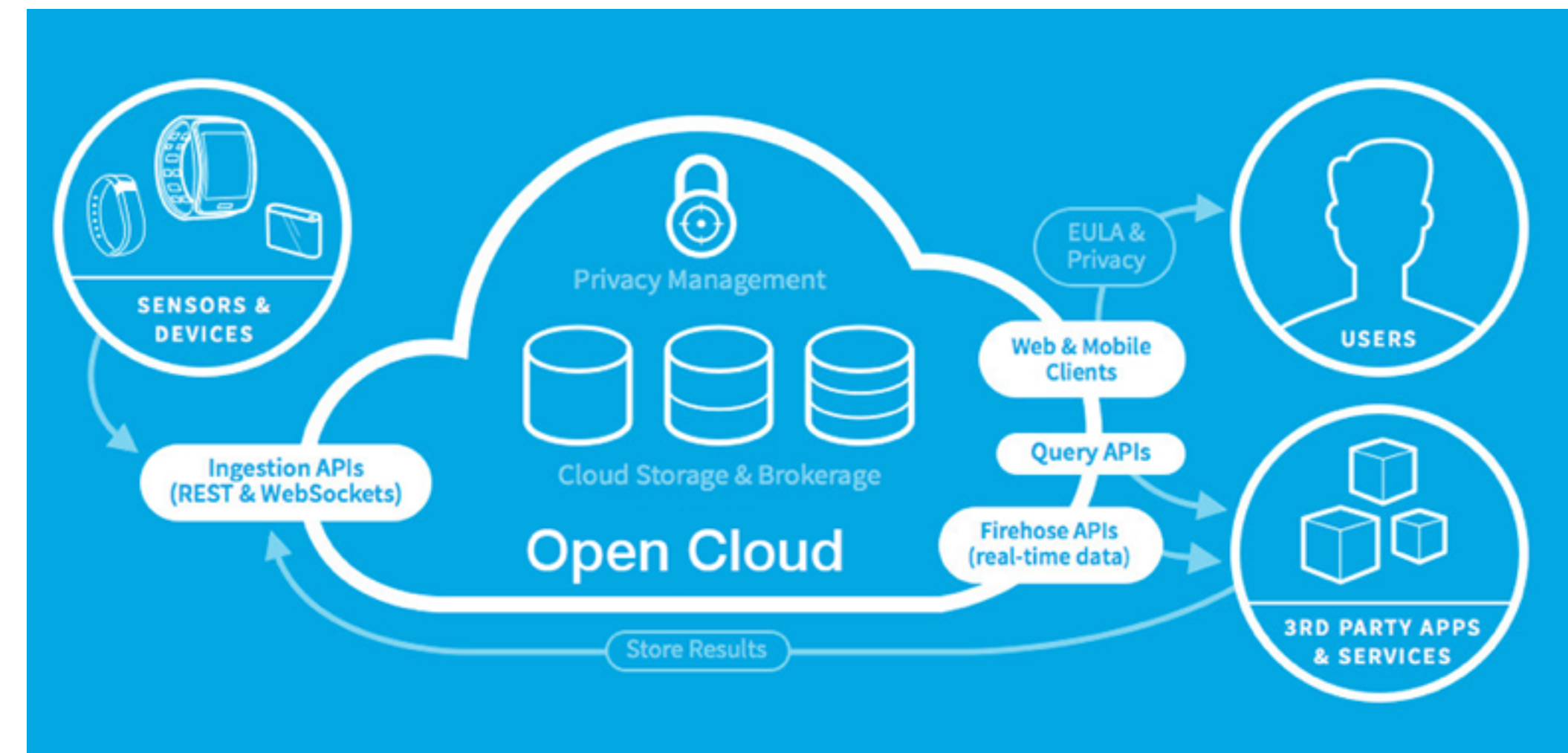
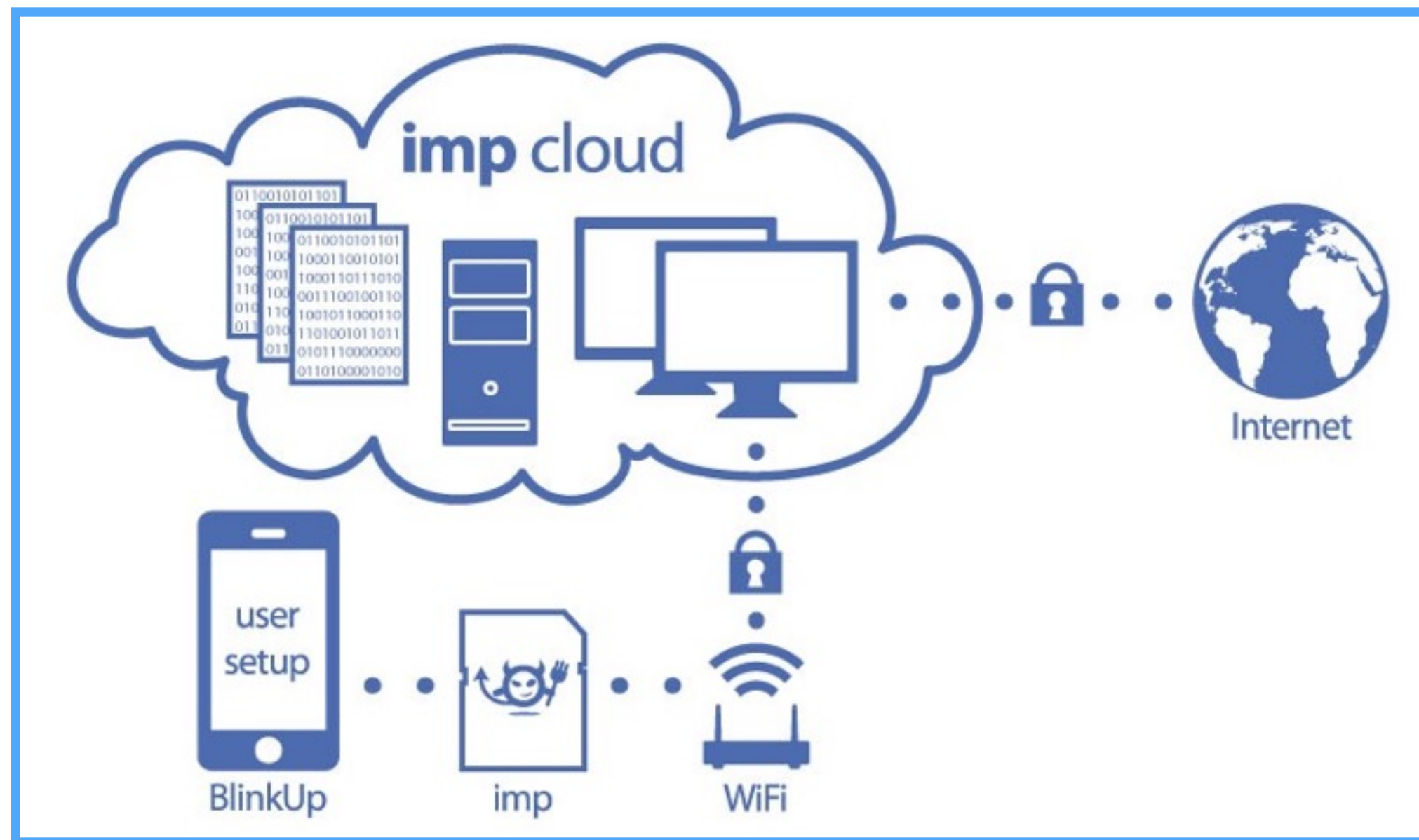


The Cloud is Not Enough Saving IoT from the Cloud

Ben Zhang, Nitesh Mor, John Kolb, Douglas S. Chan, Nikhil Goyal
Ken Lutz, Eric Allman, John Wawrzynek, Edward Lee, and John Kubiatoicz
University of California, Berkeley

Internet of Things with the Cloud

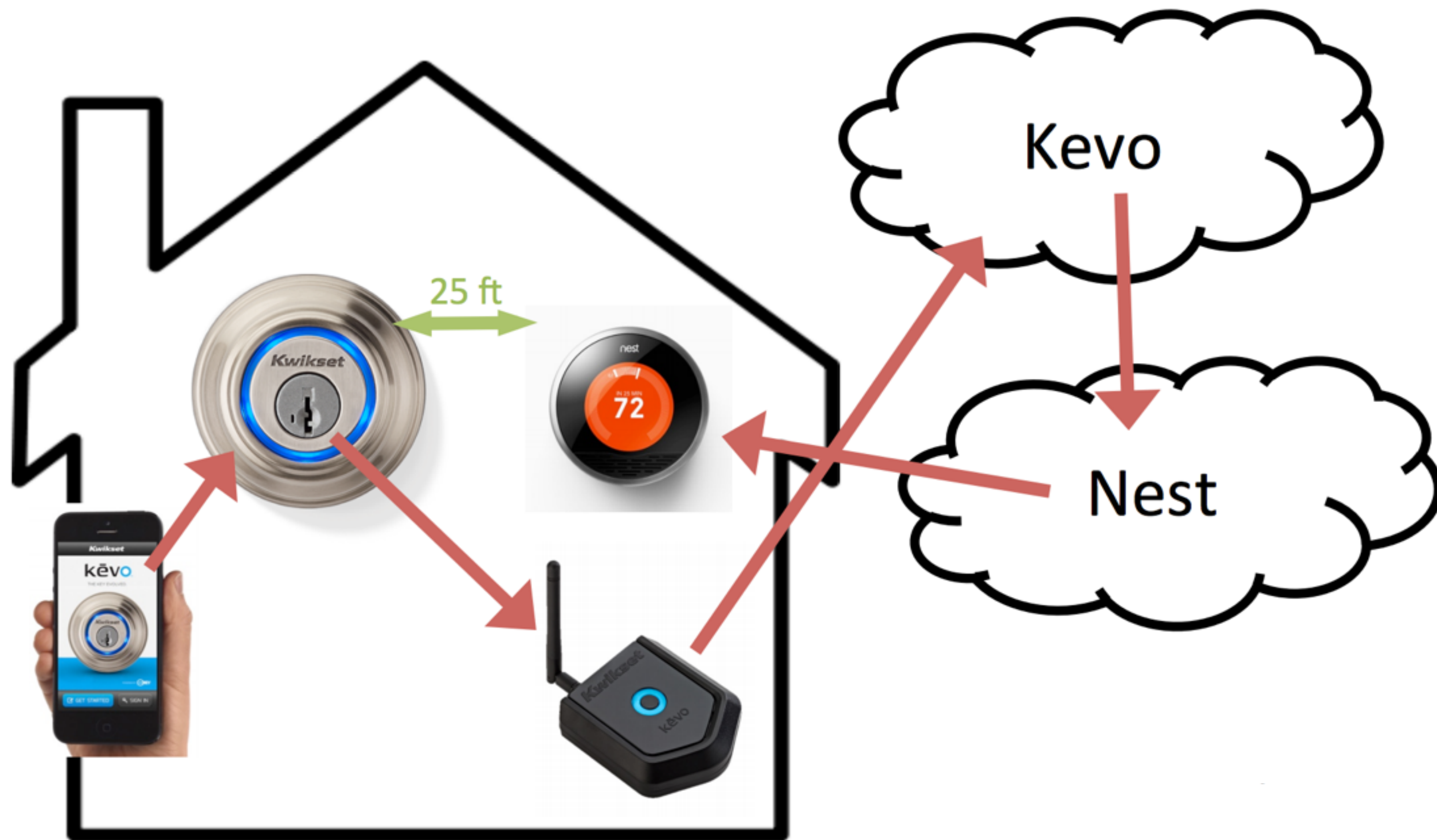


Electric Imp: <http://www.limetrace.co.uk/electric-imp-platform>

Samsung SAMI: <https://developer.samsungsami.io/sami/sami-documentation/>

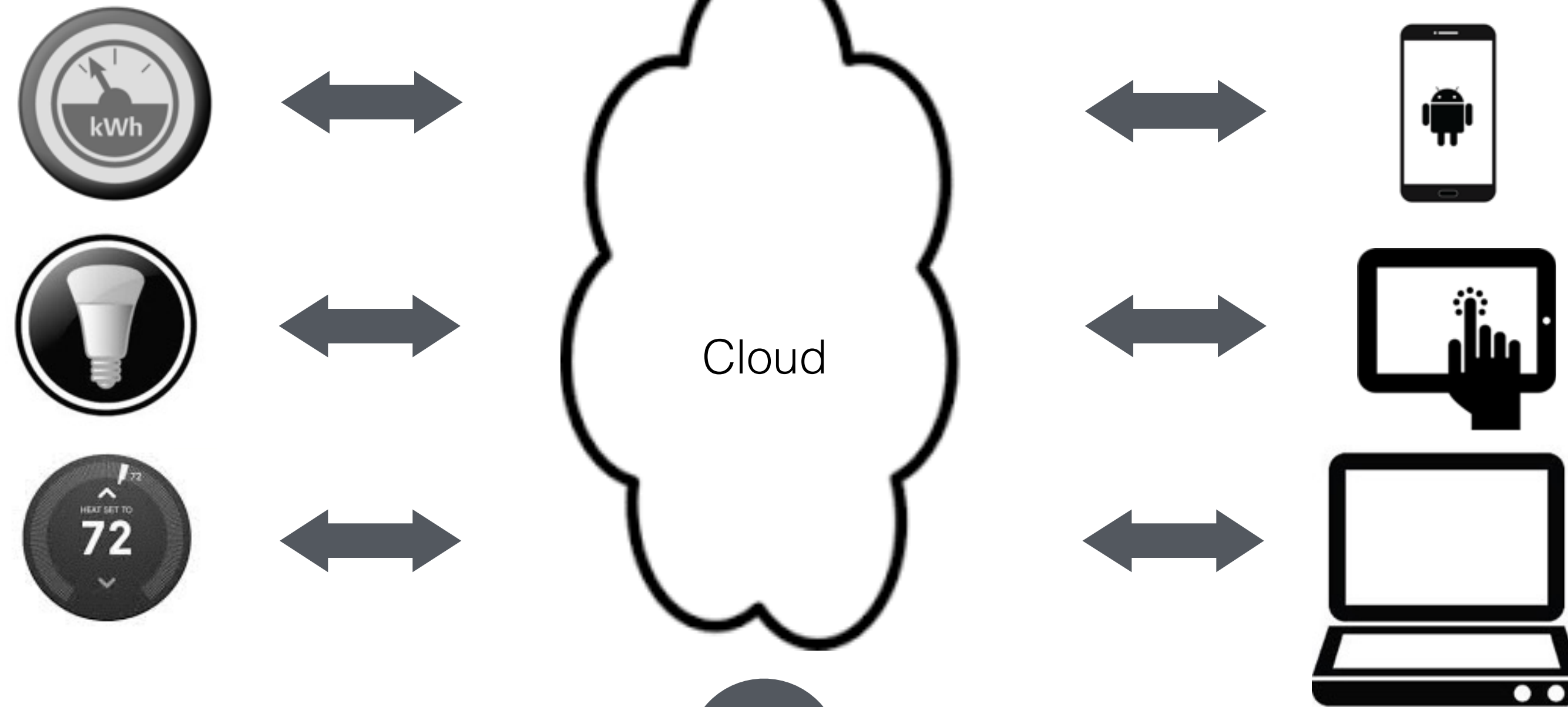
Ninja Sphere: <http://lucept.files.wordpress.com/2012/06/ninja-blocks-capture.jpg>

When I enter my home, turn the AC on.



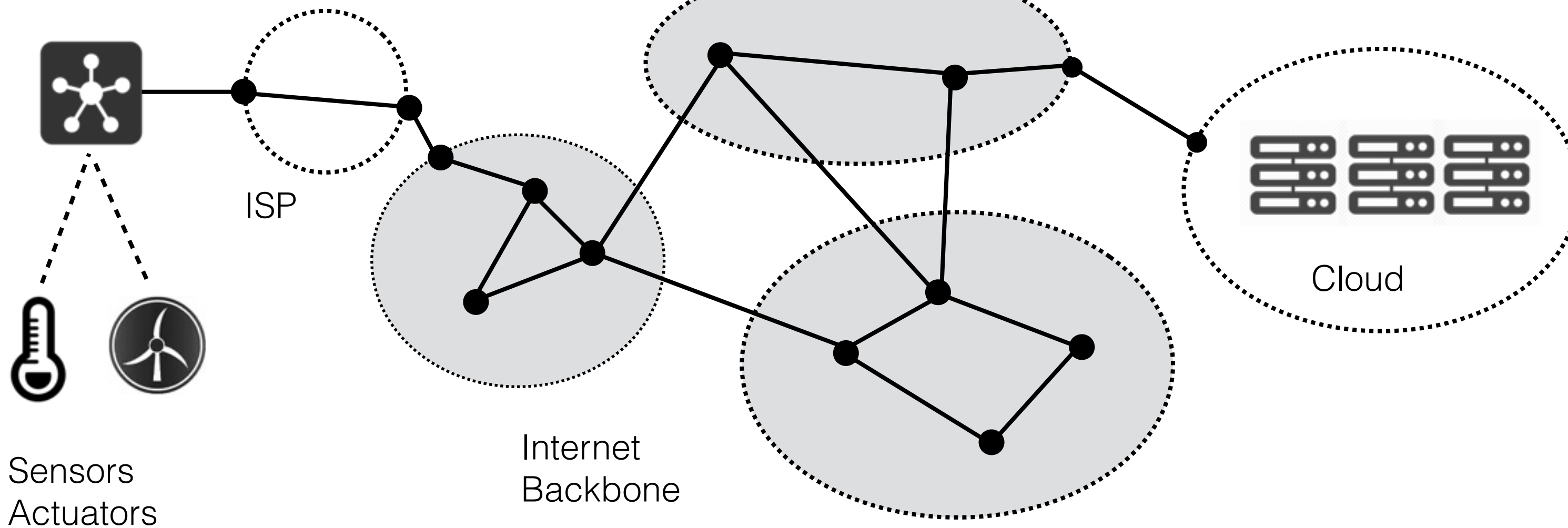
- vendor lock-in
- latency
- privacy

Slides borrowed from Brad Campbell
Brad Campbell. "Accessing the Swarm". Tutorial, 19, March, 2015.



VS

Gateway



Web vs. IoT: What is different?

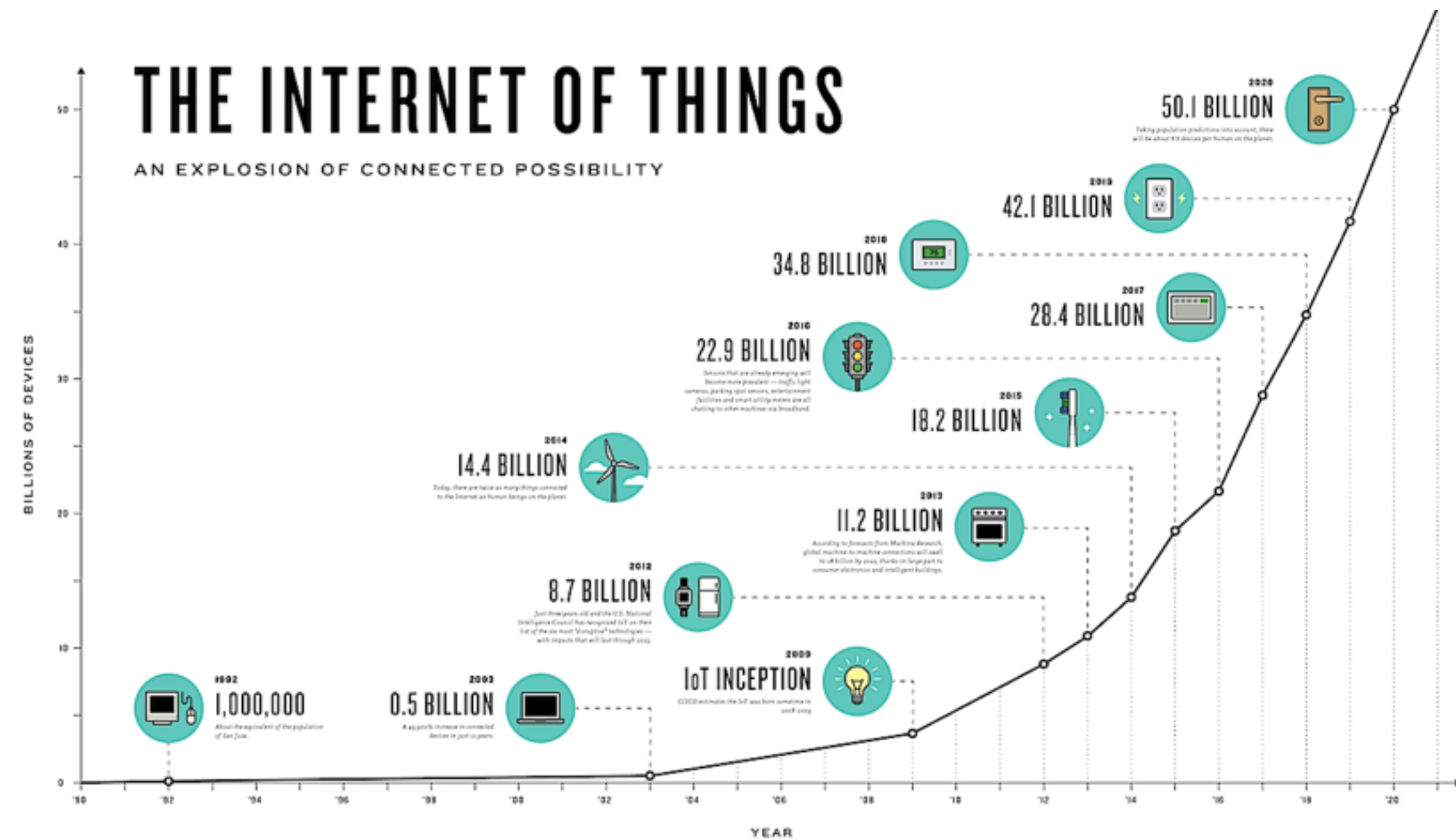
	Web	IoT
Privacy & Security	Open for access	Personal sensitive data
Scalability	Power law	Billlion devices & updates
Interaction Model	Human	Machine
Latency	Variable	Deterministic
Bandwidth	Downstream	Upstream
Availability (QoS)	No guarantee	Requirement
Durability Management	Cloud controls	Users control

Open for access or personal sensitive data?



left: <https://www.usenix.org/conference/hotcloud15>
right: <http://www.applehealthkit.com/>

Power law vs. billions devices



left: https://en.wikipedia.org/wiki/Power_law

right: <http://theconnectivist-img.s3.amazonaws.com/wp-content/uploads/2014/05/Unknown.png>

Security & Privacy

Scalability

Interaction Model

Latency

Bandwidth

Availability

Durability Manage

Interaction Model



left: <http://smallbusiness.chron.com/switch-between-users-macbook-62571.html>

right: <http://humancapitalist.com/how-machine-to-machine-technology-puts-people-first/>

Security & Privacy

Scalability

Interaction Model

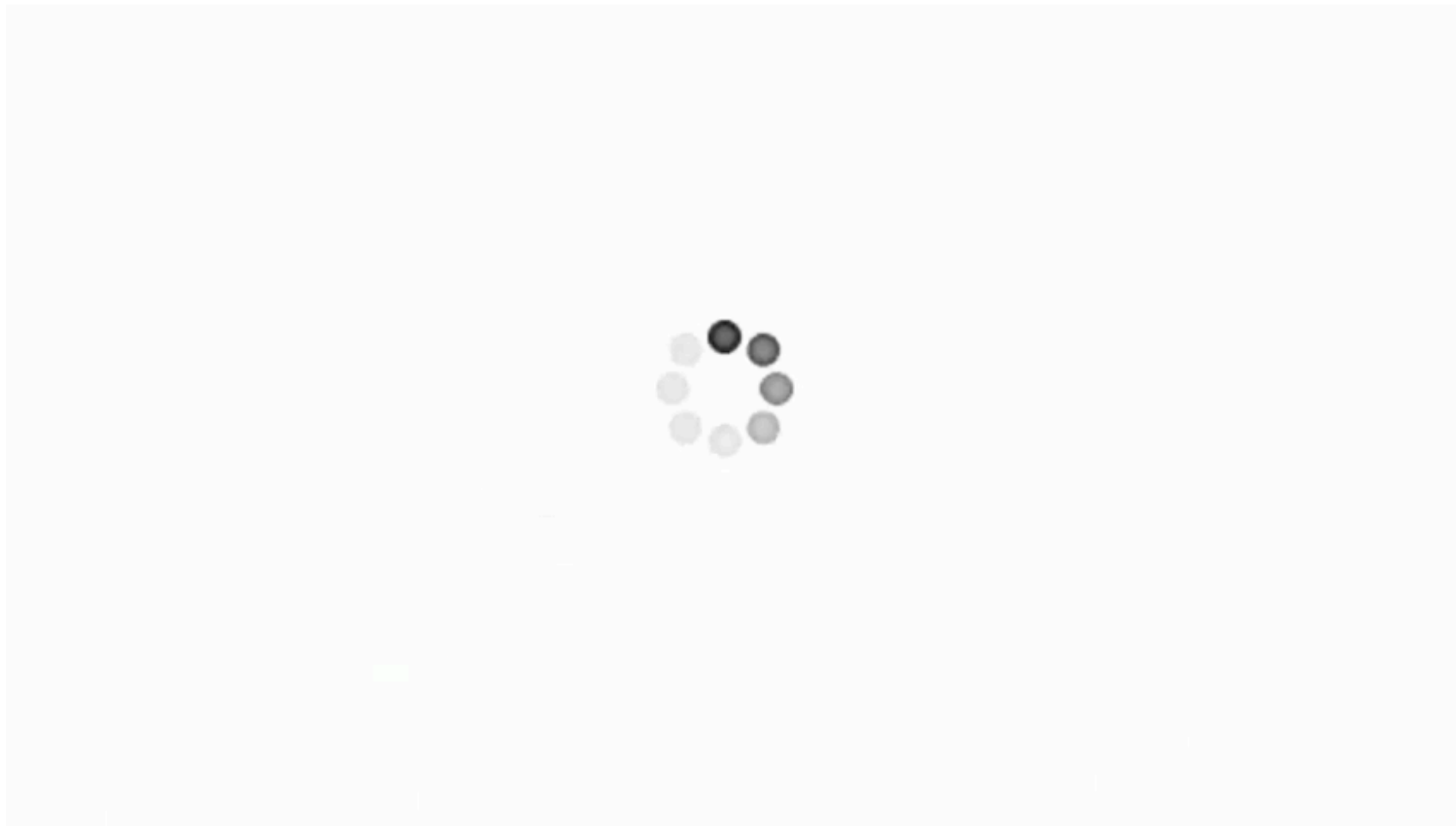
Latency

Bandwidth

Availability

Durability Manage

Latency and QoS Requirement



right: <http://news.thomasnet.com/tech-trends/2014/02/25/m2m-communication-is-prelude-to-smart-manufacturing-systems>

Security & Privacy

Scalability

Interaction Model

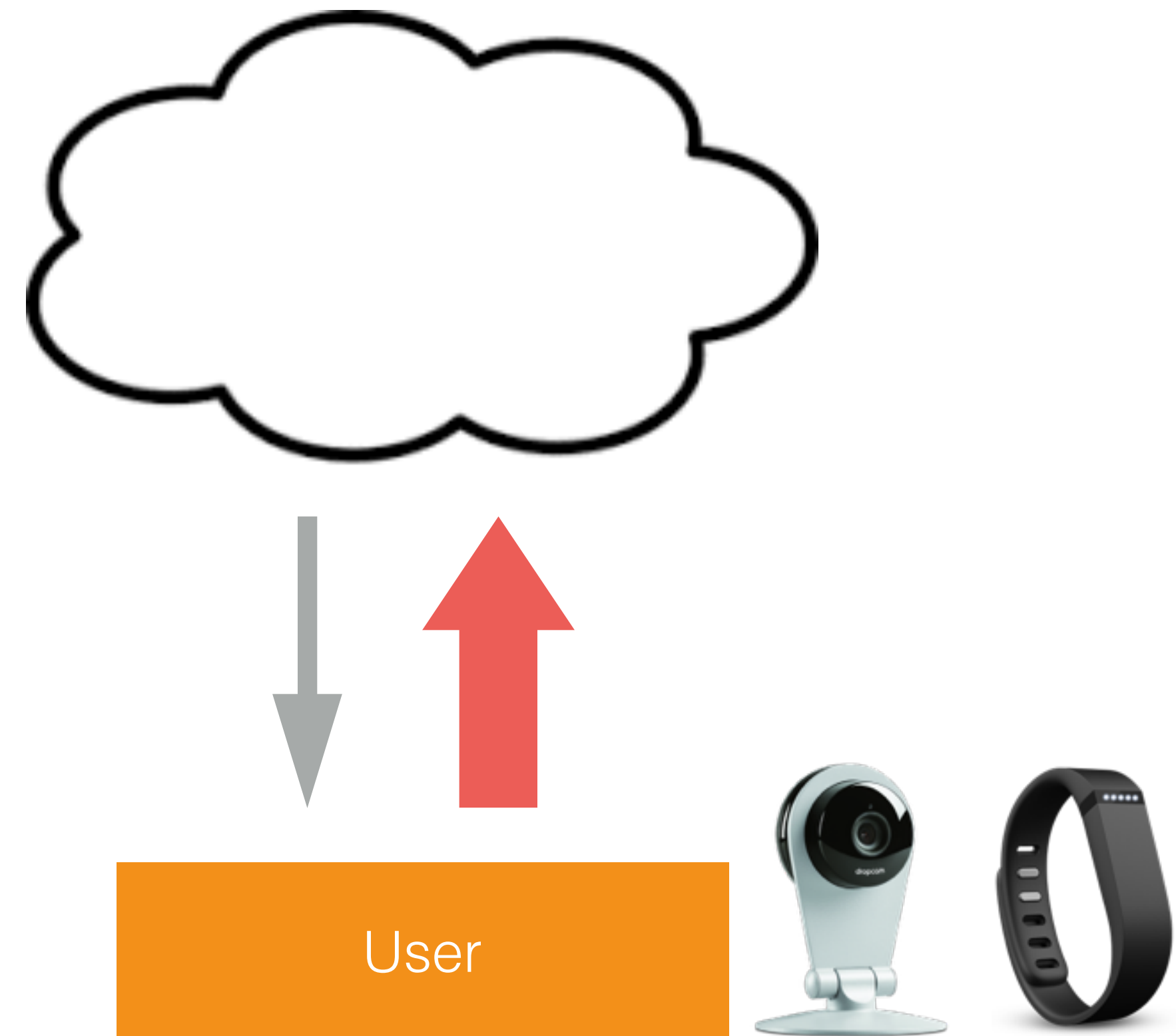
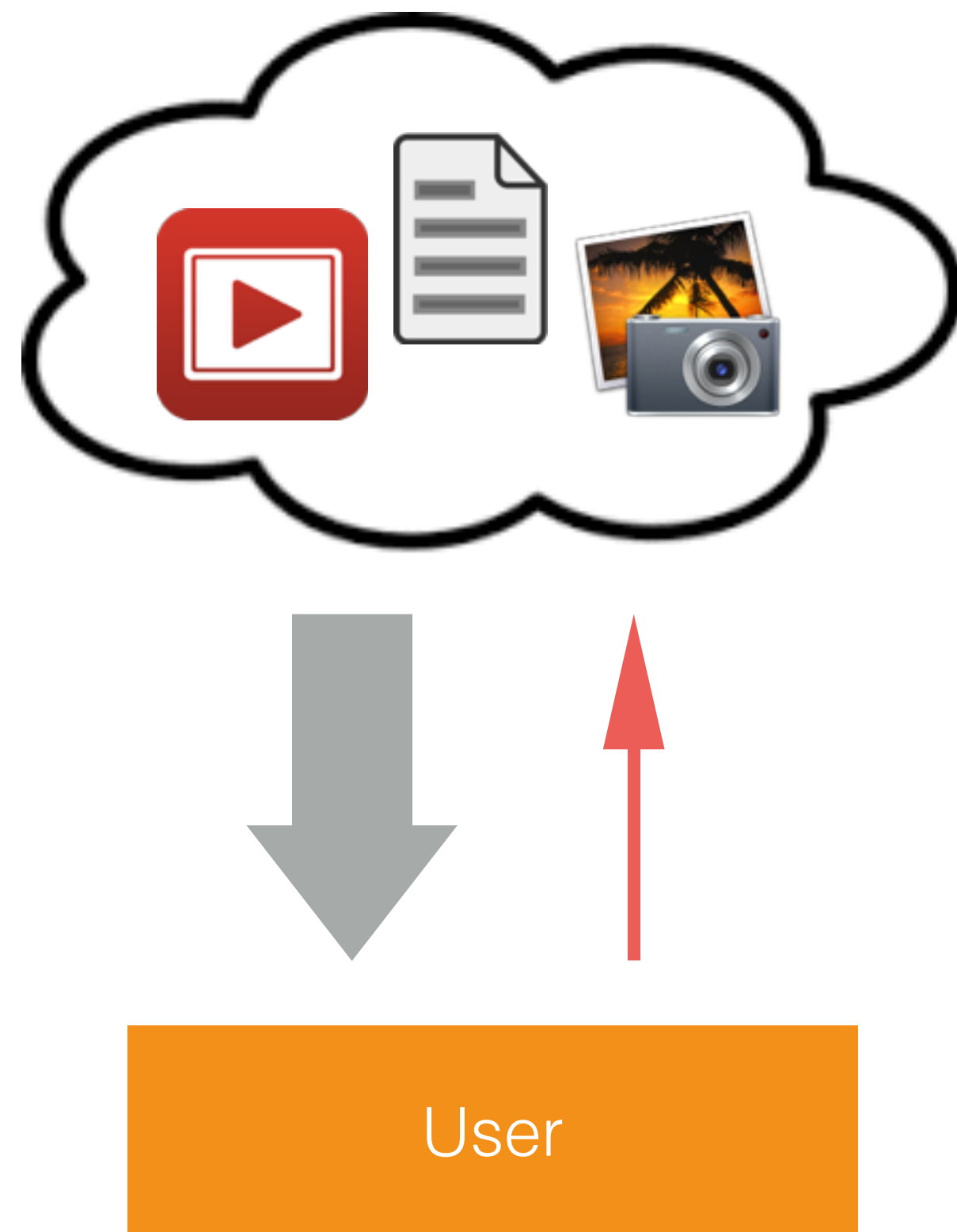
Latency

Bandwidth

Availability

Durability Manage

Bandwidth: downstream vs. upstream



Durability management: who controls?



Web vs. IoT: What is different?

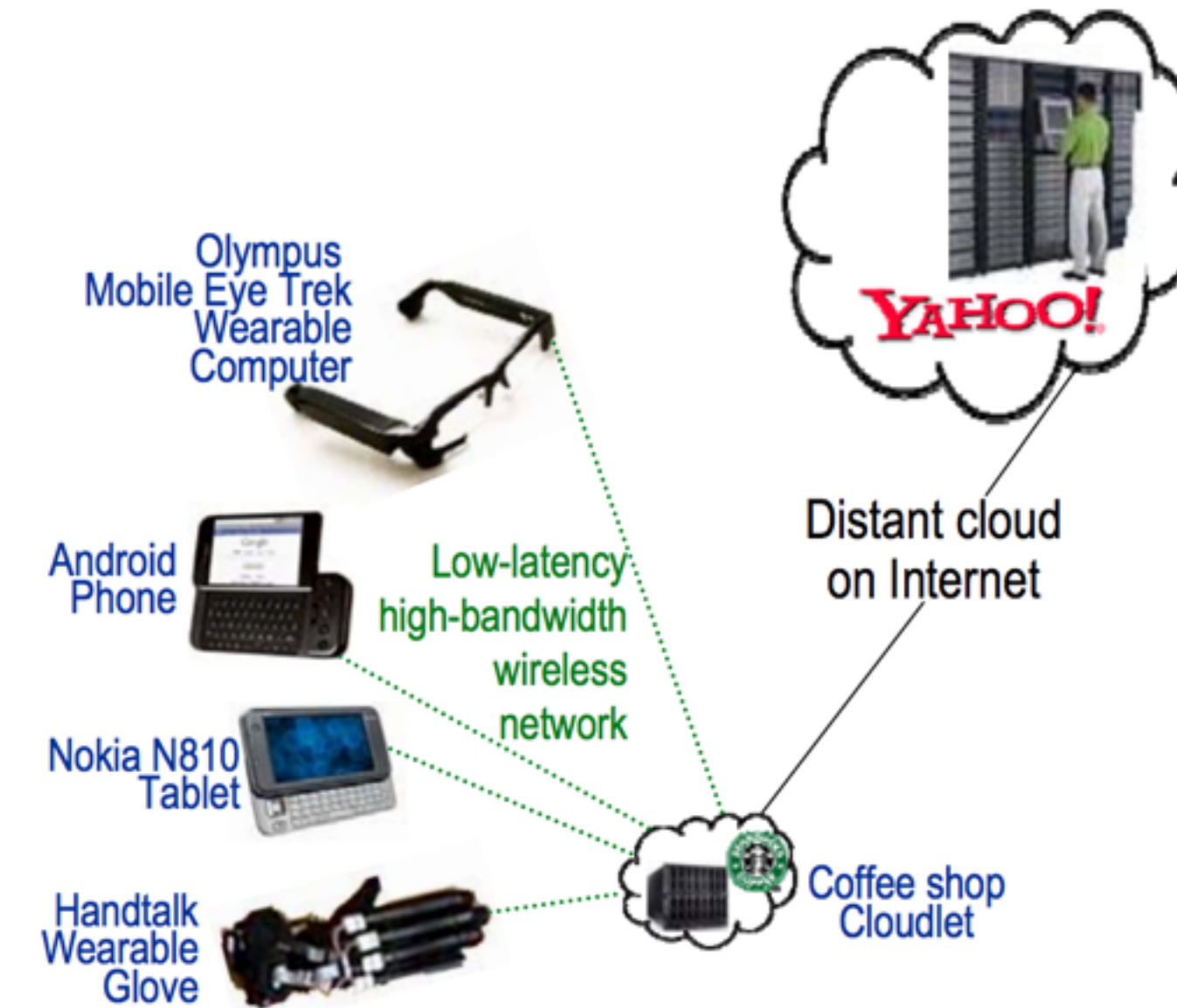
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Durability Management	Cloud controls	Users control

The Cloud is Not Enough

Existing Research Efforts



Cisco Fog Computing [2012]



CMU Cloudlets [2009]

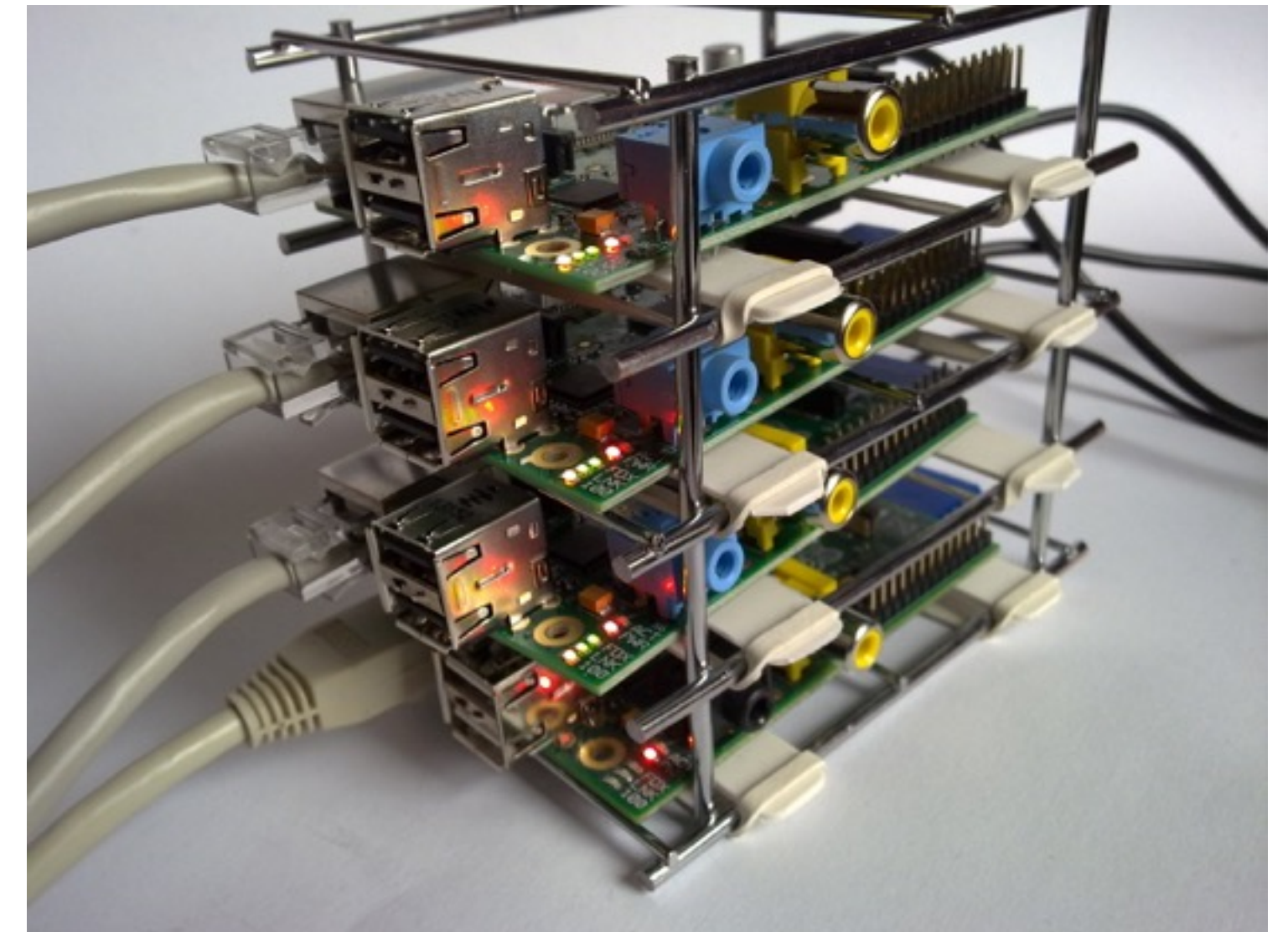
This is happening!



Intel NUC



Nexus 6



Raspberry Pi cluster

The Missing Piece



Infrastructure

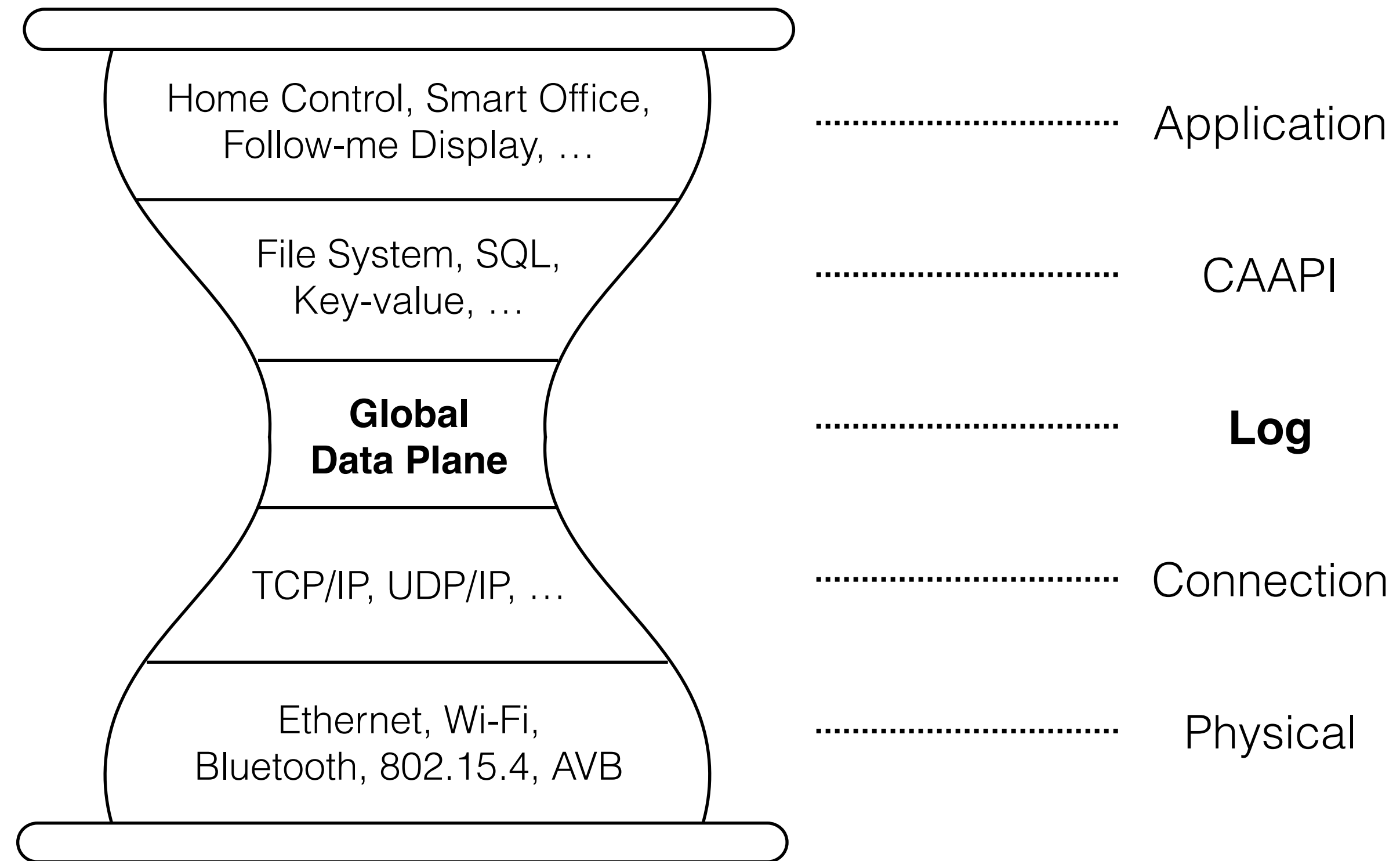
Research Question:

What is a **well-architected** system that extends the cloud and provides seamless interplay among the **heterogeneous** components in the IoT space?

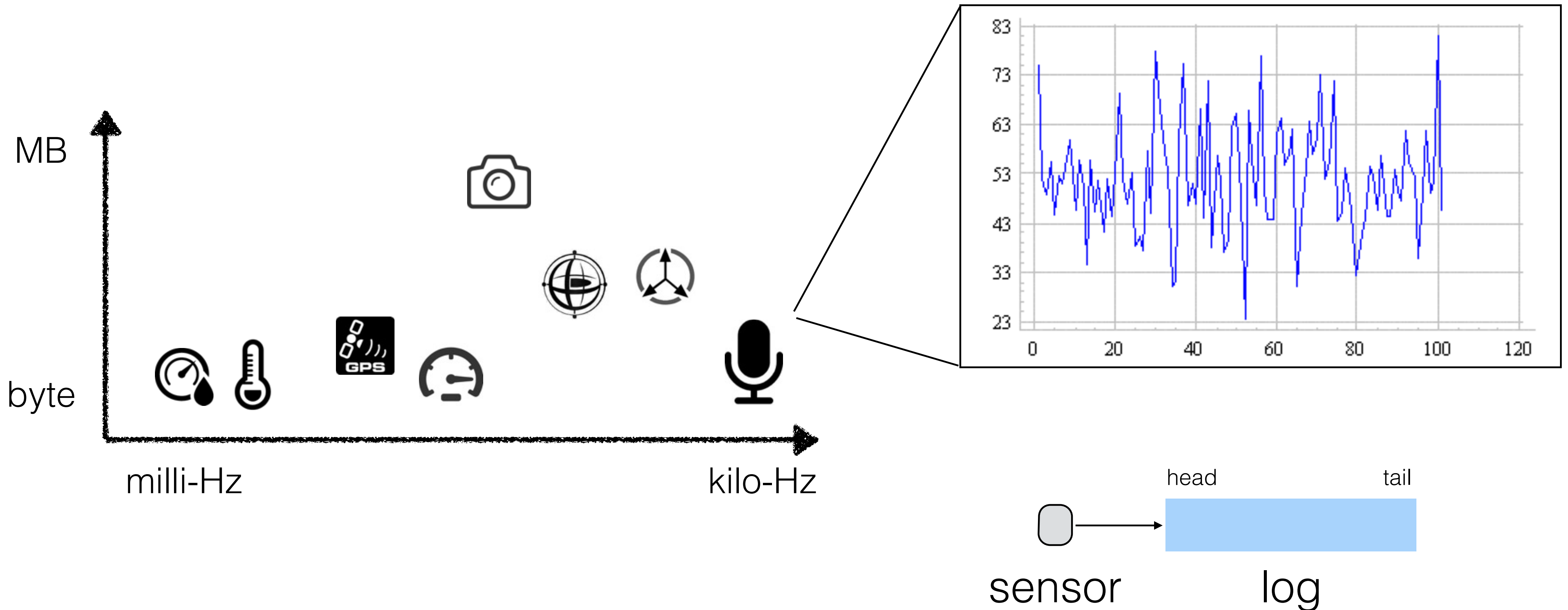
Our stand:

- Appropriate API abstraction
- System with locality, security, mobility, and so on built-in

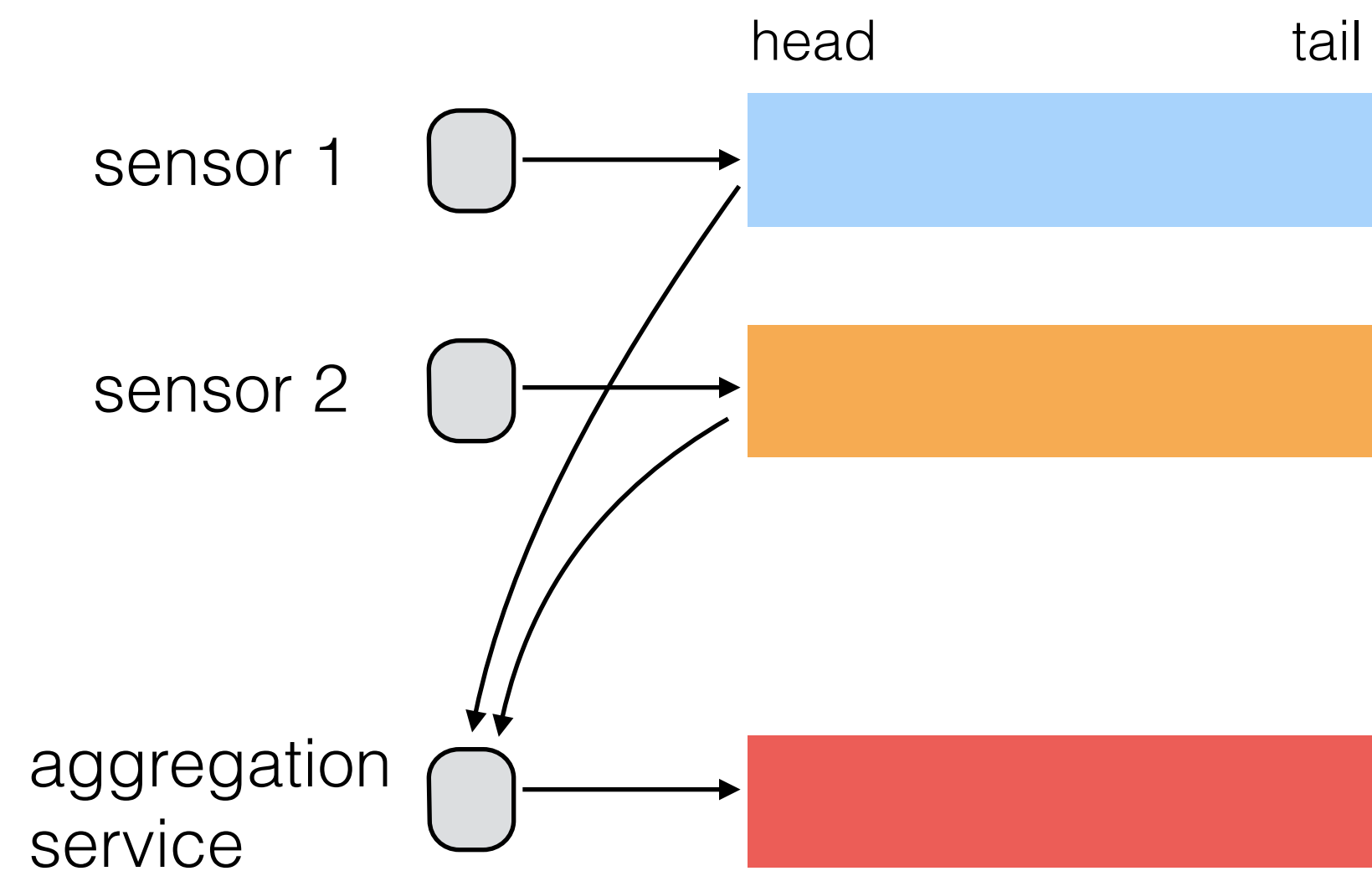
The Global Data Plane



Single-writer Append-only Log

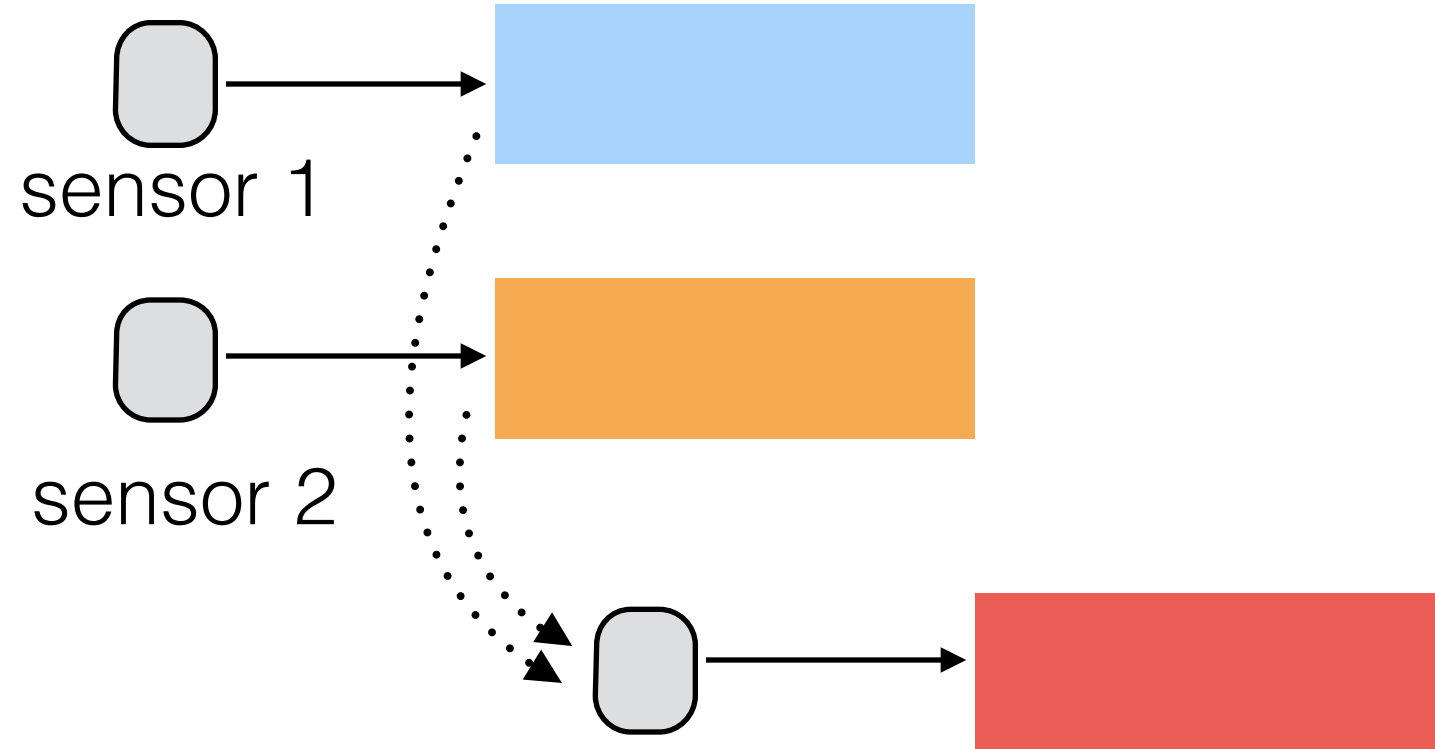
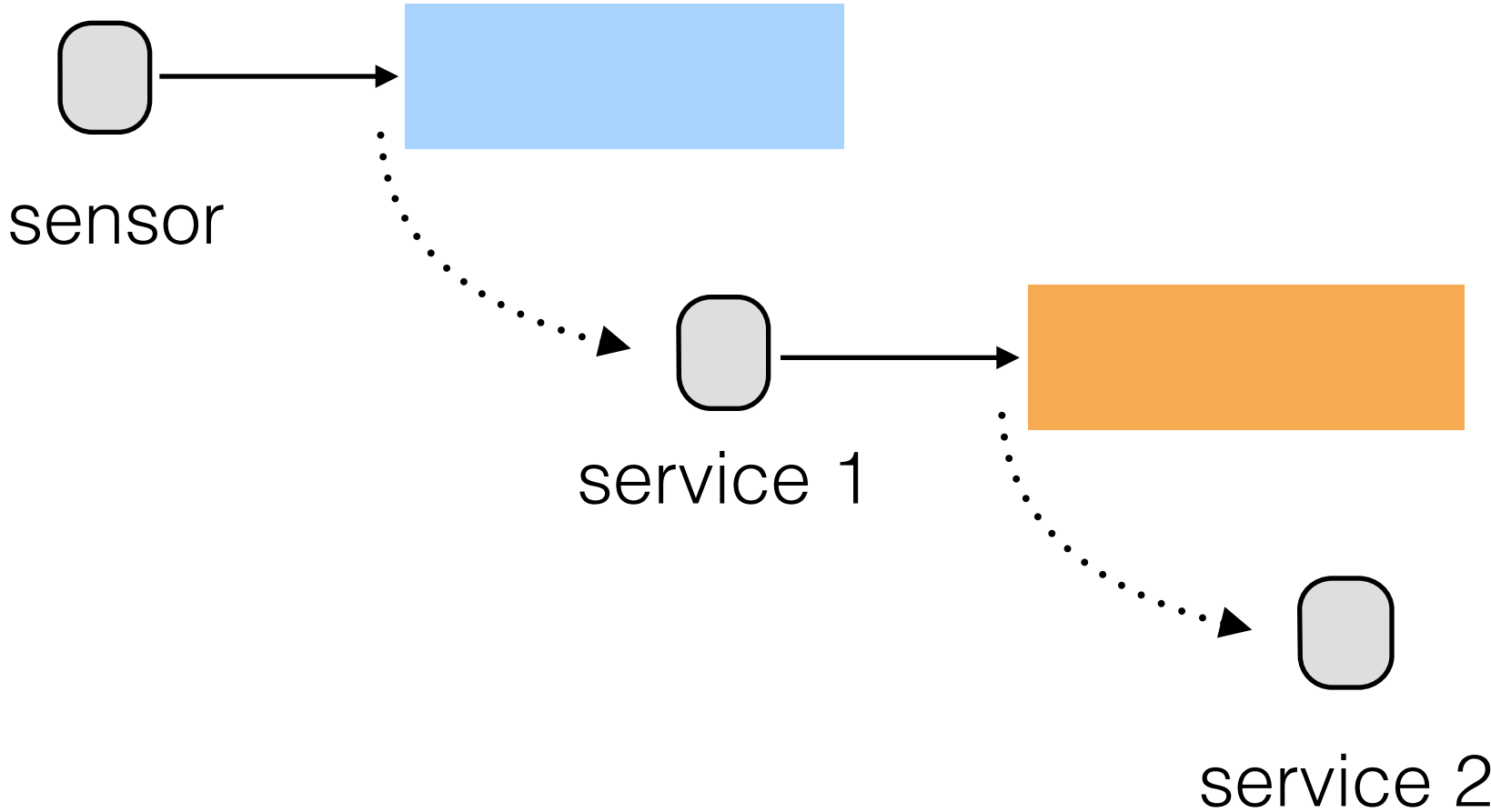
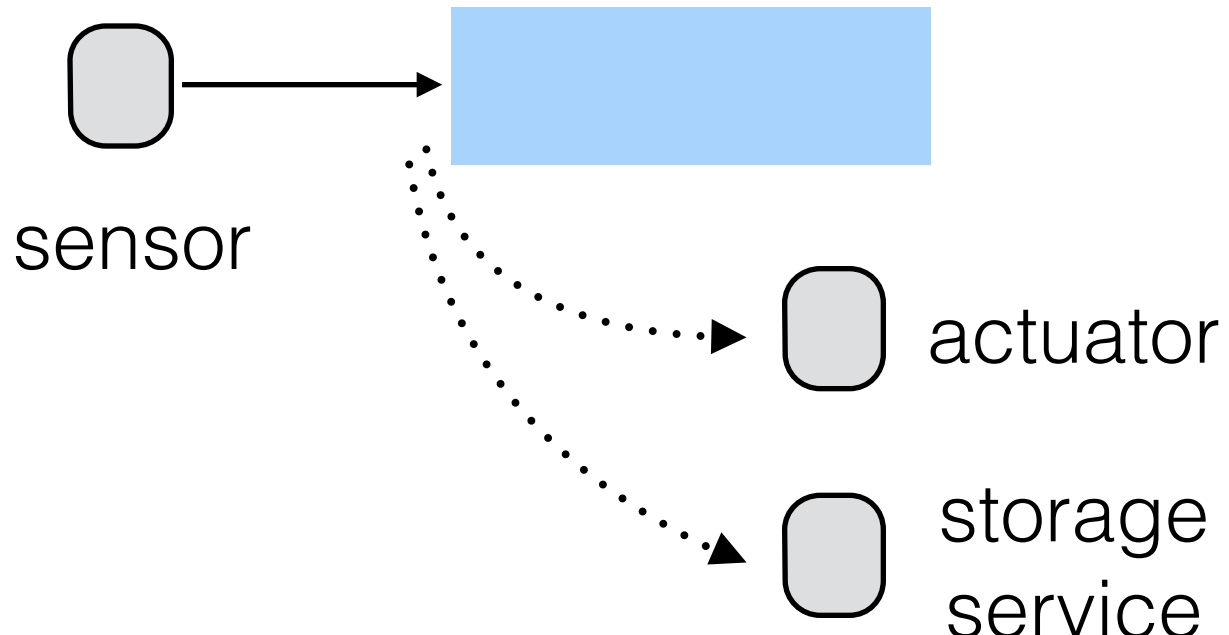
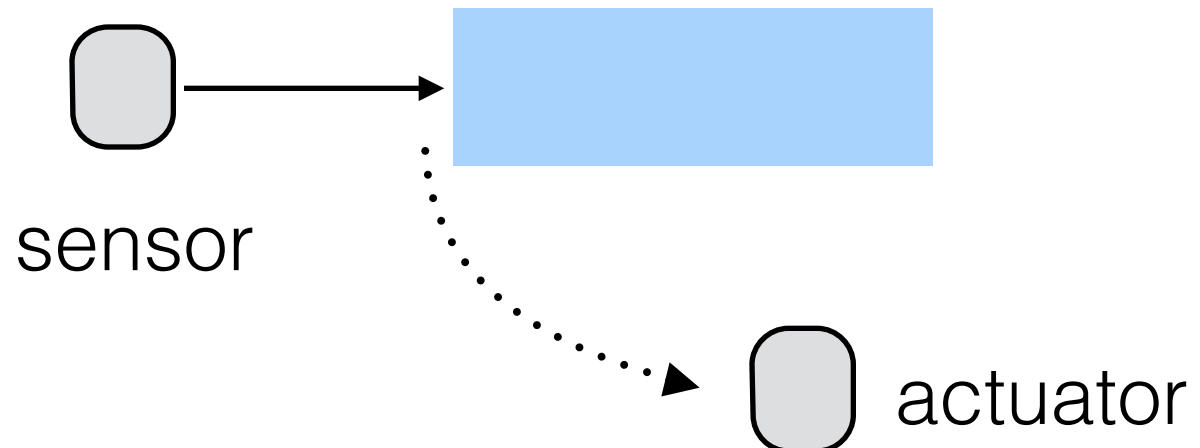


Single-writer Append-only Log

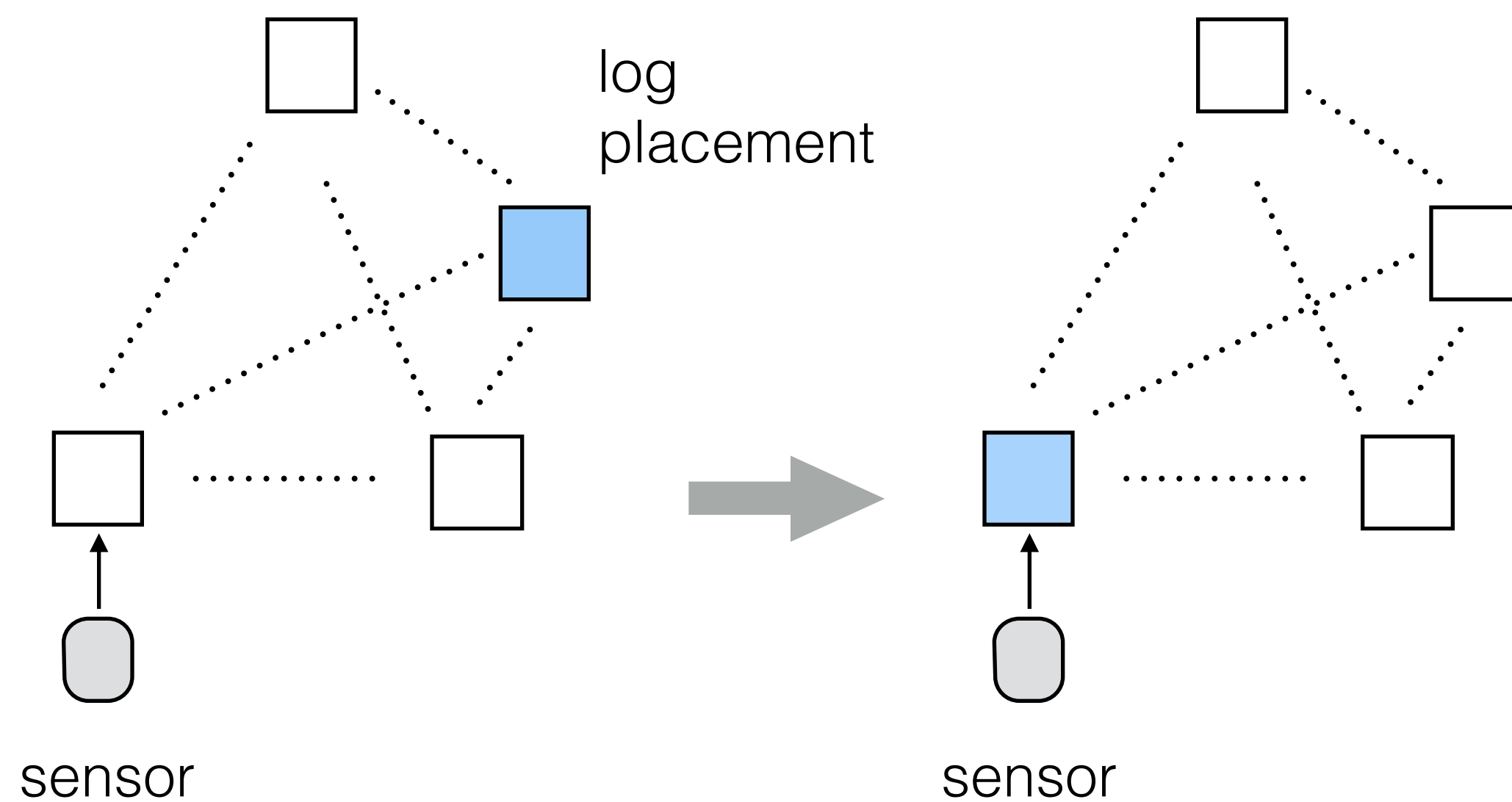


- Log as the basic data model abstraction
 - Flexible (composition for multi-writers)
 - Easier access control
 - Authenticity and integrity
 - Encryption
 - Durability and consistency

Pub/sub — Programming Information Flow



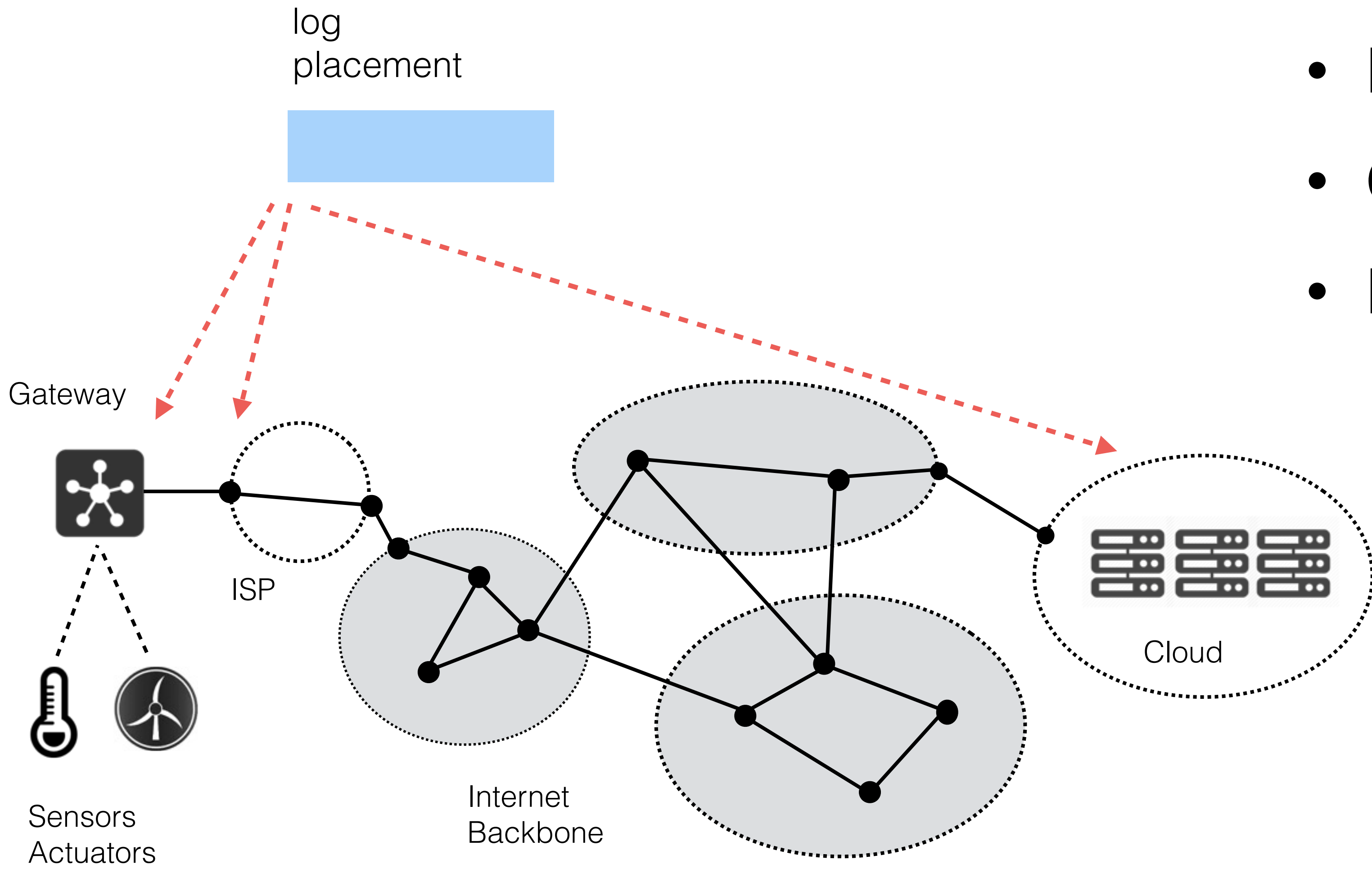
Distributed in Flat Namespace



□ GDP node: log servers or routers
could be gateway, cloudlet, fog, cloud

- Logs should be placed in arbitrary places
- Migration should happen on-demand
- Flat namespace (like 256-bit name)
- Location-independent routing
 - Peer-to-peer
 - Direct routing

- Latency
- Bandwidth
- QoS
- Durability management



Challenges and Mechanisms

	IoT Properties	GDP mechanisms
Privacy & Security	Personal sensitive data	Authentication, encryption
Scalability	Billlion devices + updates	Peer-to-peer, direct link
Interaction Model	Machine	Single-writer append-only, pub/sub
Latency	Deterministic	Log placement + migration
Bandwidth	Upstream	Log Placement + multicast
Availability	Requirement	Log placement + migration
Durability Management	Users control	Log placement + replication

Conclusions

- We presented the problems in current IoT development.
- To address them, a new layer of abstraction is proposed.
- This is still an ongoing piece of work
 - We have implemented the log interface and a basic routing.
 - Still working on the security, placement, and replication.

Discussion

	Web	IoT	GDP
Privacy & Security	Open for access	Personal sensitive data	Authentication, encryption
Scalability	Power-law	Billion devices + updates	Peer-to-peer + direct link
Interaction Model	Human	Machine	Single-writer append-only + pub/sub
Latency	Variable	Reactive	Log placement + migration
Bandwidth	Downstream	Upstream	Placement + multicast
Availability	None	Requirement	Log placement + migration
Durability Management	Cloud controls	Users control	Log placement + replication