Ubiquitous Witness & reverse CDNs (rCDNs)

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COIN Use Case Discussion

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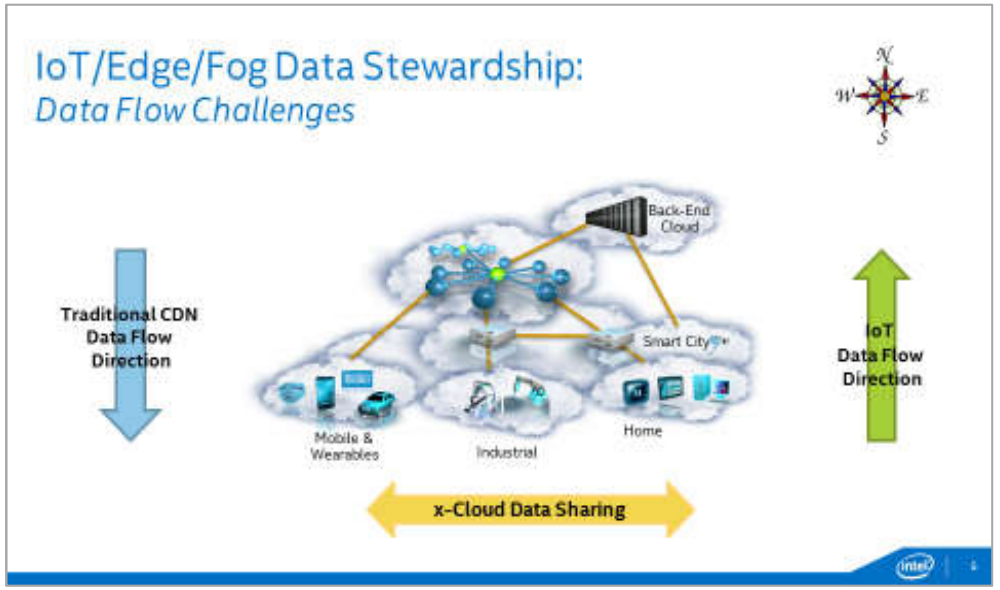
Discussion

- Backdrop
- Ubiquitous Witness Use Case
- How is this related to COIN?
- Other implications…
  - Edge/Distributed Data Discovery & Stewardship

Backdrop

- IoT disruption: sheer #s of devices → data deluge at the network edge
- Increasing percent of Things: are or include cameras
- Increasing percent of Things: wireless/mobile
- Edge computing:
  part of bigger trend toward
  Fog & Ambient computing



Goal: Data Stewardship in a Multi-tiered Cloud-of-Clouds

Visual Cloud… to Edge… to Fog
Video Storage/Processing

Cloud-only?

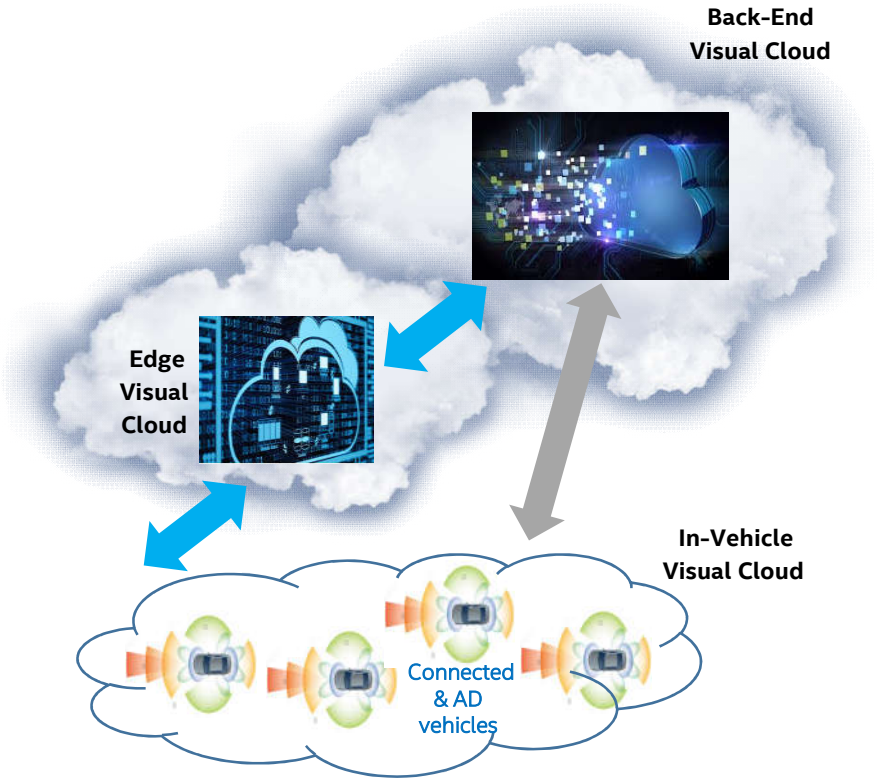
- ***Challenge:*** Huge amount of data generated by each car vs. network bandwidth (even with 5G), cost, real-time requirements

In-Vehicle-only?

- ***Challenge:*** Not enough in-vehicle compute, due to space, heat dissipation, and cost of executing heuristics or AI needed

Distributed from Car-to-Cloud?

- ***Challenge:*** Storage efficiencies of CDN (Content Delivery Network) model helpful, but need to comprehend reverse data flows



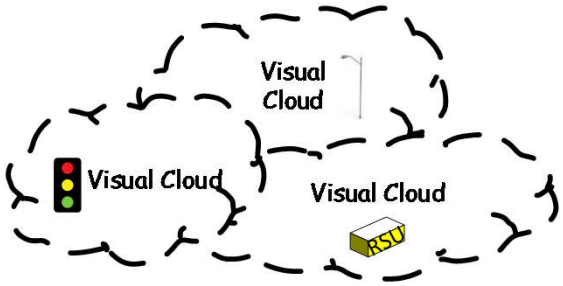
[3] FWC'17

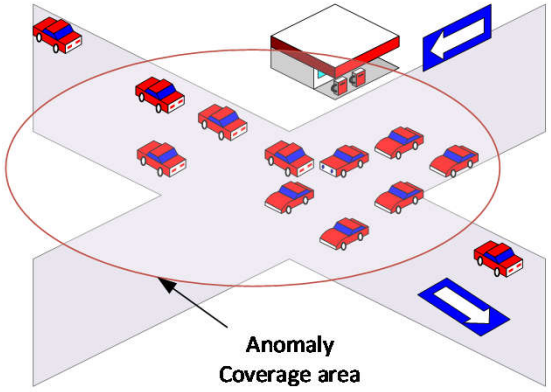
Goal: Seamless interoperation of static & mobile Edges

Ubiquitous Witness

Multi-dimensional Anomaly Reconstruction

- Anomaly detected (or predicted)
  - *e.g.*, an accident occurs
- Triggers secure (video) evidence collection from proximate witnesses
  - directly involved & nearby observers
  - ICN – with vs without
- Data collected and securely stored in 360-degree "black box"
  - composite from multiple perspectives within an approximate region of interest, e.g., <x,y,z,time>
- Post facto, enable exploration of multi-dimensional evidence
  - Leverage point-cloud VR standards





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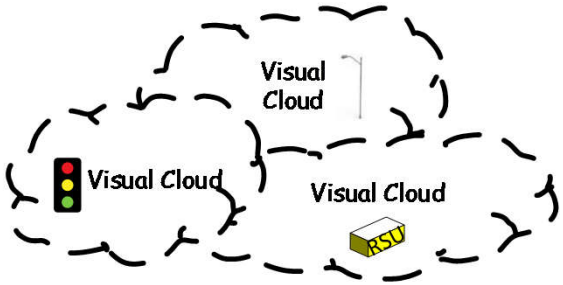
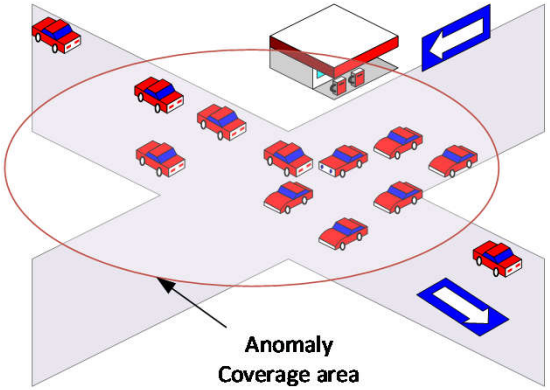
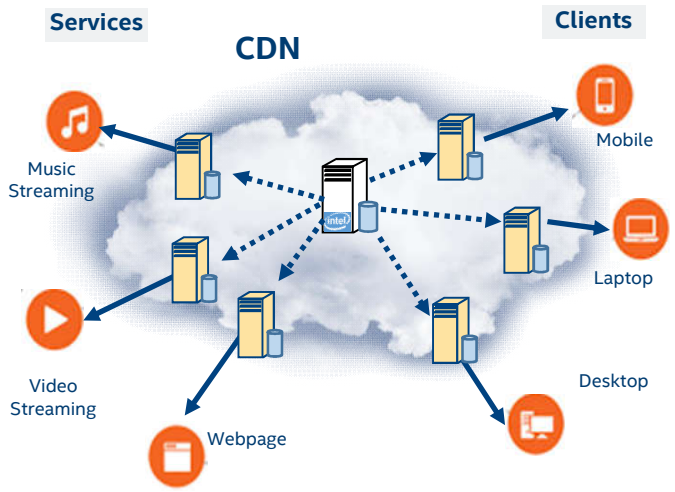
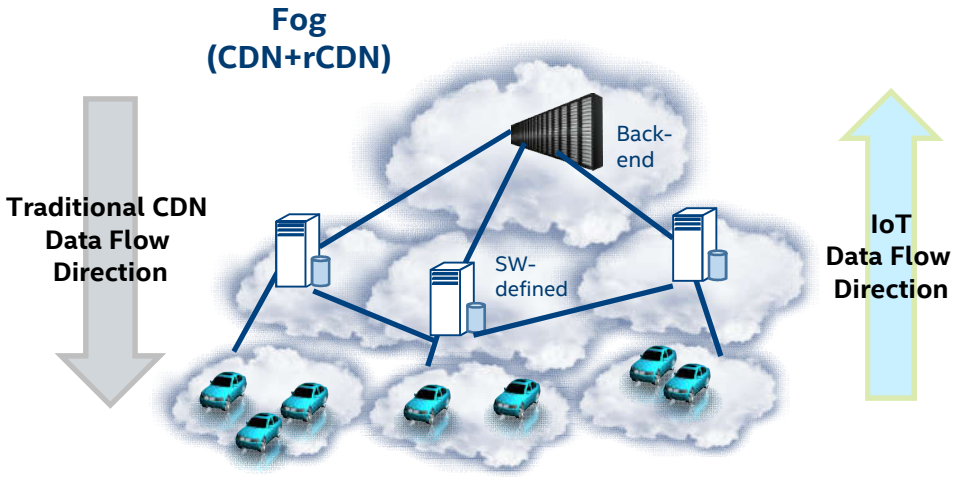




How does this relate to COIN?

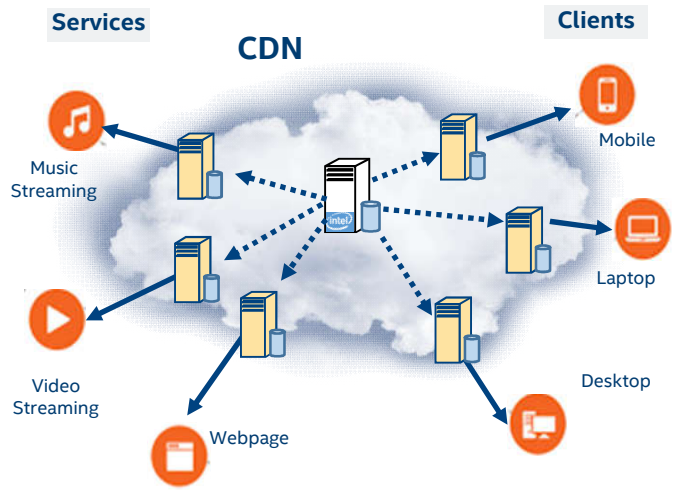
Video CDNs & Reverse CDNs (rCDNs)
content distribution networks





[3] Fog World Congress'17

Video CDNs



Traditional CDN (e.g., Akamai, Cloudflare, Amazon)

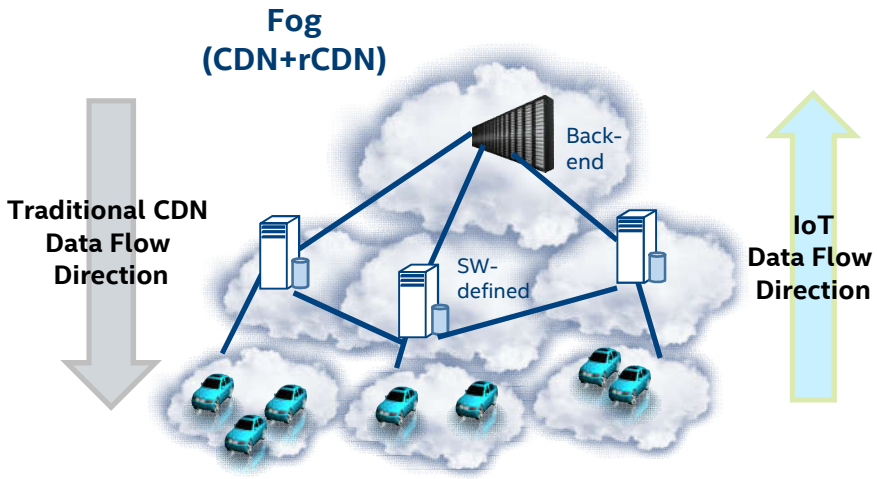
Lifecycle of Forward Data Flows

- One-to-many distribution
- Content comes from an origin server and flows downstream
- **Cache or pre-fetch popular content closer to consumer**
- Classic retention policies (LRU, LFU, etc)

(Video) Reverse CDNs (rCDNs)

Lifecycle of Reverse Data Flows

- Client devices are data sources
- Dynamic **contextually-related** data is sent upstream & collects at rCDN nodes
- **Process/transform/analyze data**
- **Converge (N-to-1)** streams into a single new stream (w/reduced size) **in-flight**
- Preserve lineage
- Deliver precise **synchronization**
- **Decide if/where to cache** new converged (meta) data stream
- **Forward** N, but possibly S and E/W
- Process potentially **repeats multiple times**, while data "en route" to final resting place



rCDN for Connected and Autonomous vehicles

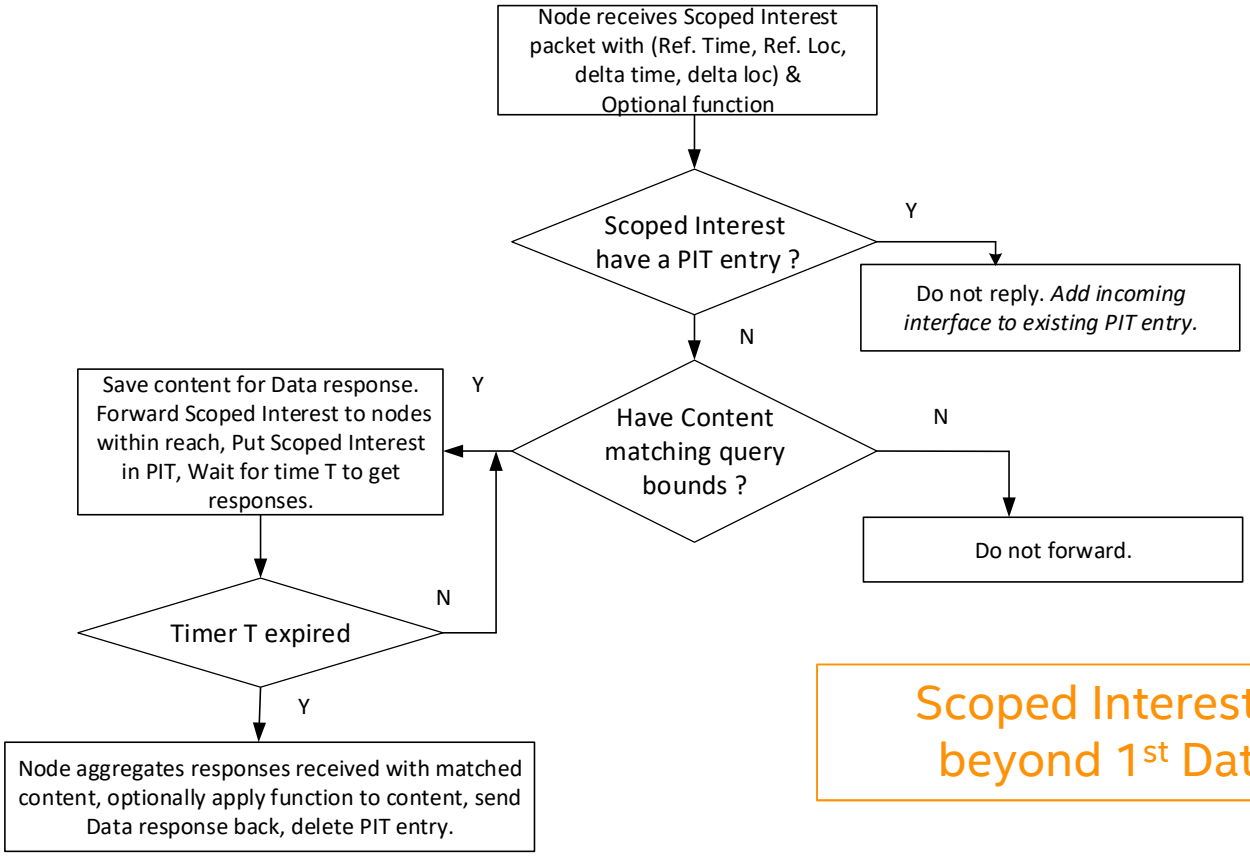
Is each rCDN node a new Converged Edge/Fog router? At what layer should it live?

How does this relate to ICN?

Why it is Interesting yet Challenging:
Extend ICN Semantics?

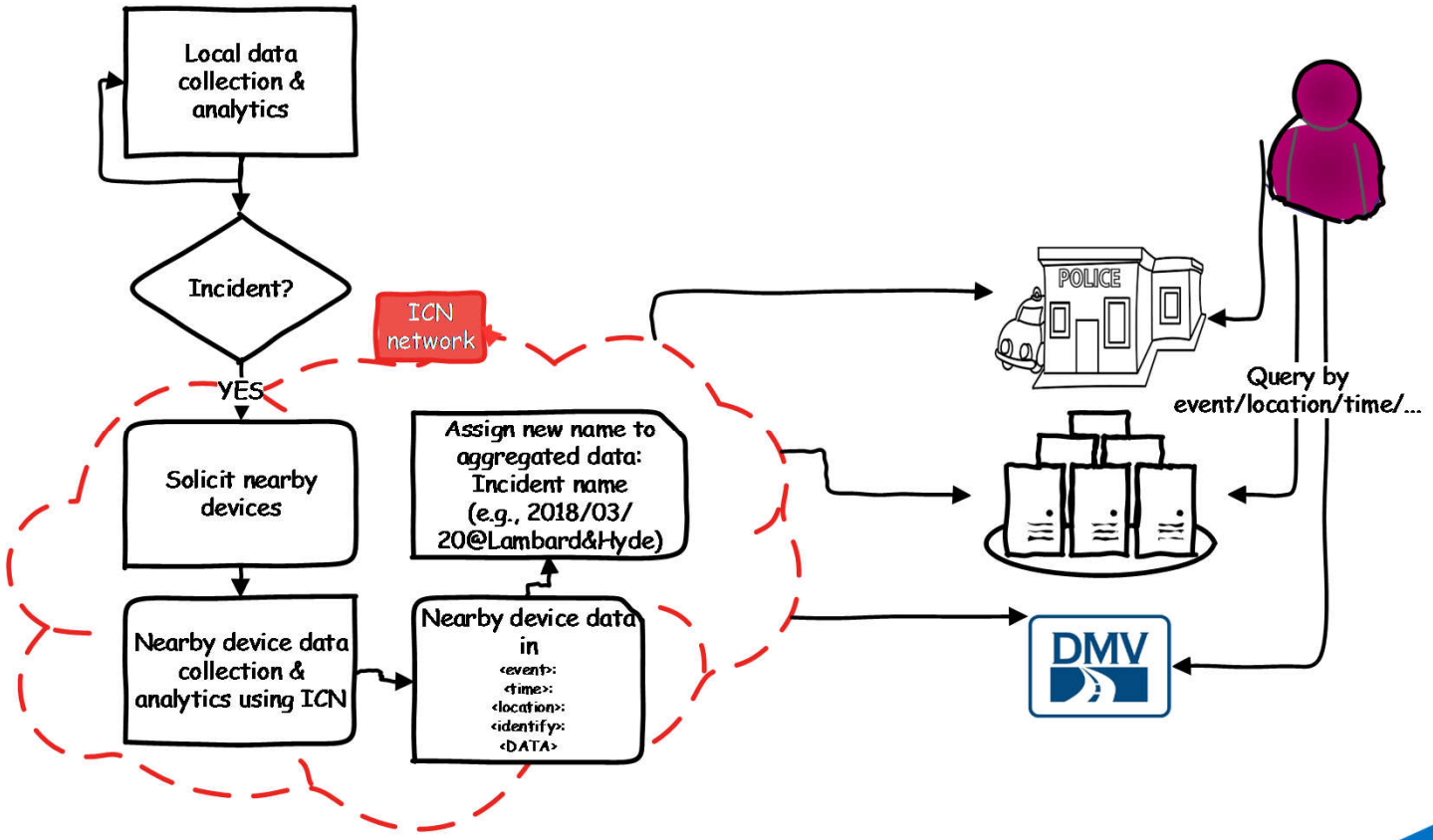
- Fuzzy names
  - <x, y, z, time> + or – some delta
  - Longest prefix match vs Exact match
    - HD Maps: GeographicalLocation/Date/Timestamp/Entityname
- "Scoped Interest" dissemination
  - Delayed Responses
  - Embedded Functions
- Congestion control
  - Identify who to solicit – explicit vs implicit
  - Who issues the request? Who is authorized? ICN vs IP
  - Collapse requests/responses within coverage area & time deltas

Scoped Interest-Data Semantics

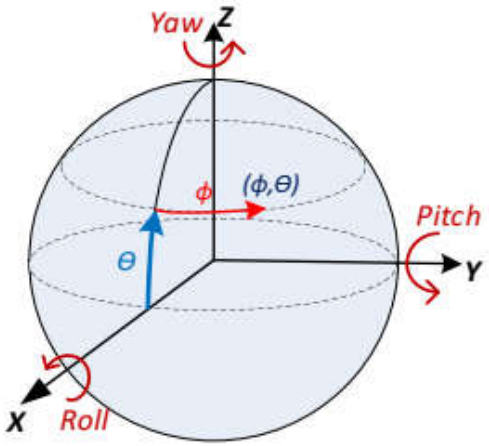


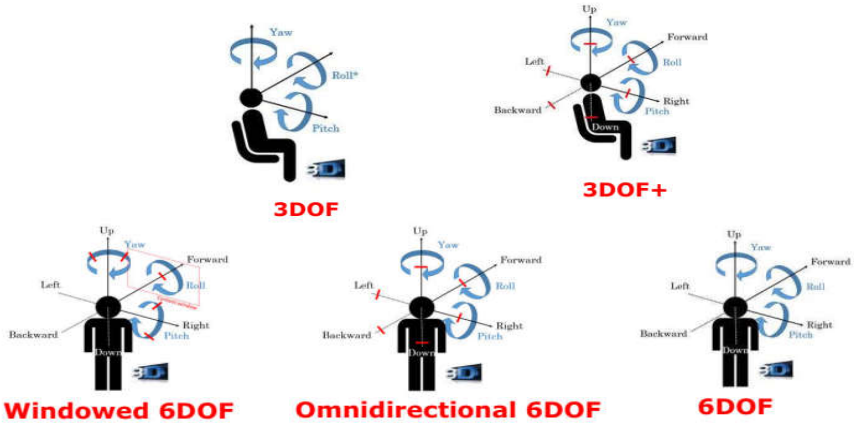
Scoped Interests propagate beyond 1st Data response

Query (ICN-enabled) Network as if a Database



Emerging MPEG-I VR Standards:
3- and 6-Degrees-of-Freedom (DOF)





Want to “walk around” in the data… whether visual or non-visual

Source: Ozgur Oyman VR Tutorial

BACKUP

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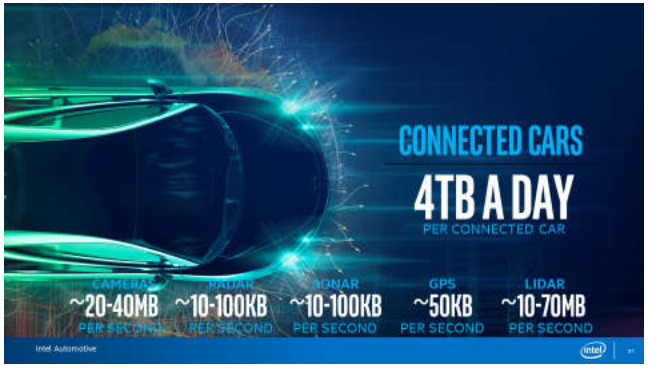
Disruption: Data Deluge

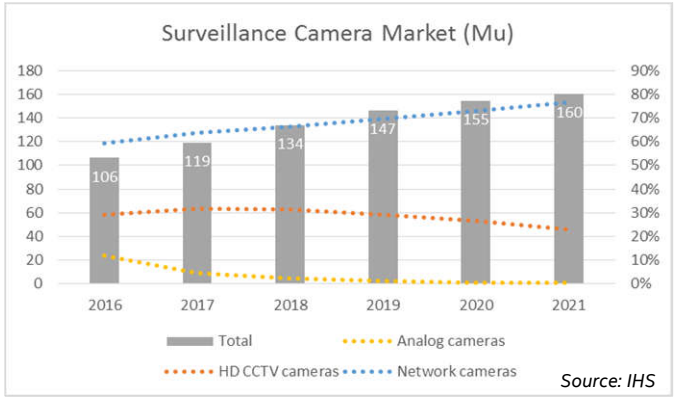
- **129 yottabytes** to be generated by 2020 *(ABI Research)*
  - *Deluge begins at the network Edge, flows upstream*
- **50%** of IoT deployments will be network constrained by 2018 *(IDC)*
  - *Data doesn't fit over the network, in its original form*
- By 2019, **45%** of IoT-created data will be stored, processed, analyzed and acted upon closest to, or at the edge of the network *(IDC)*
  - *Cloud functionality migrating closer to the data*



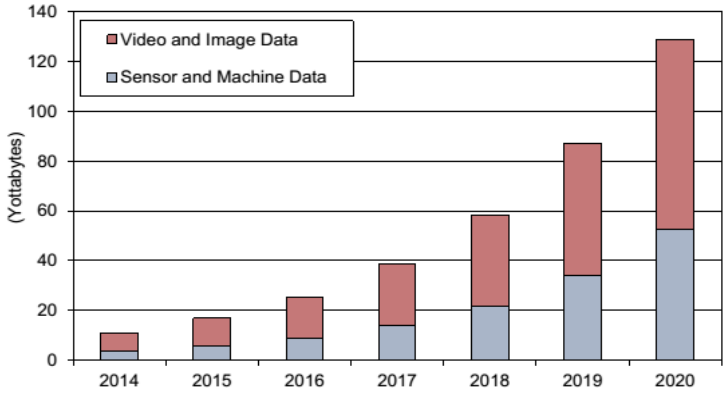
Cameras and Video

- By 2020, there will be 256M cameras on the planet. One camera for every 29 people *(IHS)*
- The number of cameras grows by 20% every year *(IHS)*
- 180/360-degree IP network cameras are the fastest growing product segment in video surveillance (*IHS*)
- Of the 129 yottabytes forecasted to be generated by 2020, 41% will come from sensors & 59% from cameras (*ABI Research*)

Coming to an intersection near you?



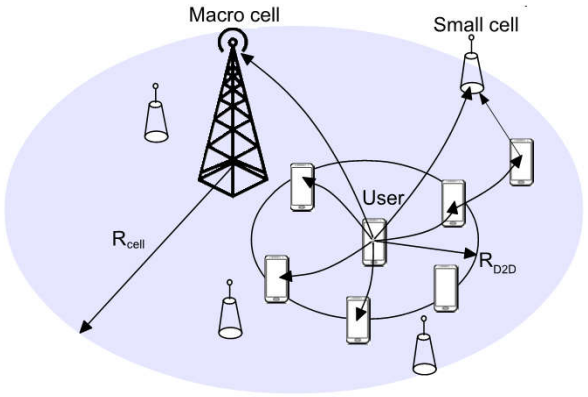
Source: IHS



Source: ABI Research

Wireless and Mobility

- By 2020
  - .5 Zettabytes mobile wireless traffic annually
  - 800x 10 years ago, 800Mx 15 years ago
- By 2021
  - 11.6B mobile devices >> fixed hosts
  - 63% of all traffic



Assumptions

- 5G high-bw usages: VR/AR, (ultra) HD video
- 5G architecture: dense HetNets, frequent small-cell handover

Toward Edge Computing... and beyond

Distant Cloud Problem:

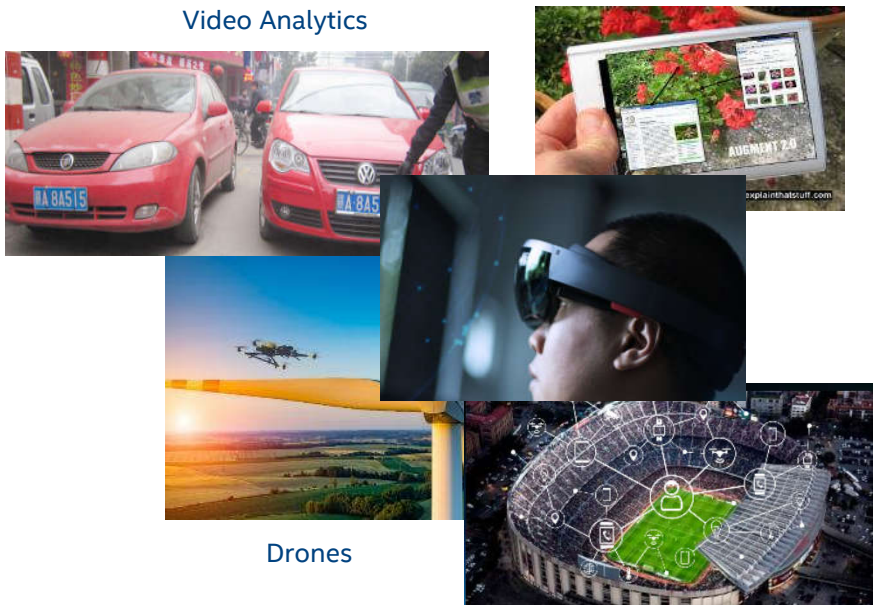
Legacy clouds are unsuitable for many IoT scenarios

If the IoT use case / data is

- High-volume
- Delay-sensitive
- Trust-sensitive
- (Intermittently) Disconnected
- Energy-constrained

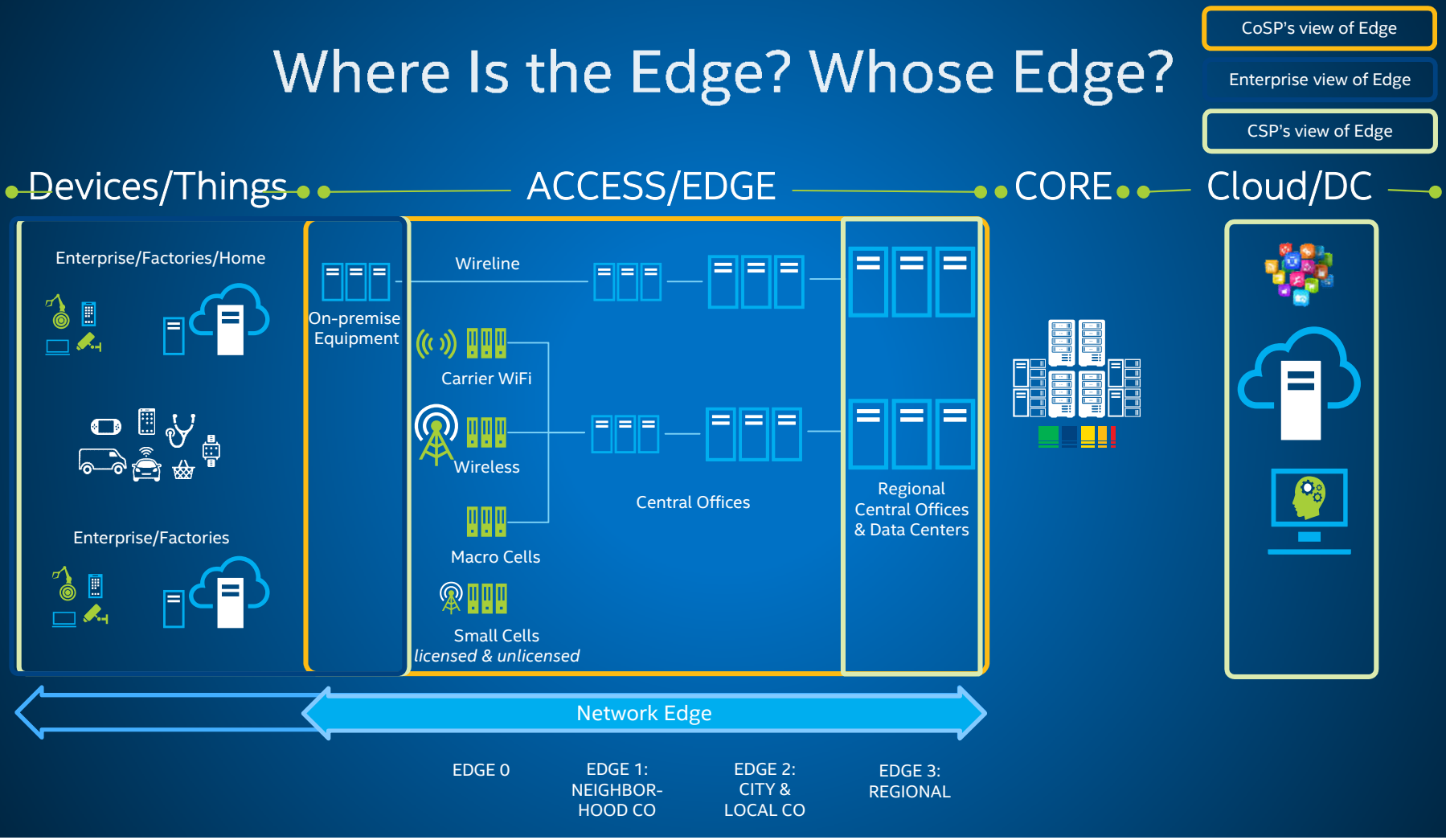
Countless examples

- Both near and further out



Need More Proximate Clouds: Edge Computing

Where Is the Edge? Whose Edge?



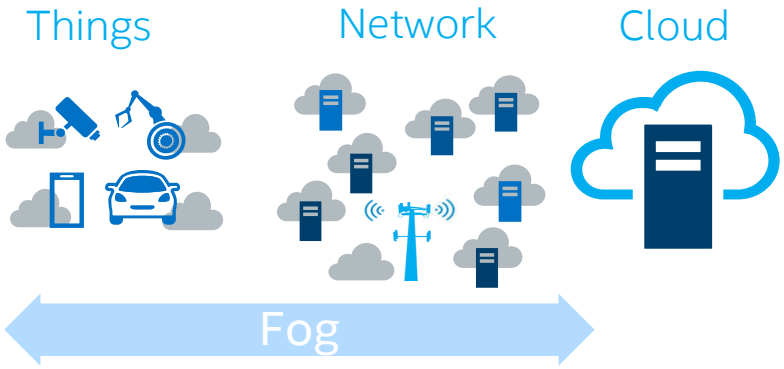
Edge Computing

Not in the Legacy Data Center

- Cloud functionality migrates closer to data creation, processing, & decision-making
- Where is the network Edge? Who owns it?
- An Edge offers an “Edge Cloud” - for more proximate HW, FW, SW, Services
- $B new business opportunity - distinct from Cloud

Fog Computing

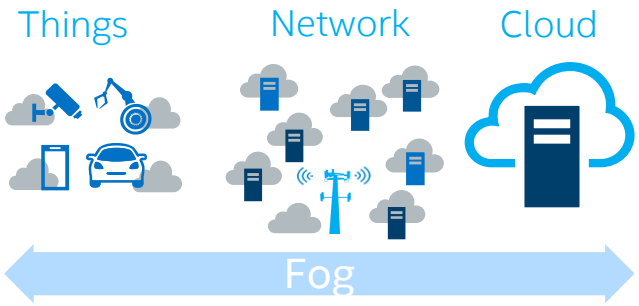
Disaggregated Data Center



- Proliferation of Cloud offerings
- Distributed, Disaggregated DC Functionality
- DC of the the Smart City, Building, Home, Car, DC of your Mobile & Wearable Devices
- Dynamic sharing of resources

Evolving Definitions:
Still up for debate…

- Cloud, Fog, Edge…Ambient computing are part of a continuum…
- Edge/Fog "Computing" encompasses more than compute



- Fog will become a Multi-tiered Cloud of Clouds