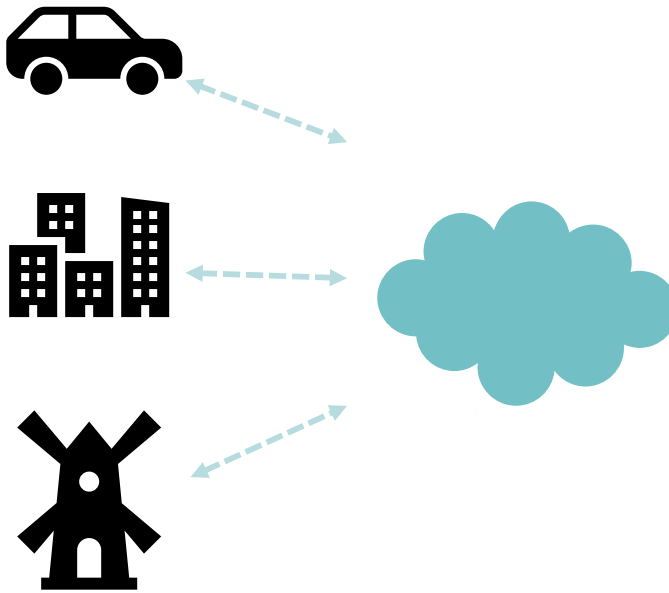
Storage @ the Edge

Vinod Eswaraprasad
Wipro Technologies

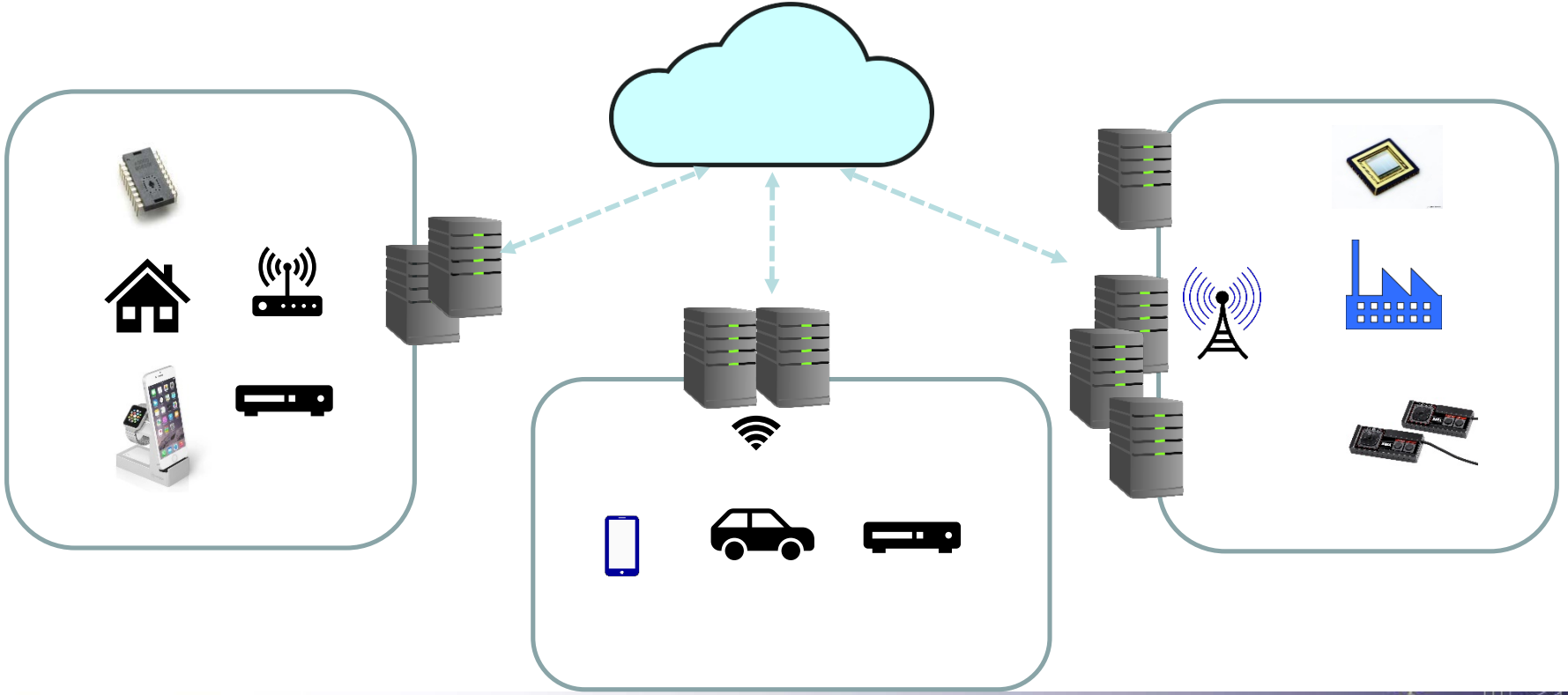
What is Edge Computing?

- Certain applications need Autonomy
  - Self Driving car
  - Industry 4.0 – smart plant
  - Smart Home
- Importance of latency
  - Certain decisions are important – cant go all the way to cloud
  - Latency can be a reason for failure.
- Application would need Significant bandwidth



Significance of Edge comes from IoT - autonomous systems

Typical Edge Scenario



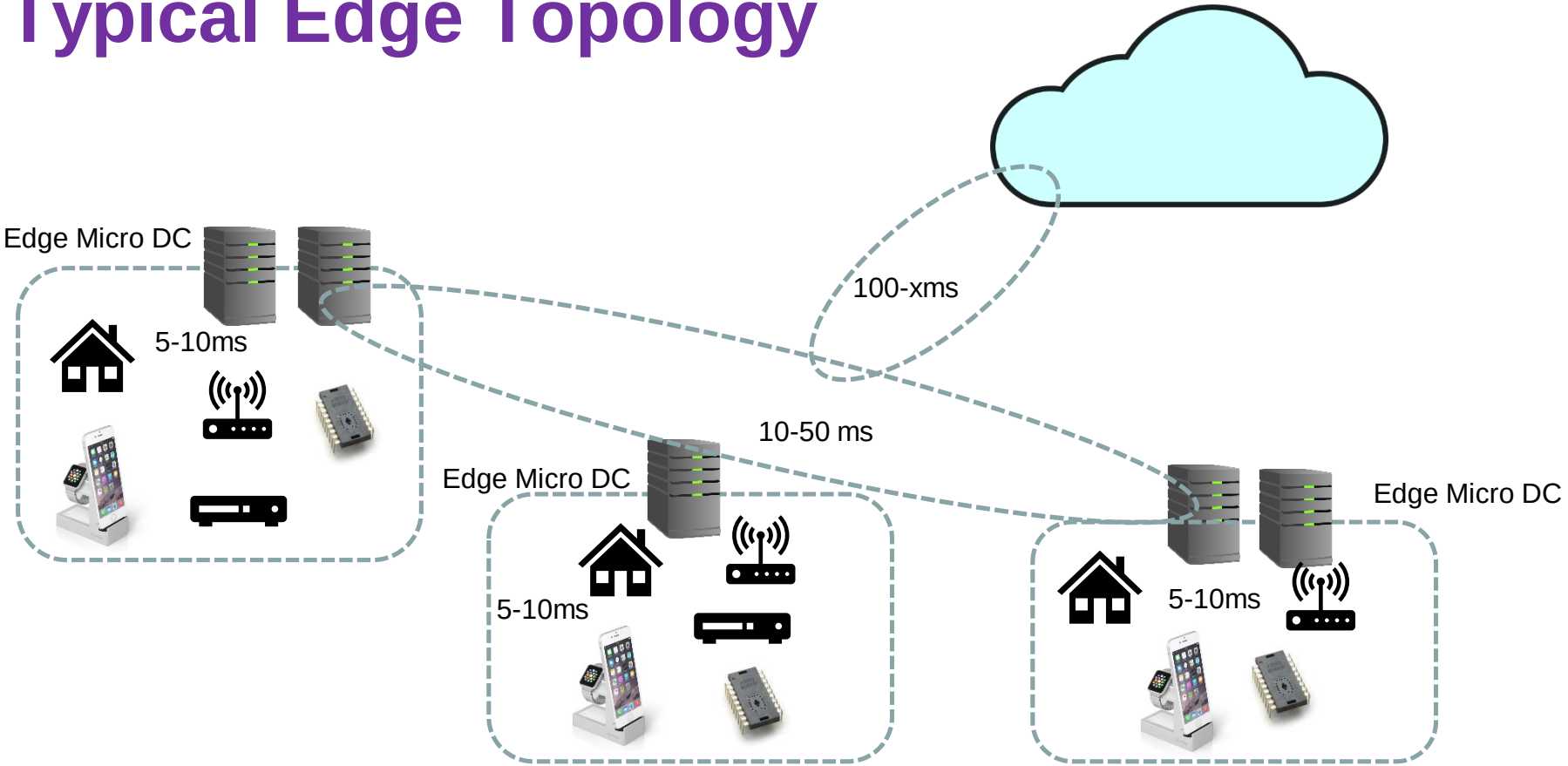
Key Characteristics of Edge

- Centralized - to de-centralized
- Real Time processing
- Real time control
- Local filtering and caching.
- At source data visualization....

- Geographically distributed
- Scalable
- Autonomous and distributed
- Contextual and low latency
- Realtime interaction.
- Heterogenous

Data + Analysis + Learning

Typical Edge Topology



Edge design Challenges

- Complex Open Environment
  - Environmental, Supportability
- Remotely Located
  - Autonomous, Robust
- De-centralized / Distributed
  - Millions of nodes
- Price Sensitive.

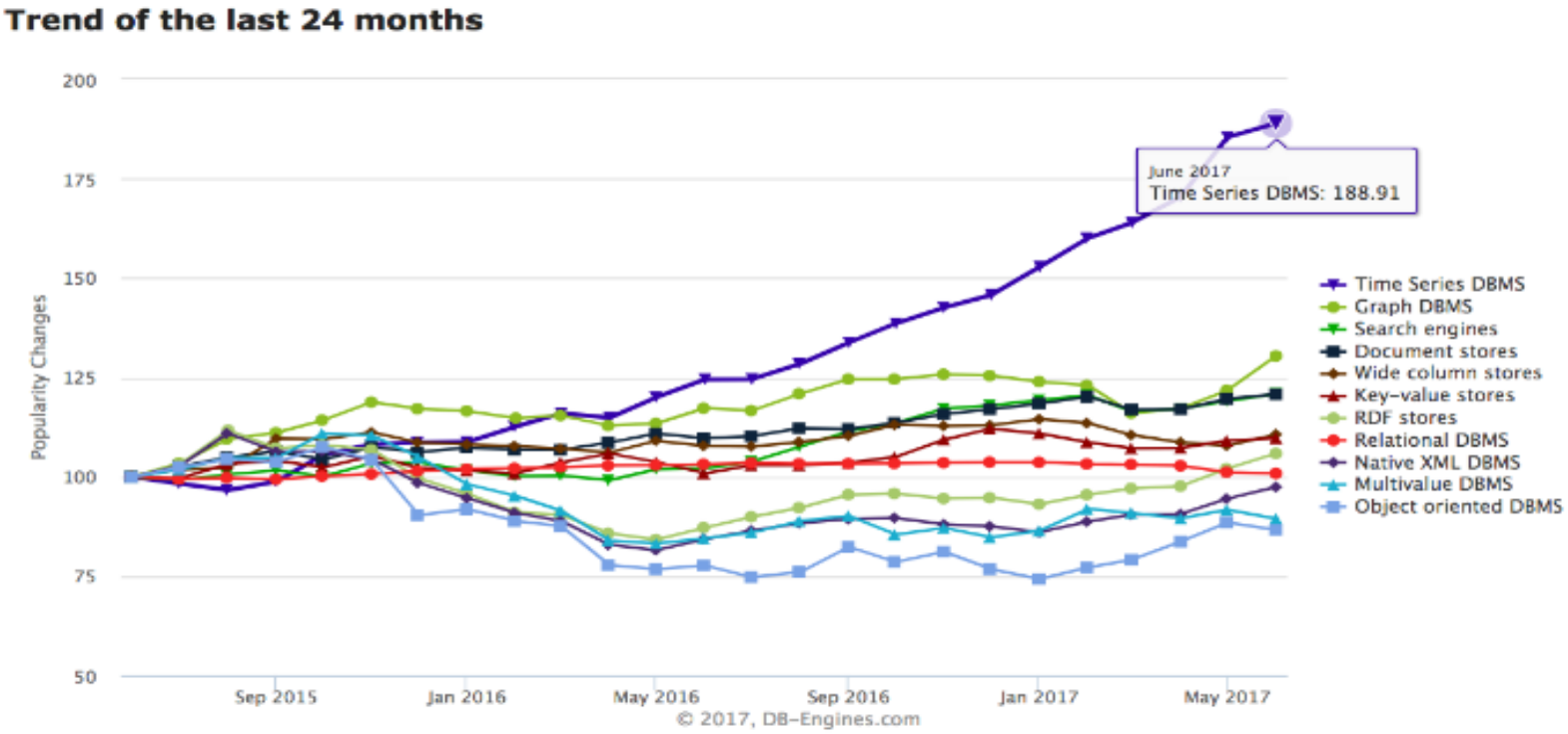
Edge workloads

- IoT data
  - Time series
  - Historian
- Video
  - Un-structured
  - Content search
- Machine Learning/ Online learning

Characterizing edge workload

Characteristics	Edge	Cloud
Latency	Low	High
Bandwidth	Very Low	High
Response Time	Low	High
Storage Capacity	Low	High
Server Overhead	Very Low	high
Energy Consumption	Low	High
Scale	High	Medium
QoS ad QoE	High	Medium

Timeseries in current times



Source: DB-Engines, June 2017. https://db-engines.com/en/ranking_categories

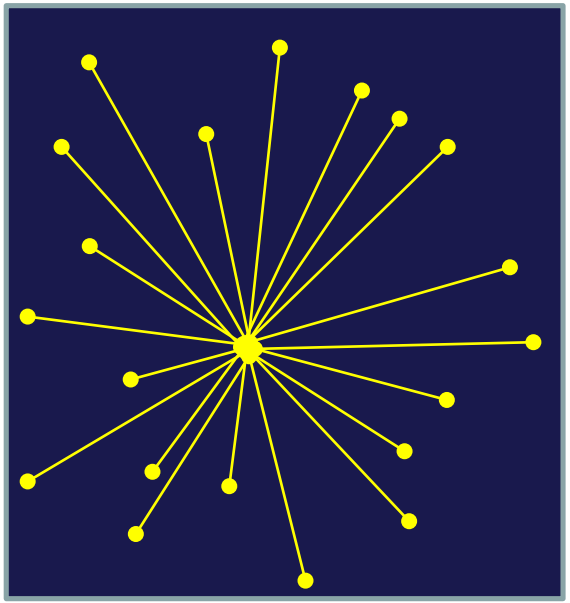
Time Series workload characteristics

- Write-mostly is common; perhaps 95% to 99%
- Writes are almost always sequential appends
- Updates are rare
- Deletes are in bulk

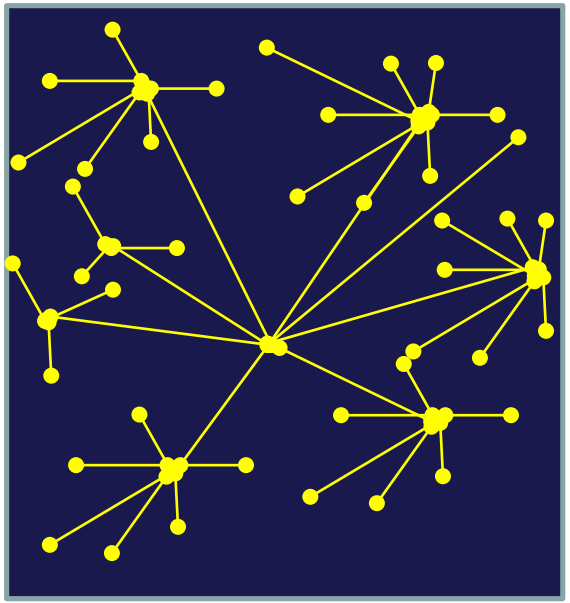
=>

- immutable storage format is better?

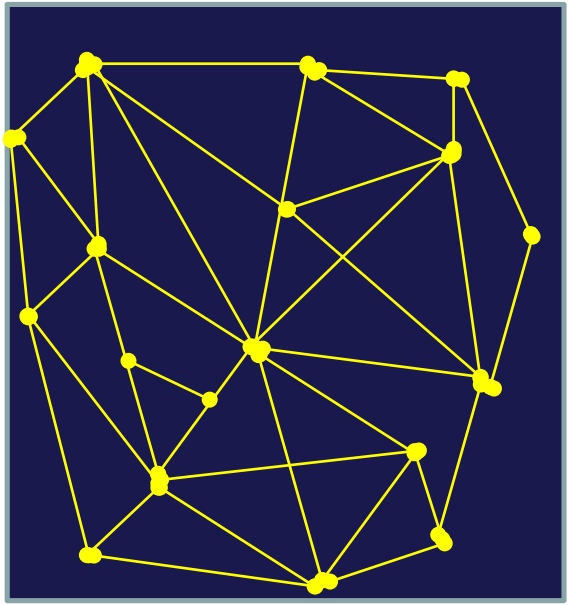
The edge topology



Centralized



De-Centralized



Distributed

Storage requirements at Edge.

- Lowest latency
  - Less than 10ms
- Distributed view, isolated actions
  - One network operation should not affect others
- Local store and forward capability
  - Ability to reduce intra node traffic
- Ability to aggregate and send to core
  - Avoid less data transfer over network.
- Data Mobility
  - Enable device movement across edges

What storage is best for Edge?

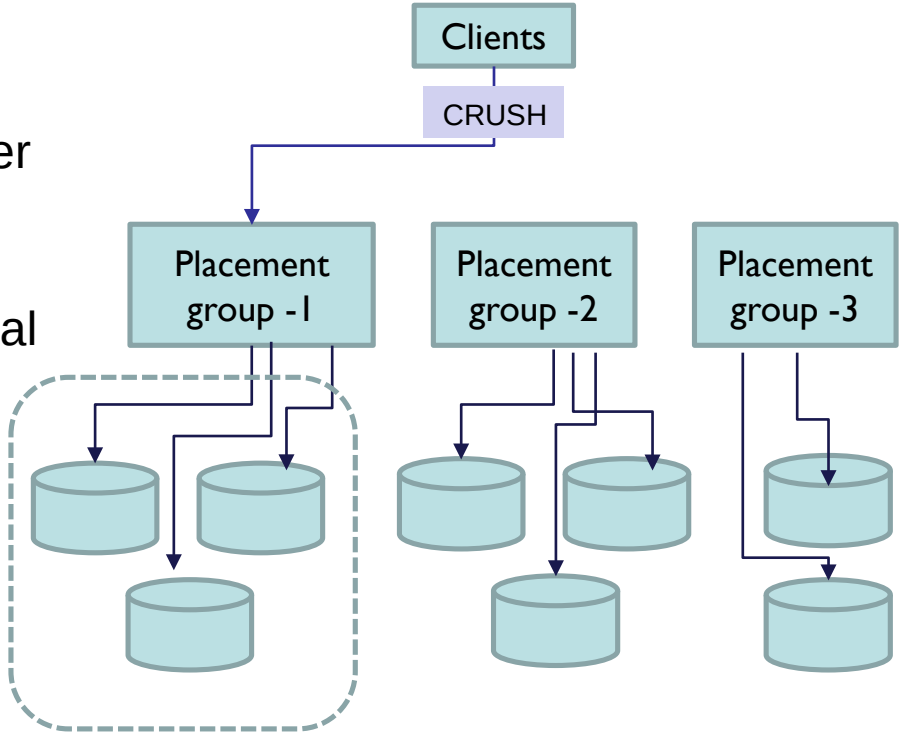
- Block based? (compatibility? Cant have local formats)
- Distributed File? (HDFS, PVFS, Lustre - centralized)
- Object store? (Decentralized ?)
- Anything Better?

Our Analysis

- Analyze edge storage specific parameters
  - Well known object storage implementation
  - De-centralized
- Choices were:
  - RADOS - CRUSH
  - IPFS (InterPlanetary File System) - DHT
  - SWARM - DTH (updated)

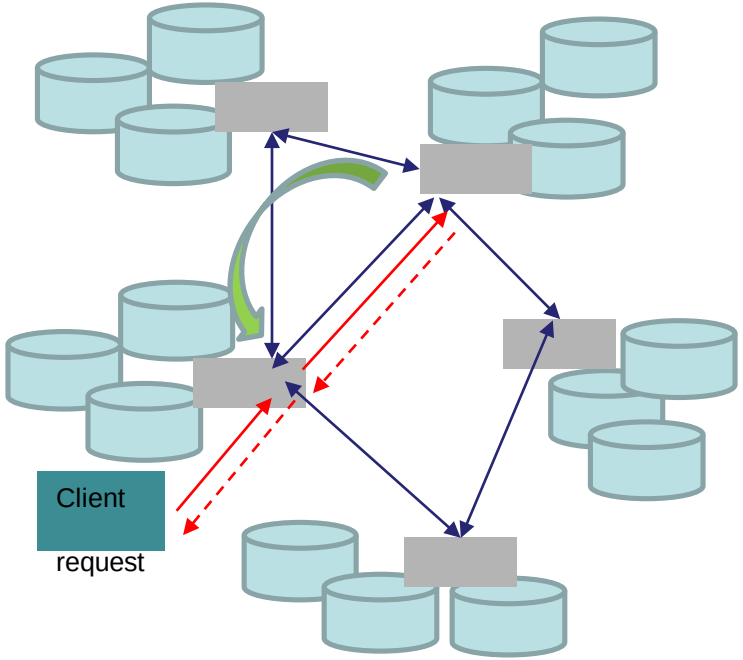
RADOS (Reliable Autonomic distributed Object Store)

- RADOS
  - CRUSH (Controlled Replication Under Scalable Hashing)
  - Set each PG as a Edge Storage
  - Placement rules - restrict data to a local site
  - Less intra Edge communication
  - CRUSH Maps equates to Local DC
  - Allows striping for higher performance
  - Maps well to the decentralization of Edge



IPFS

- IPFS (InterPlanetary File System)
  - Distributed Hash Table (DHT) approach
  - Content based Hashes - in a Merkle DAG
  - DHT - stores the pointer to data - one level indirection
  - Always makes a local copy
  - Built-in security and data reliability



SWARM

- Decentralized - Peer to Peer
  - Bzz protocol - slightly different than DHT
- Distributed content-addressed chunk store (4K)
  - Better for small chunks of data
- Content Addressed

Feature comparison

	Data proximity	Network isolation	Store n Forward	Data Migration	Remarks
RADOS	Good	Good	Bad	Moderate	Algorithmic, less chatty, paxos
IPFS	Good	Bad	Moderate	Good	Data management, O (logN) lookup
SWARM	Good	Bad	Good	Good	Smaller sized IO,

Parameters

- Latency
  - Impact on number of nodes: 10,50,100
  - Latency for 4K, 1M, 10M object size
- Network traffic
  - Network traffic as the node scale (10,50,100)
- Remote/Local Reads
  - The time taken for reading data on remote node

Findings

- IPFS has lowest latency and scale
- IPFS has the lowest remote reads
- SWARM has lowest network traffic
- RADOS has lowest data traffic for co-ordination

Future of Edge storage?

- Tailored for edge workload
  - Time series - writes, append, no updates
  - ML/DL/Online Learning
- Bring intelligence to storage
  - Intelligent comes from data
  - To process data you need intelligence ☺
  - Edge storage will have built-in AI capability
- Smart data - hierarchical
  - Data payload
  - Metadata
  - Detachable code with data.

Conclusion

- Edge requirement is here to stay
- Need for an Edge specific storage requirement exists
- No new architectural changes are proposed today
- An opportunity to innovate.

Thank You