ij}(x) = P_j \cdot (\overline{W}_j + X_{ji}^{FI} + Y_{ji}^{FI}) + (1 - P_j) \cdot \Big[[1 - \phi(x)] \cdot [X_{jj'}^{FF} + Y_{jj'}^{FF} + L_{ij'}(x+1)] + \phi(x) \cdot [X_{jk}^{FC} + Y_{jk}^{FC} + \overline{H}_k + X_{ki}^{CI} + Y_{ki}^{CI}] \Big]$$

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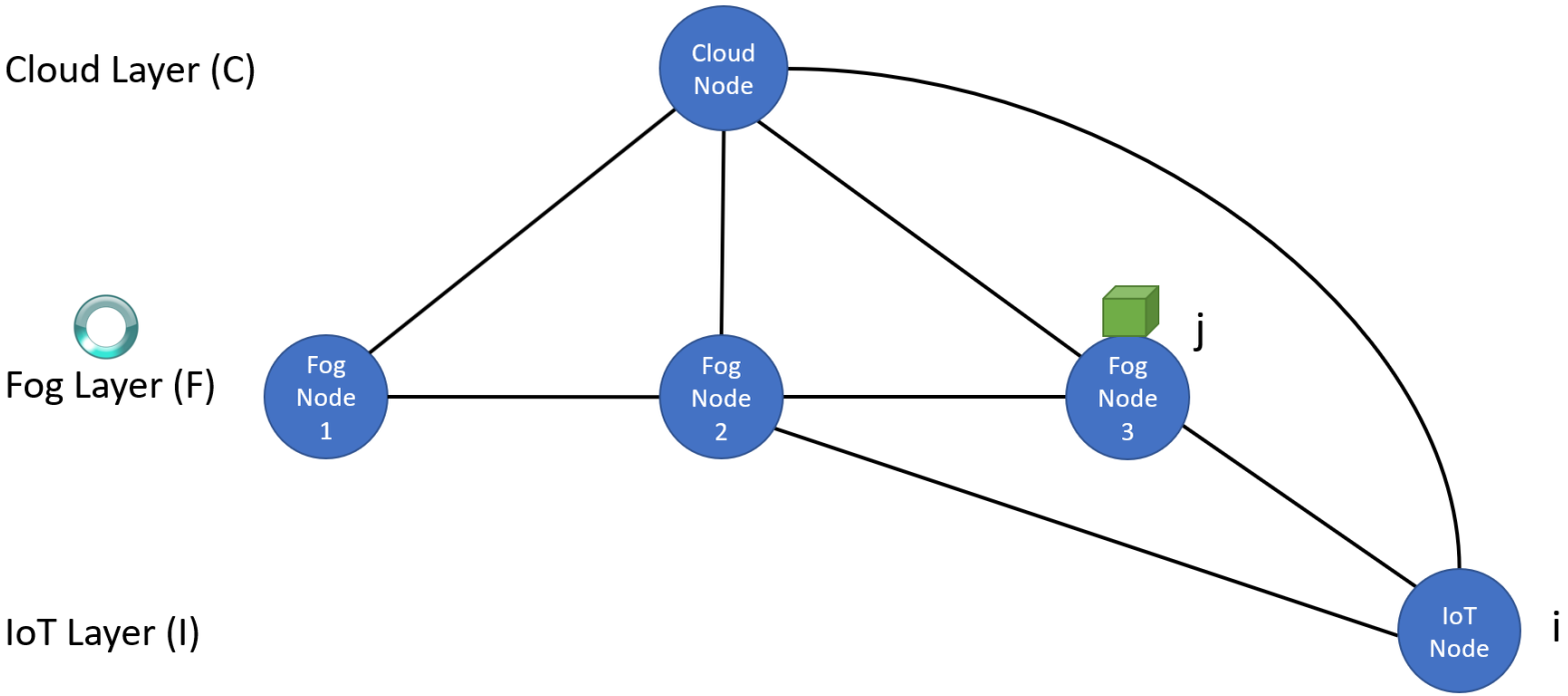

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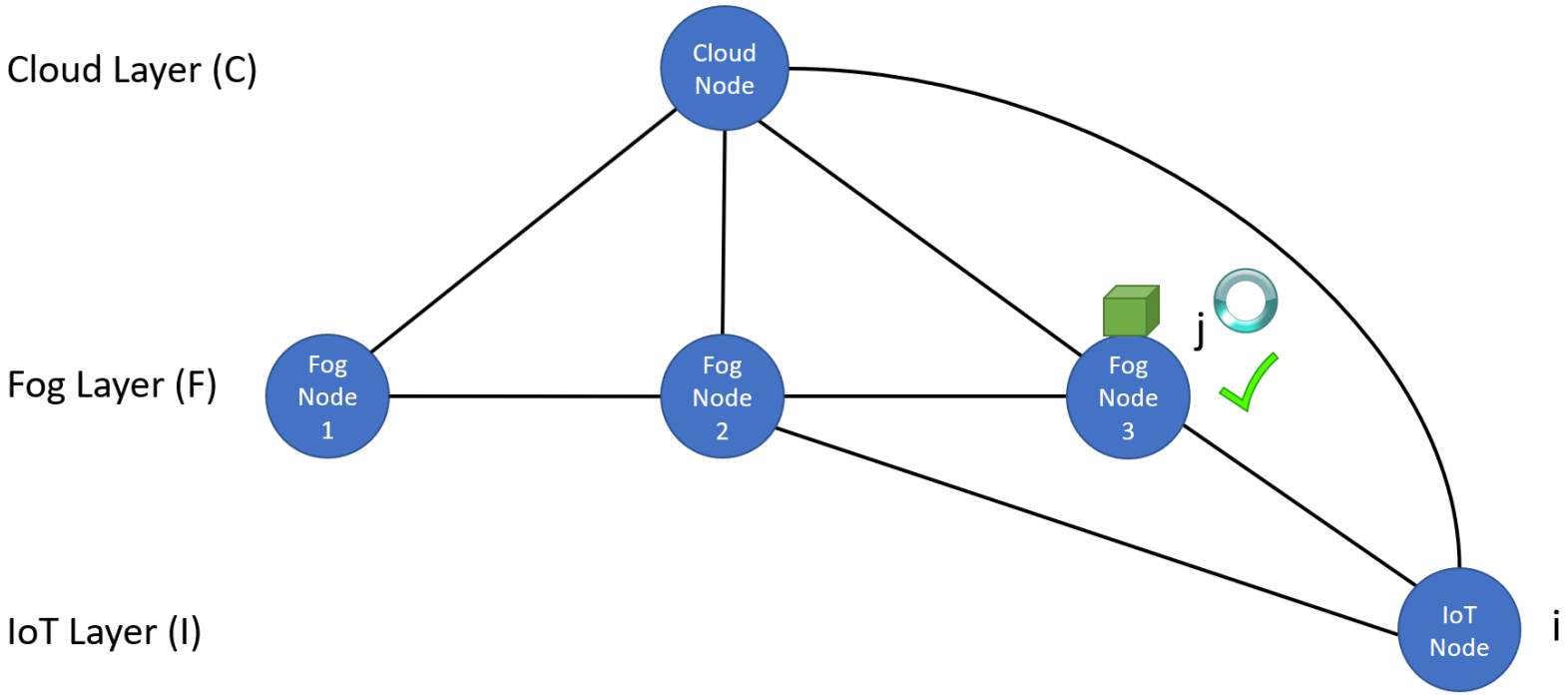
Fog Layer Delay



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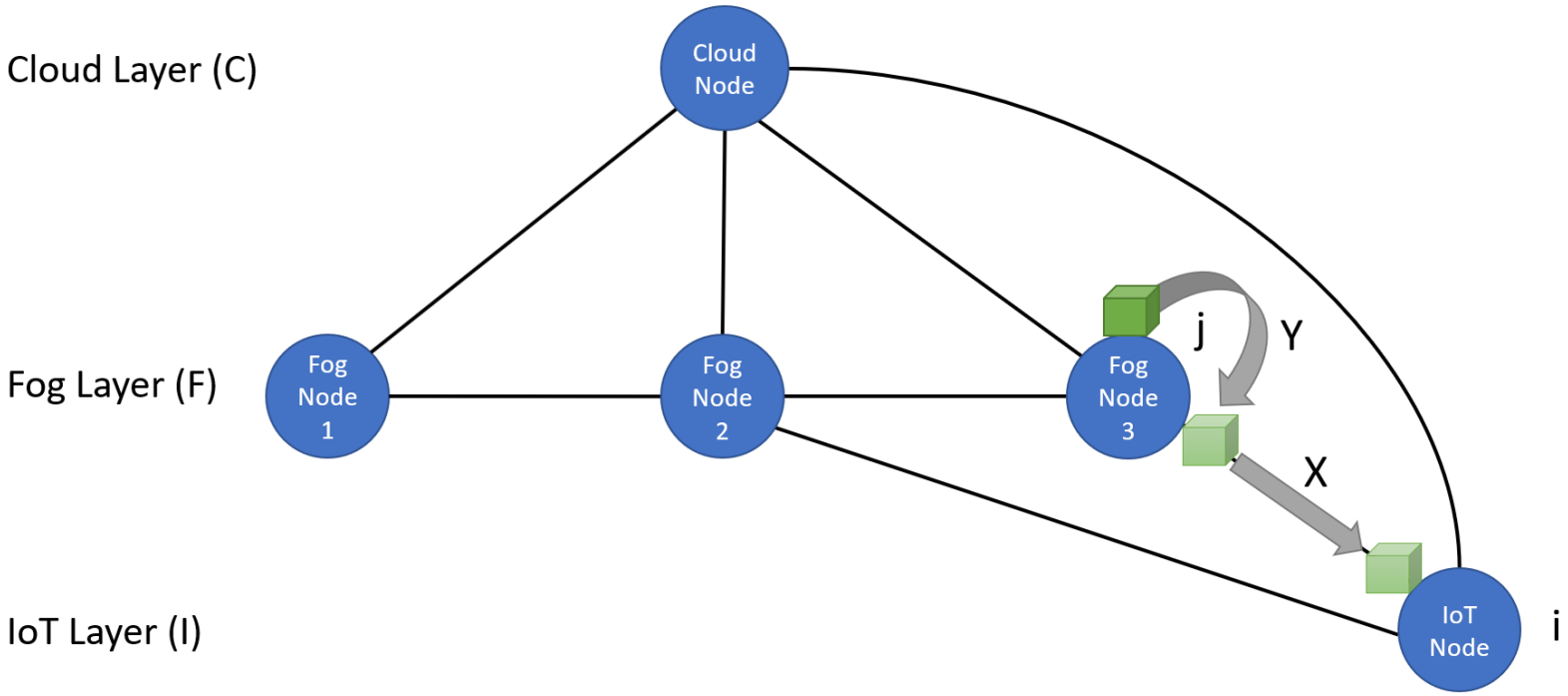

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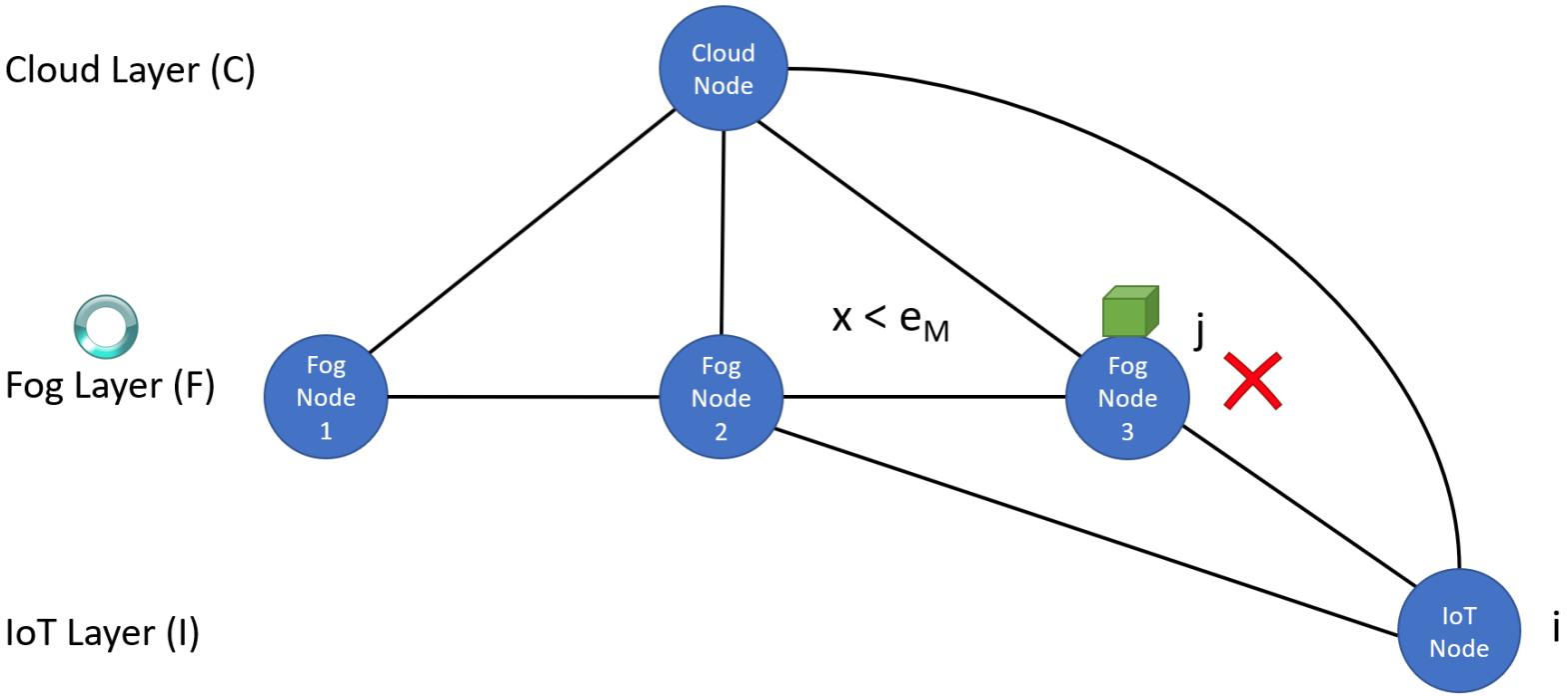

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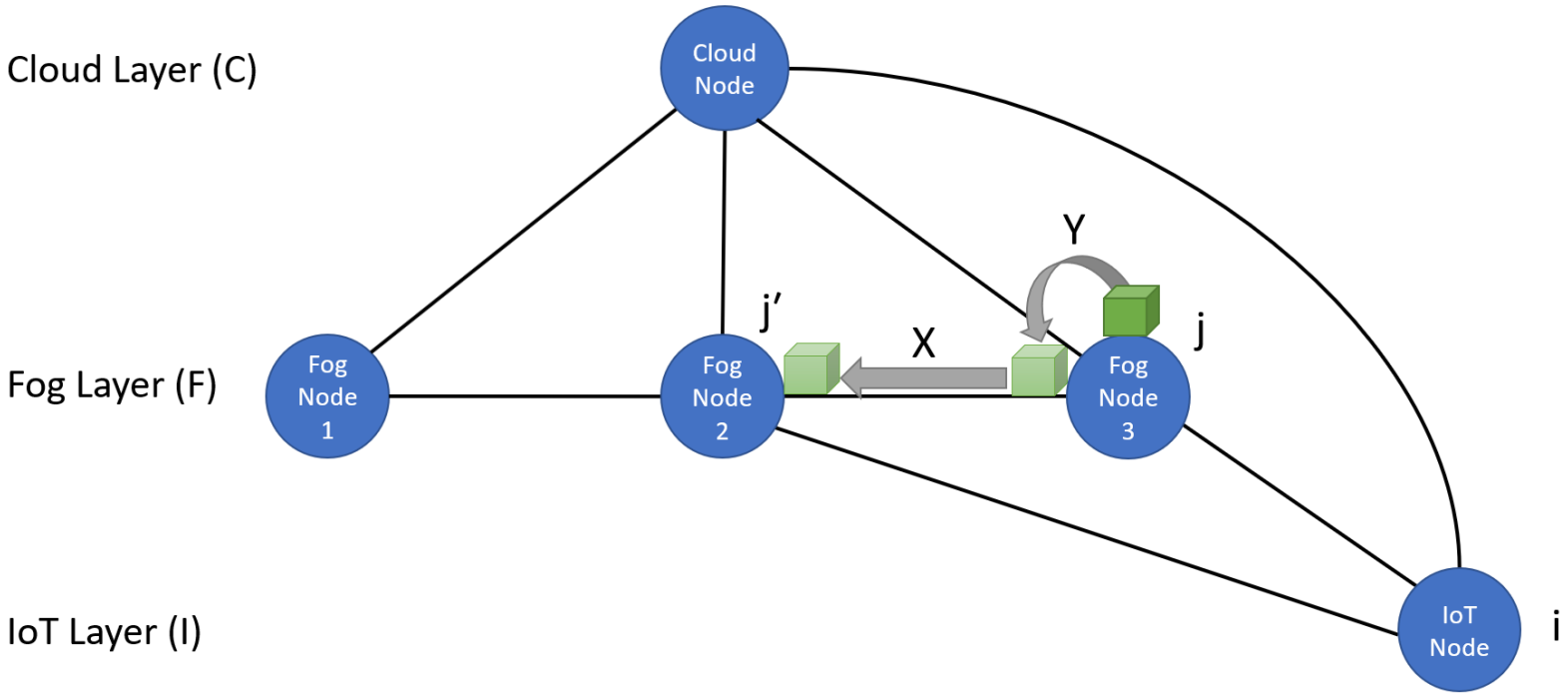

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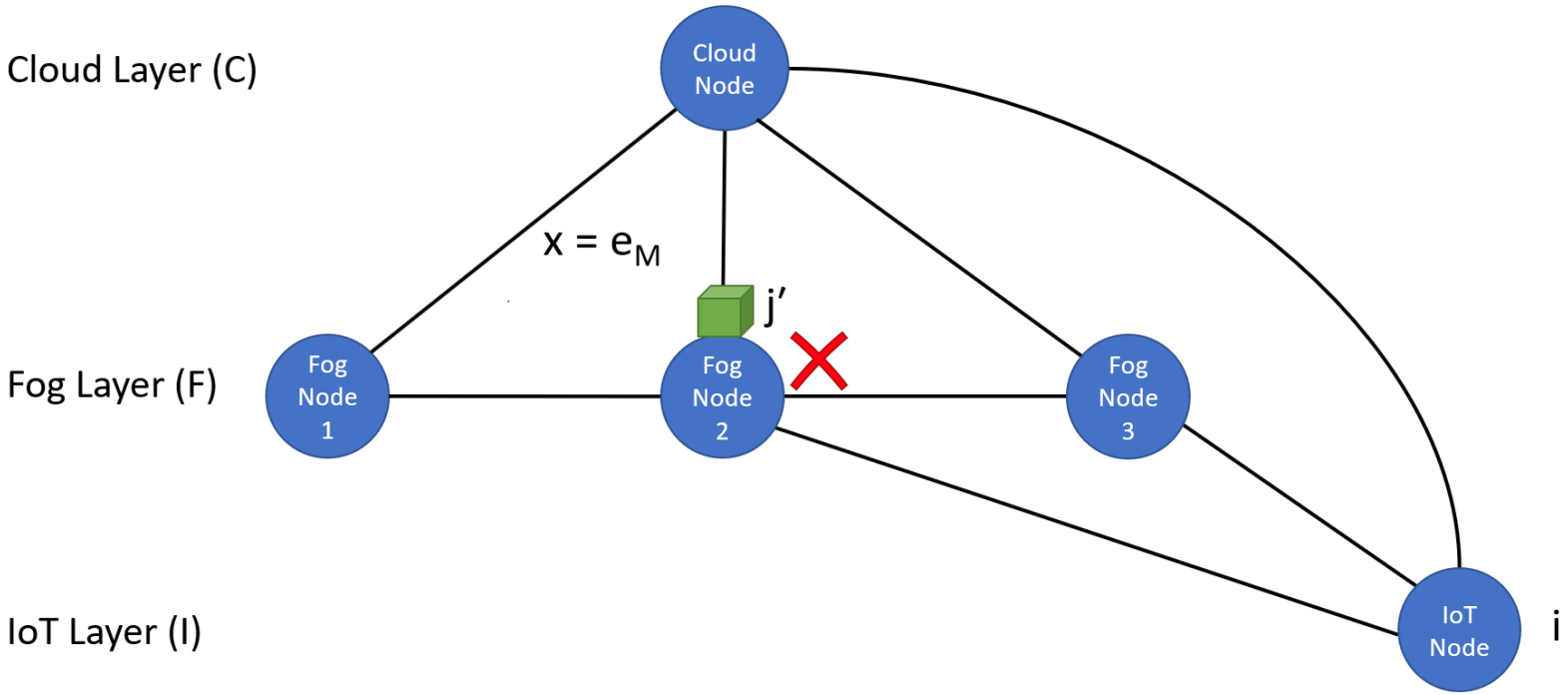

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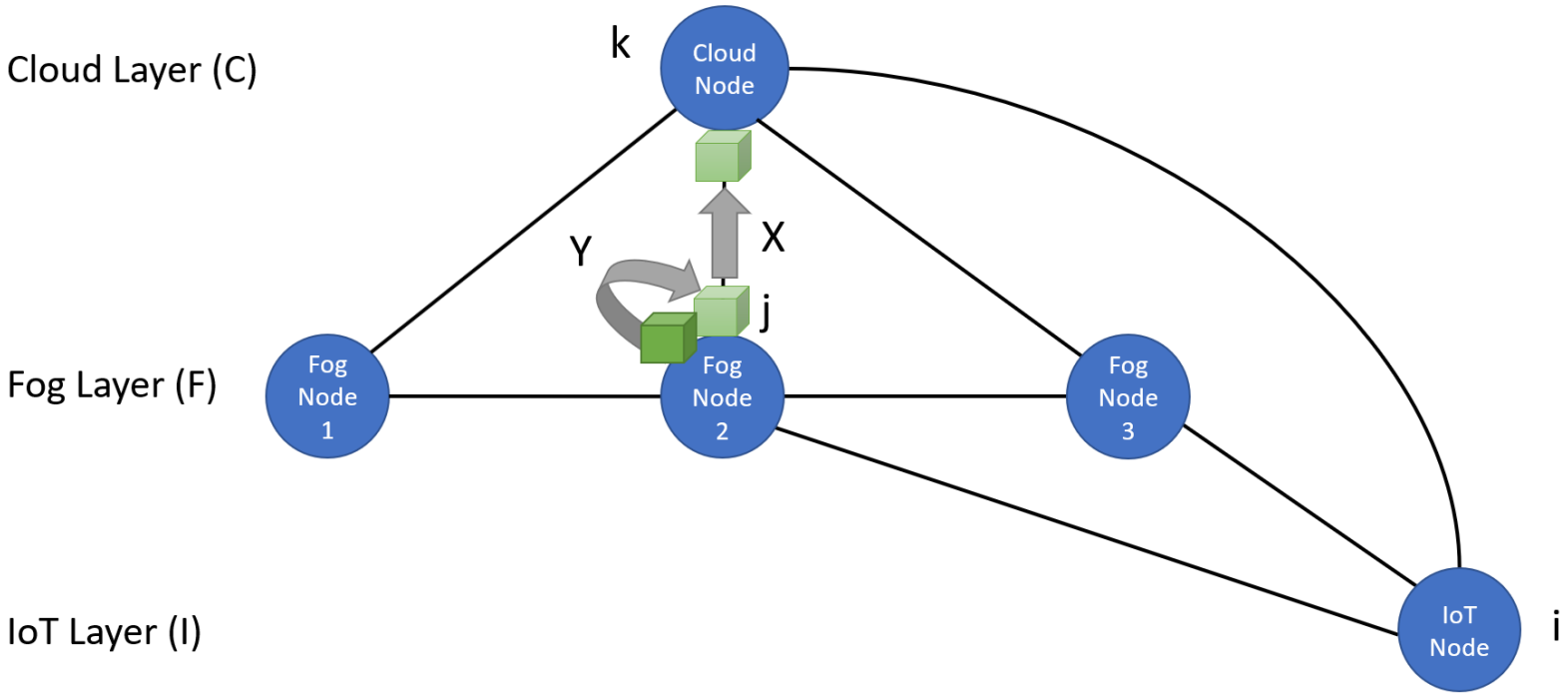

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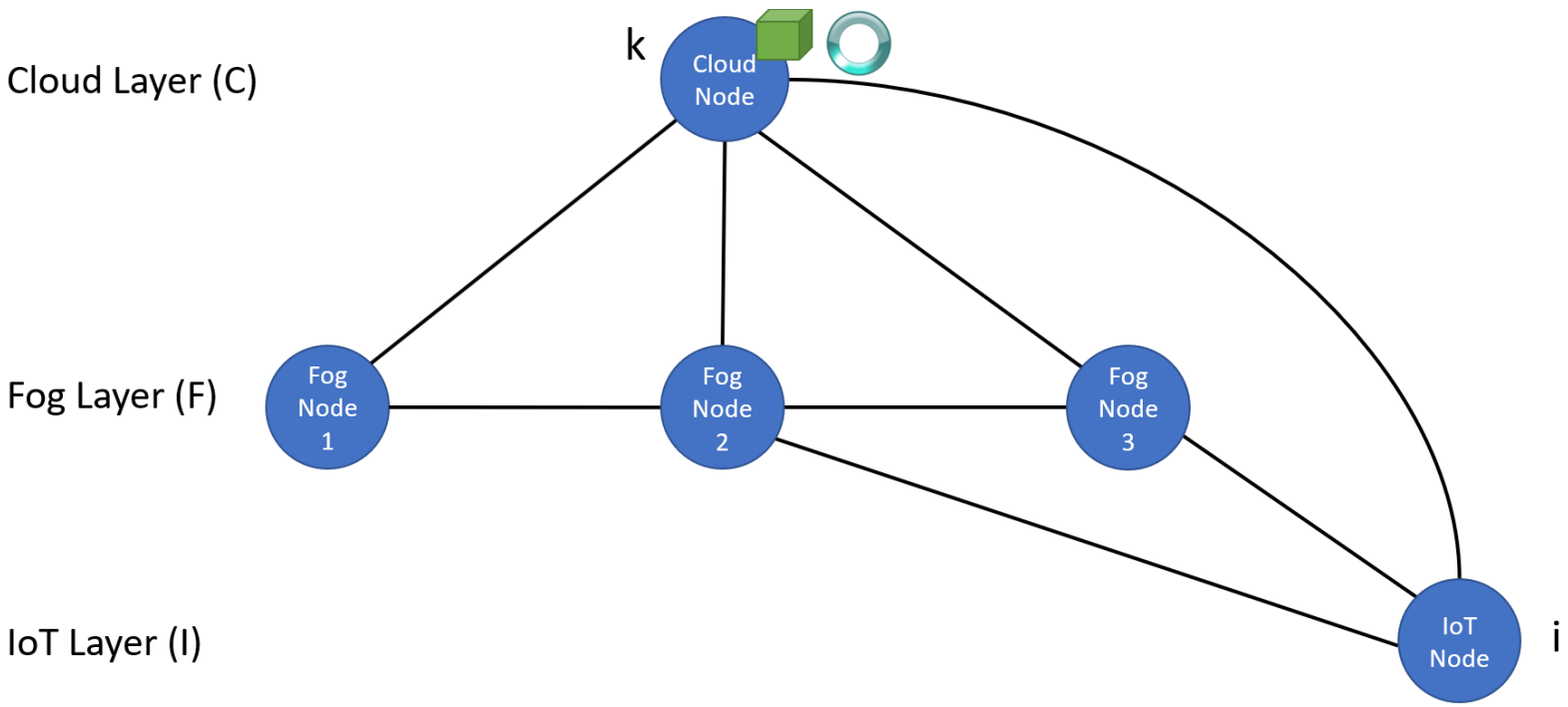

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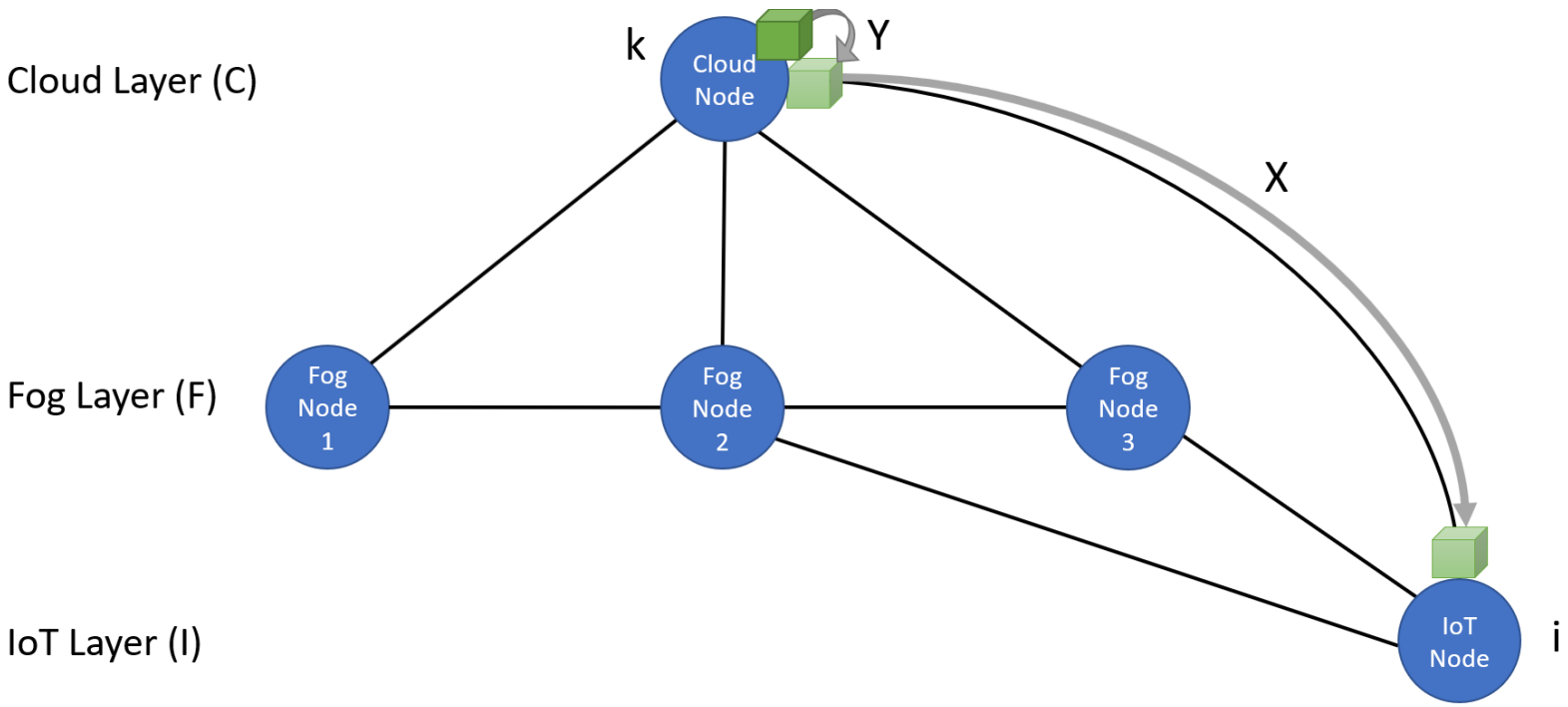

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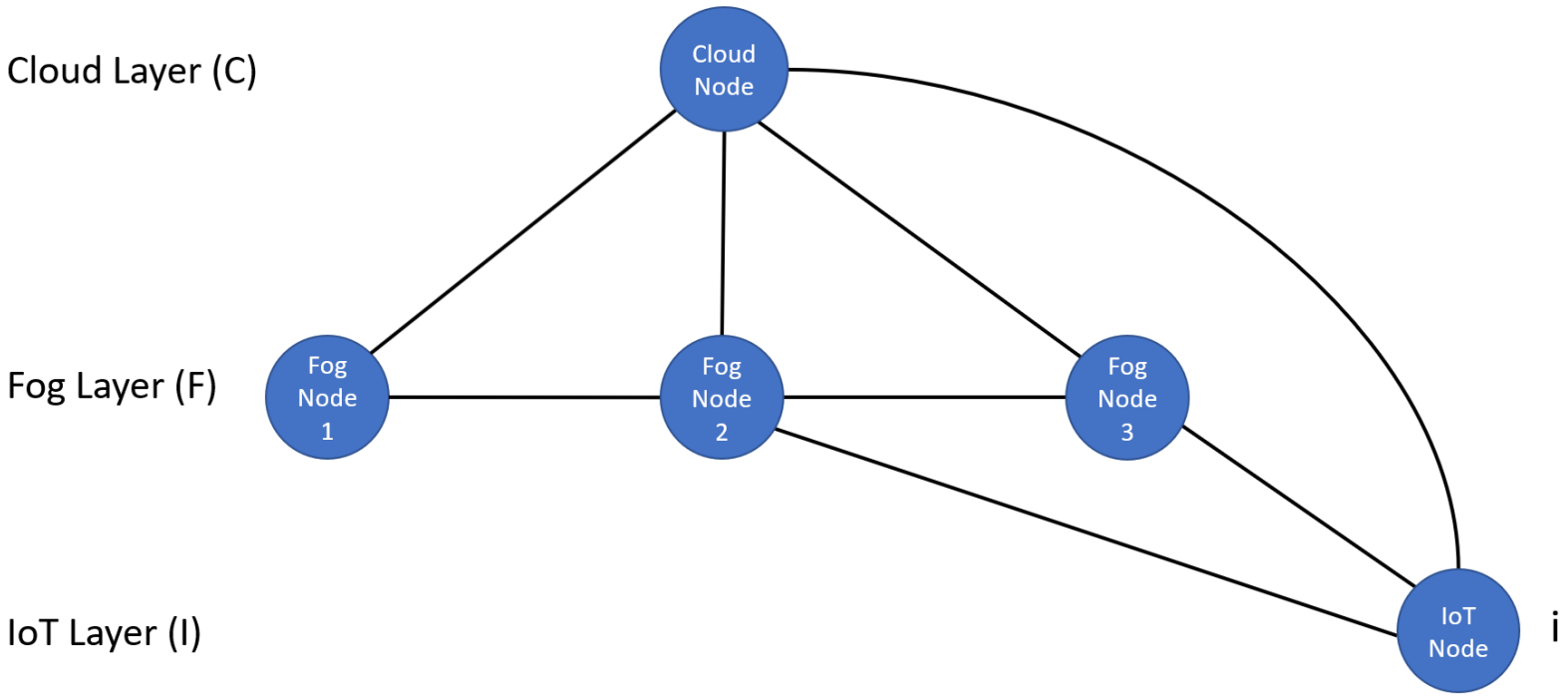

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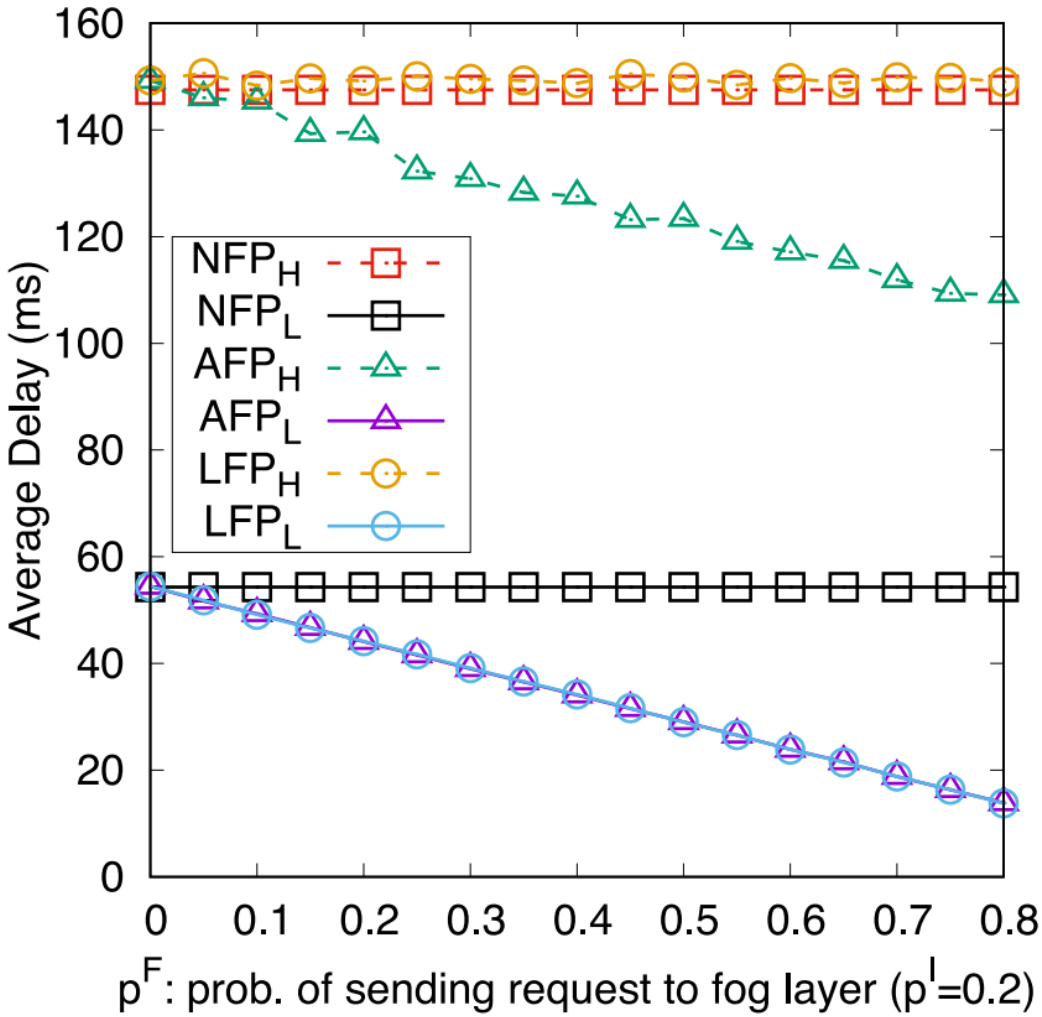
Outline

Simulation Setup

- To test this model, researchers simulate processing power of nodes
- Processing power of Arduino Uno R3 microcontroller for IoT nodes, dual core i7 processor for fog nodes
- Operates in three different modes, NFP, LFP, AFP
- Key settings include probabilities of sending request to each layer, waiting threshold, and offload limit

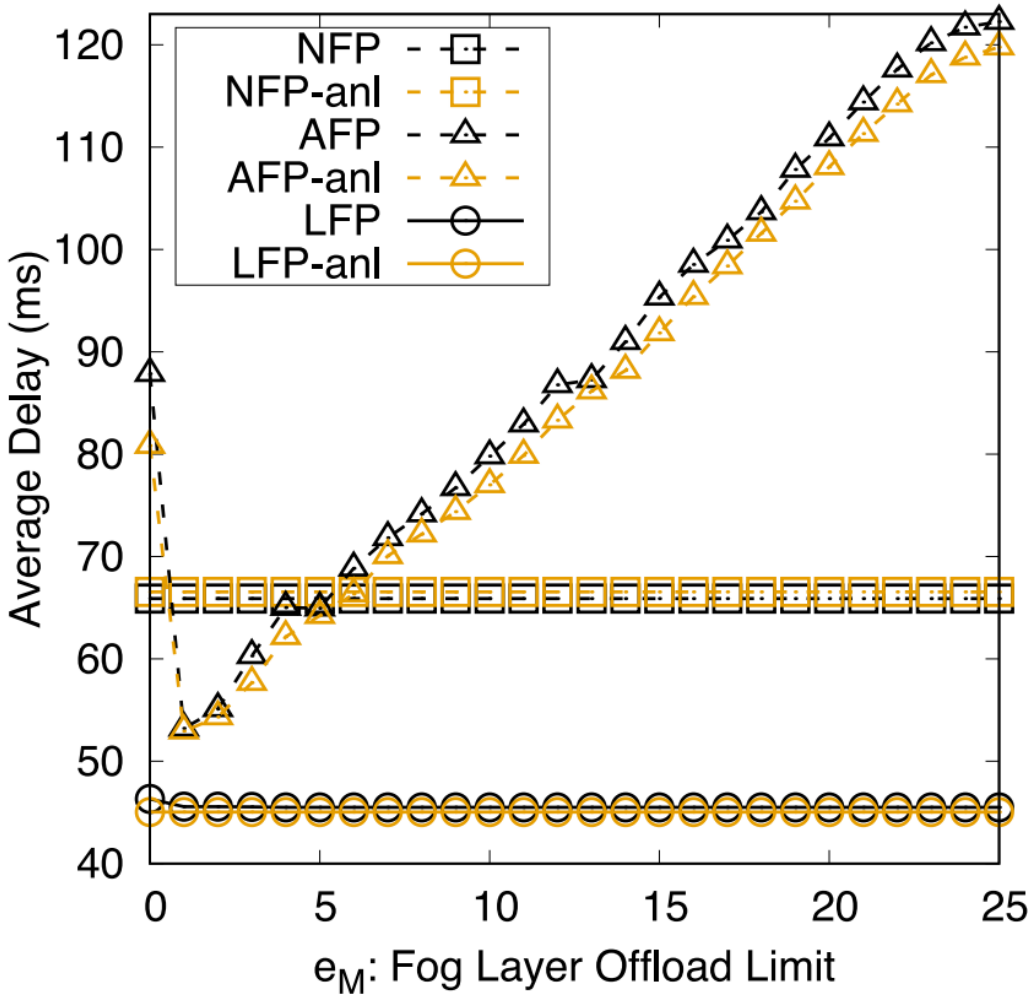
Results

- AFP mode performed best on average
- LFP and AFP modes performed better as the probability of sending tasks to the fog layer increased



Results cont.

- Optimal offload limit for this simulation found to be 1
- All fog nodes were overwhelmed with tasks in their queues



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Conclusion

- Edge computing significantly decreases task completion times
- Task offloading, with the proper optimizations, is one technique that enables this to happen
- May speed up the development of new products and technology

Acknowledgements

I would like to give a special thanks to KK and Elena Machkasova for their helpful feedback incorporated in this talk

Questions

Questions?

References

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