Software Defined User Centric Adaptive Traffic Management

KNOM2016 Tutorial

2016. 5. 12

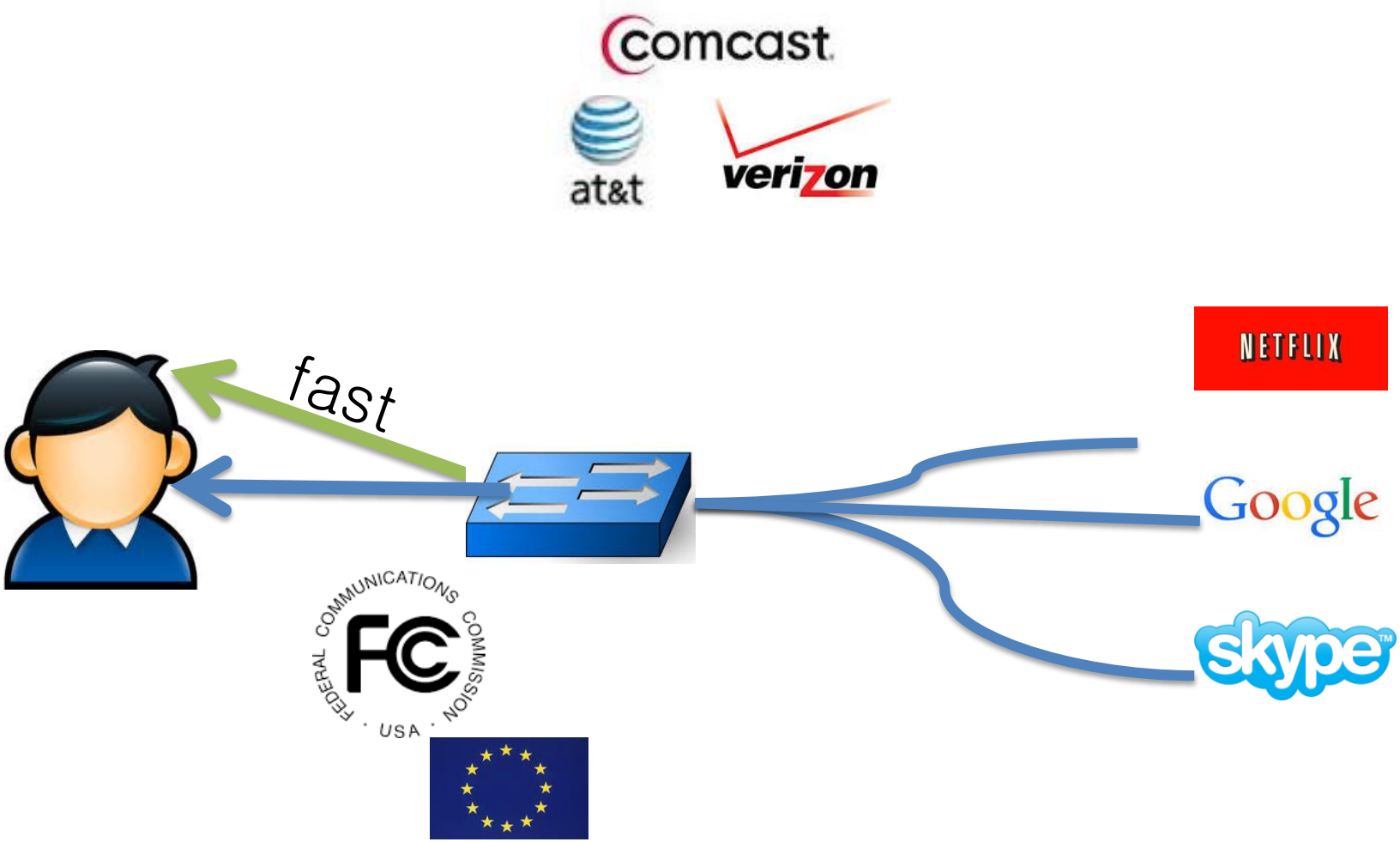
Taesang Choi

ETRI

Talk Outline

- Challenges & Requirements
- Available Proposals
  - Expressing User Preferences with Network Cookies
  - P4-based In-Network Telemetry
  - ACORD (Analytics for Central Office Re-architected as a Data Center)
  - CLONA (Cross Layer Open Networking with Analytics)
  - TSaaS (Time-Shift as a Service)
  - OPEN-TAM (Open Traffic Analysis and Management) and its extension
- Suggestion for Related Research

Who controls your network access?



Source: Yiannis Yiakoumis, Standford Univ., 2015. 11.

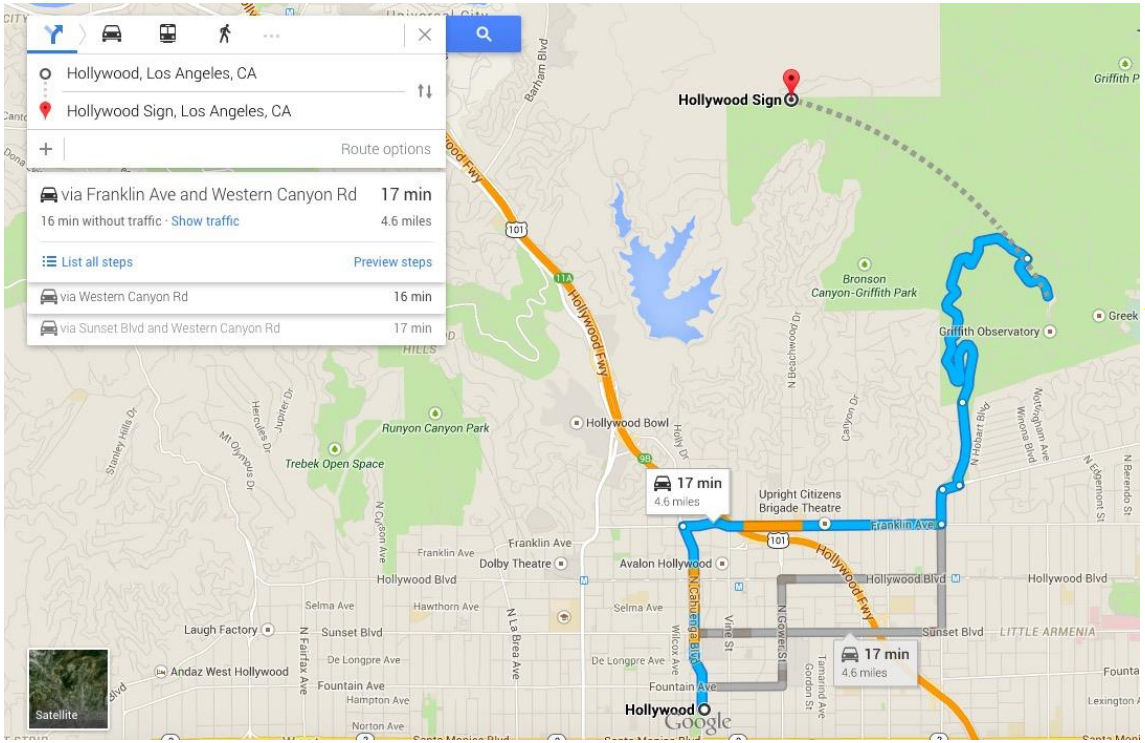
What if we let users decide?

Neutral Network

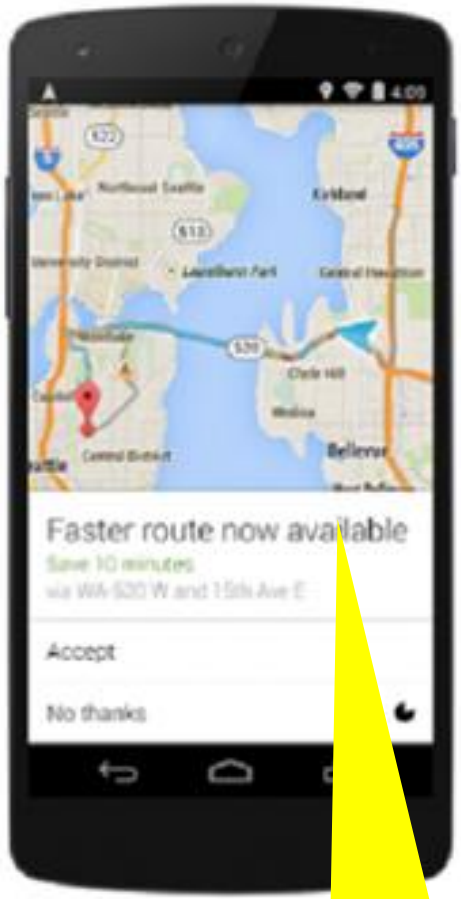
ISP-defined Fast Lanes

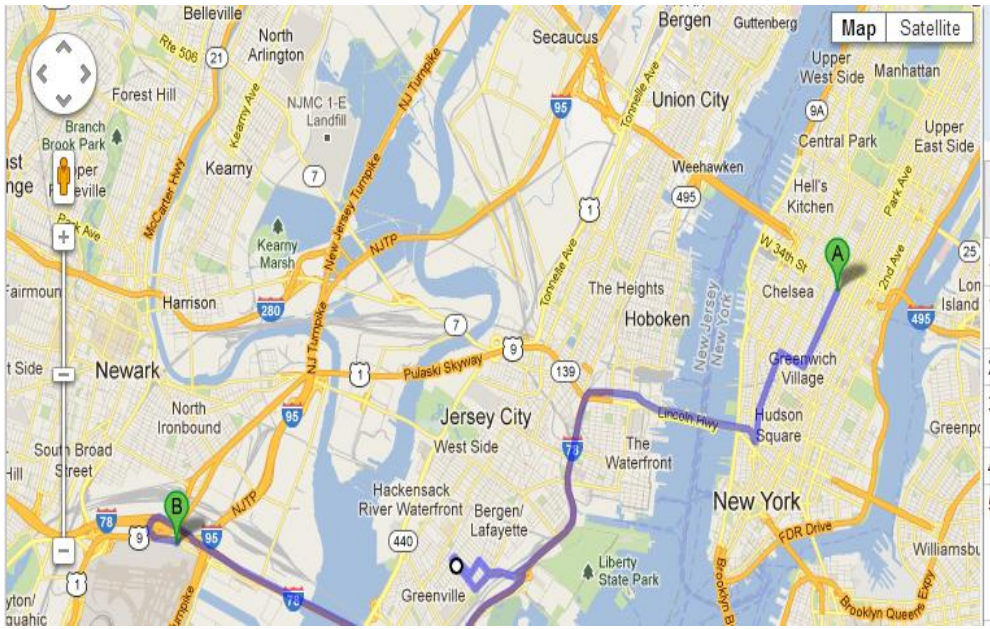
User-Driven

Source: Yiannis Yiakoumis, Standford Univ., 2015. 11.



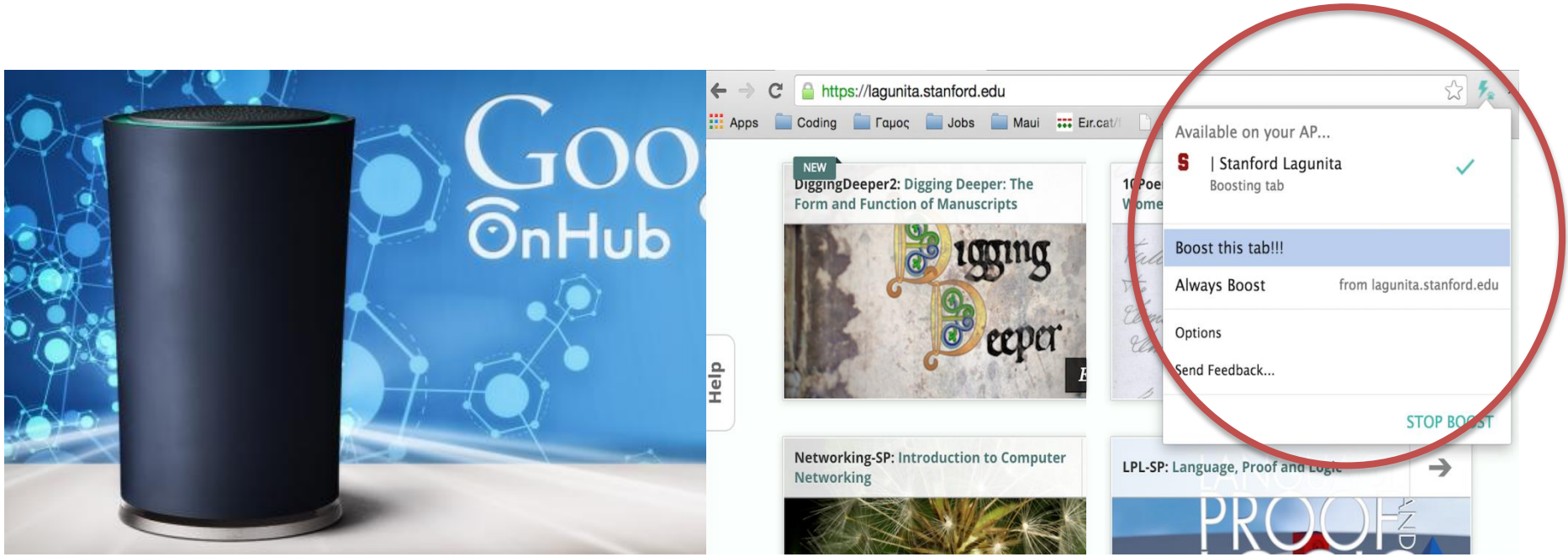
Shows direction, traffic status, travel time, alternatives in real-time





You can boost your driving by accepting this "faster route now available" option

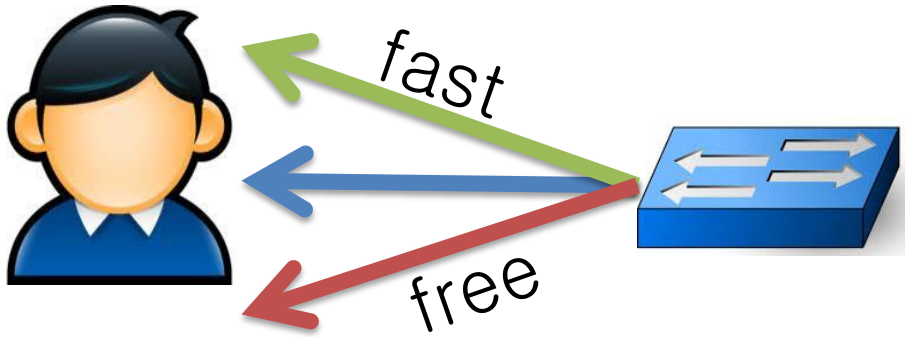
Boost v2 : Fast-Lane for home networks



- Deployed in ~300 homes (Google employees)
- Boost this tab / Always Boost this website
- One Boost lasts for one hour
- Last Boost wins
- WMM + throttling other traffic

Source: Yiannis Yiakoumis, Standford Univ., 2015. 11.

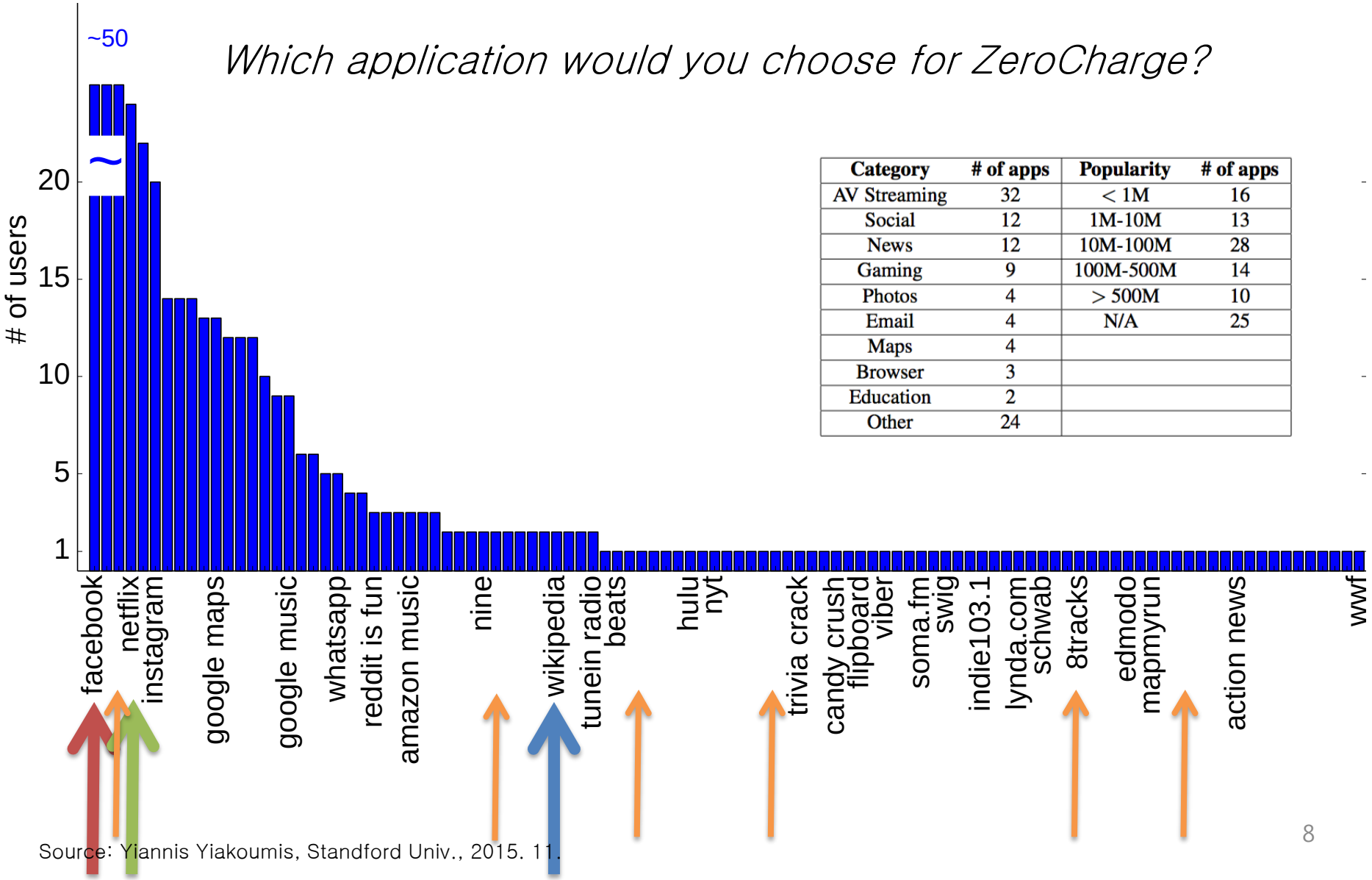
Zero-rating



Source: Yiannis Yiakoumis, Standford Univ., 2015. 11.

What do users want to zero-rate?

Which application would you choose for ZeroCharge?



Category	# of apps	Popularity	# of apps
AV Streaming	32	< 1M	16
Social	12	1M-10M	13
News	12	10M-100M	28
Gaming	9	100M-500M	14
Photos	4	> 500M	10
Email	4	N/A	25
Maps	4		
Browser	3		
Education	2		
Other	24		

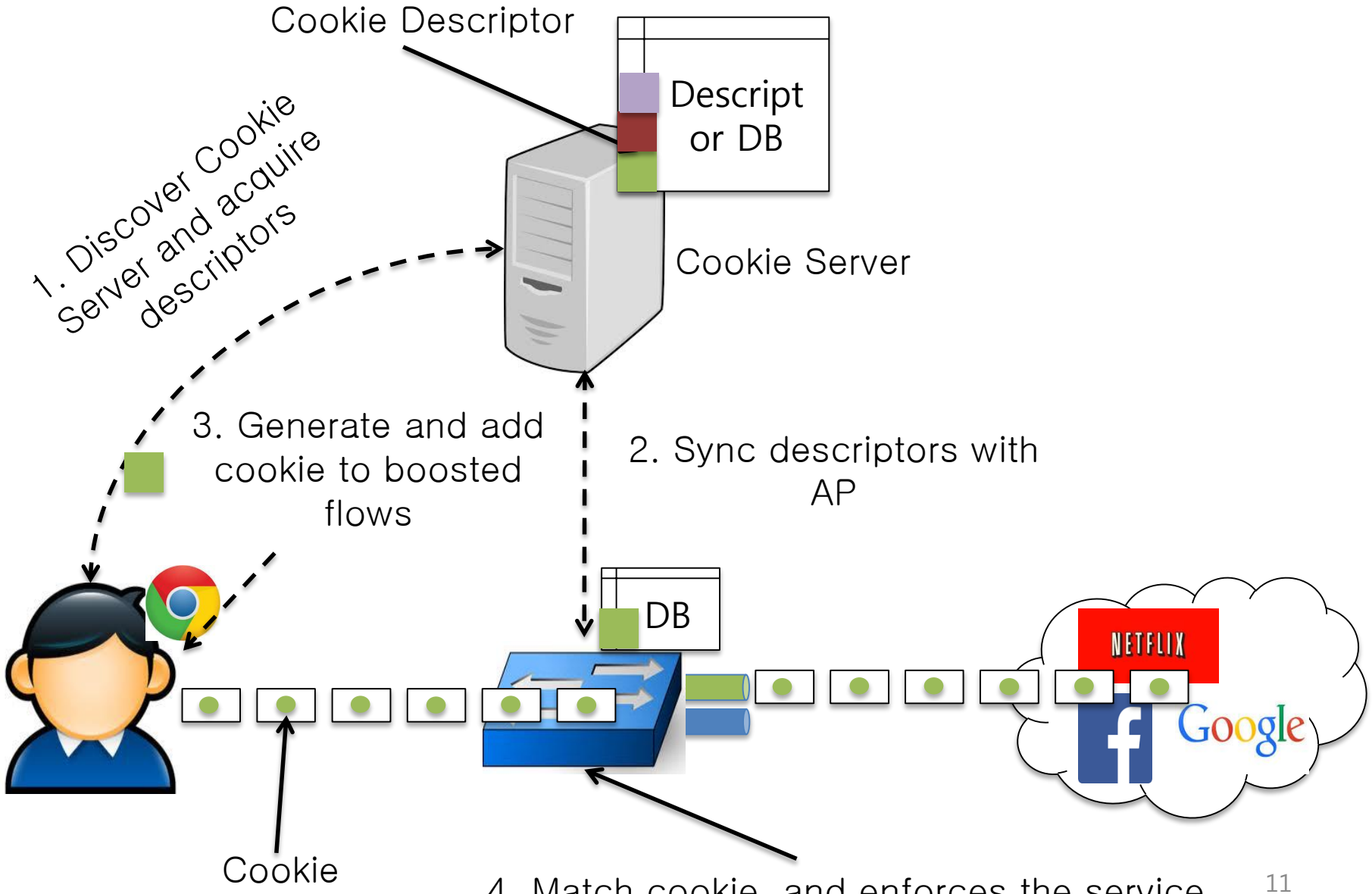
Source: Yiannis Yiakoumis, Standford Univ., 2015. 11.

Challenges / Key Requirements

- Applications Perspective
  - Blind to network status
  - Want to get differentiated services whenever possible
  - Bind to static service options provided by the Internet/Content Service Providers
  - No available mechanisms to apply user preferences
- Carrier Perspective
  - Blind to user preference
  - But need to meet customer care requirements
  - Network resource optimization
  - Fairness (network neutrality)
  - No mechanism to access user behavior and application, ISP & CSP resource status
  - No dynamic feedback loop to its resource status into user/application/ISP/CSP
- Internet/Content Service Provider Perspective
  - Blind to application/network status
  - Want to build various elastic BMs to meet diverse customer's preferences
  - No mechanism to access user behavior, application and network status
- Common Challenges
  - Open programmability to access behavior and resource status
  - Open interfaces for dynamic feedback loop

Available Proposals

Expressing User Preferences with Network Cookies



Source: Yiannis Yiakoumis, Standford Univ., 2015. 11.

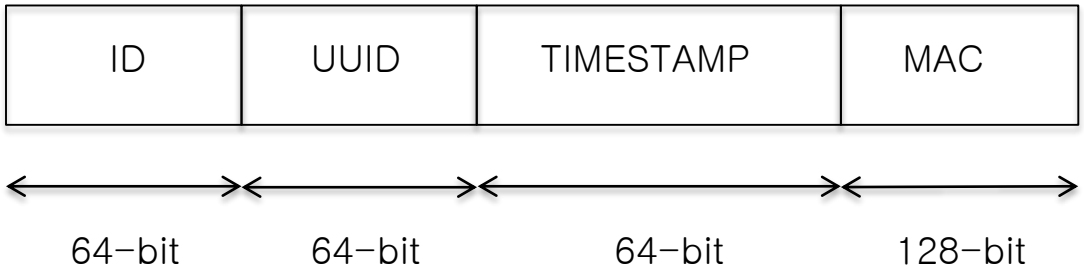
Solution Requirements

- Simple & expressive
- Deployable
- Respect Trust (accountability, authentication)

Source: Yiannis Yiakoumis, Standford Univ., 2015. 11.

What does a cookie look-like?

Cookie : Unique + Use-Once + Signed



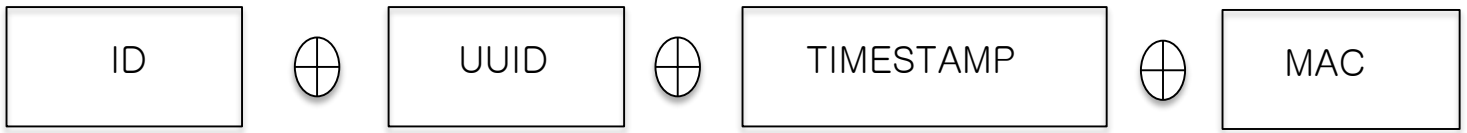
Cookie Descriptor

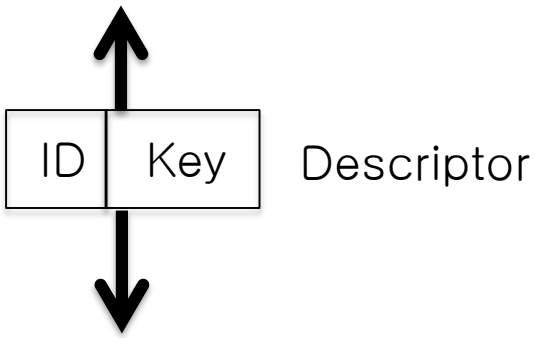
- **ID** : unique look-up identifier
- **Key** : key to generate a MAC (Message Authentication Code)
- **Attributes** : metadata for when/how to use a cookie (e.g. expiration, granularity)

Source: Yiannis Yiakoumis, Standford Univ., 2015. 11.

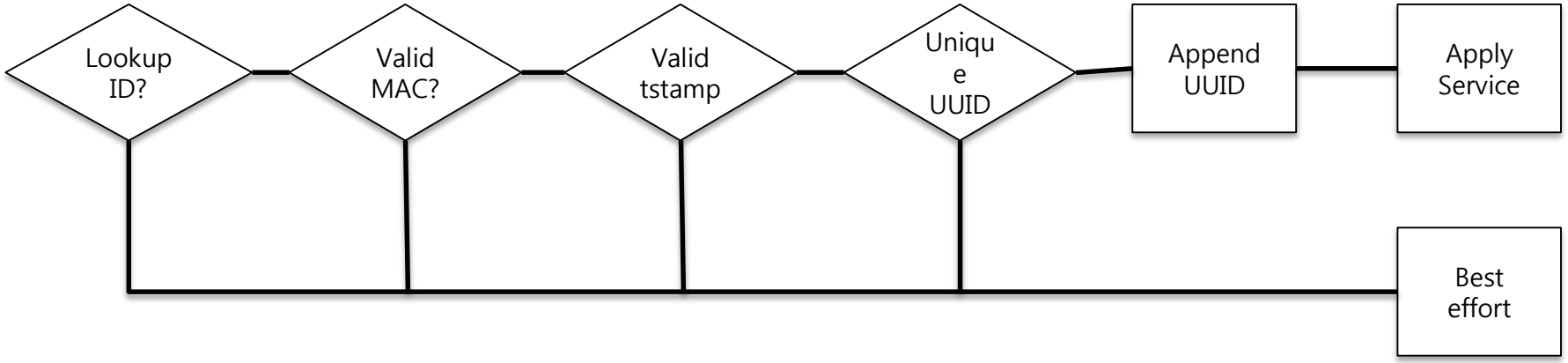
What does a cookie look-like?

Generation





Matching



Source: Yiannis Yiakoumis, Standford Univ., 2015. 11.

How to insert a cookie?

- Who
  - Cookie Engine (e.g. Chrome, OS)
  - Application (e.g. Netflix, Spotify)

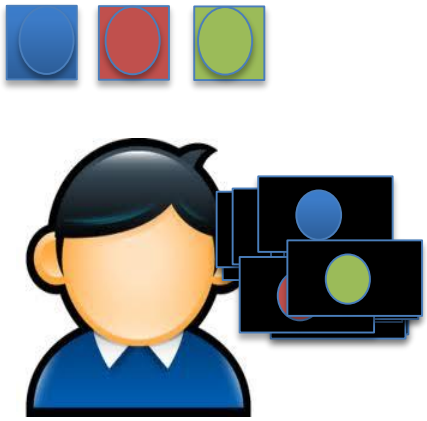
- When
  - When the user wants
  - Application-dependent
  - Cookie attributes (SSID/cellular, target domain)

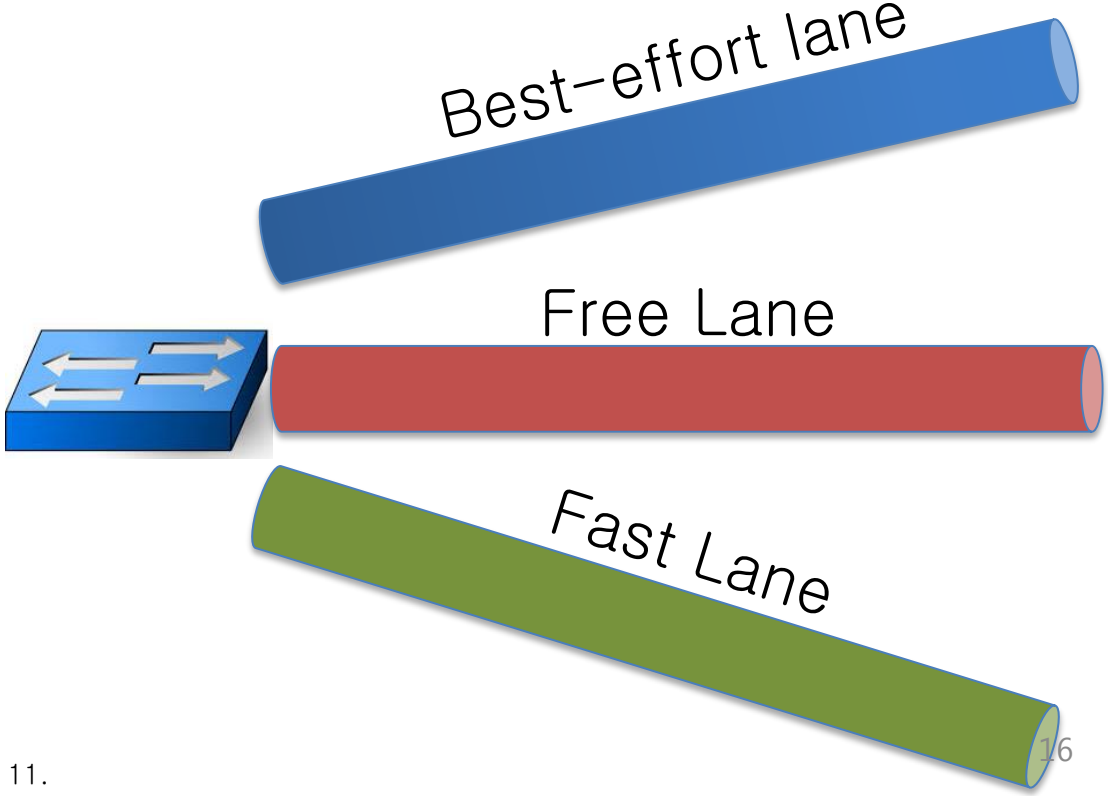
- Where
  - ….anywhere we can put a few extra bits
  - HTTP header
  - SSL/TLS extension
  - TCP Long-Options
  - IPv6 extension header
  - QUIC extension

Source: Yiannis Yiakoumis, Standford Univ., 2015. 11.

Putting it all together…

1. Discover Cookie service and acquire cookie descriptors
2. Generate unique, use-once, signed ***cookies***
3. Append them to desired traffic (HTTP header, TLS extension, TCP, …)
4. *Match in network*





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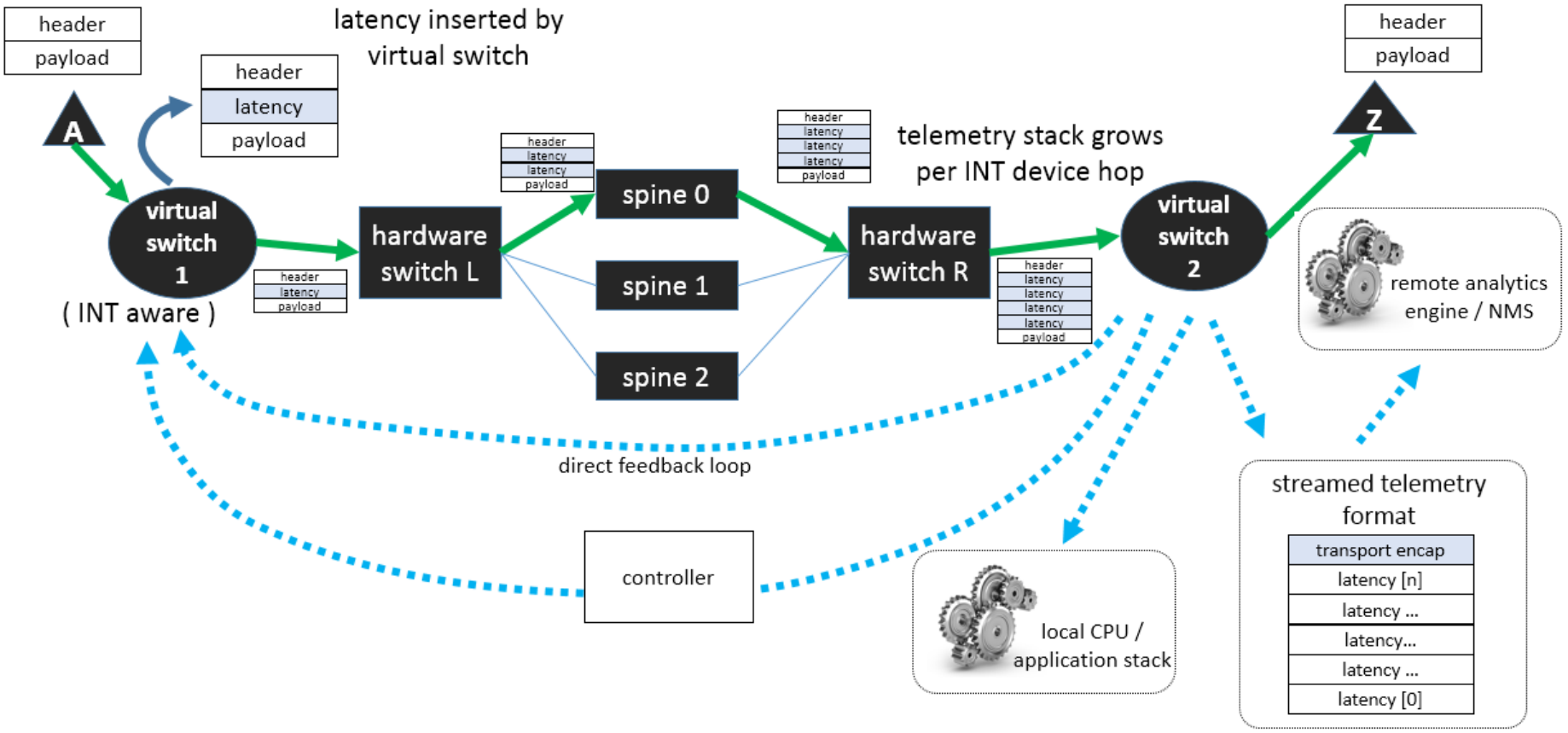
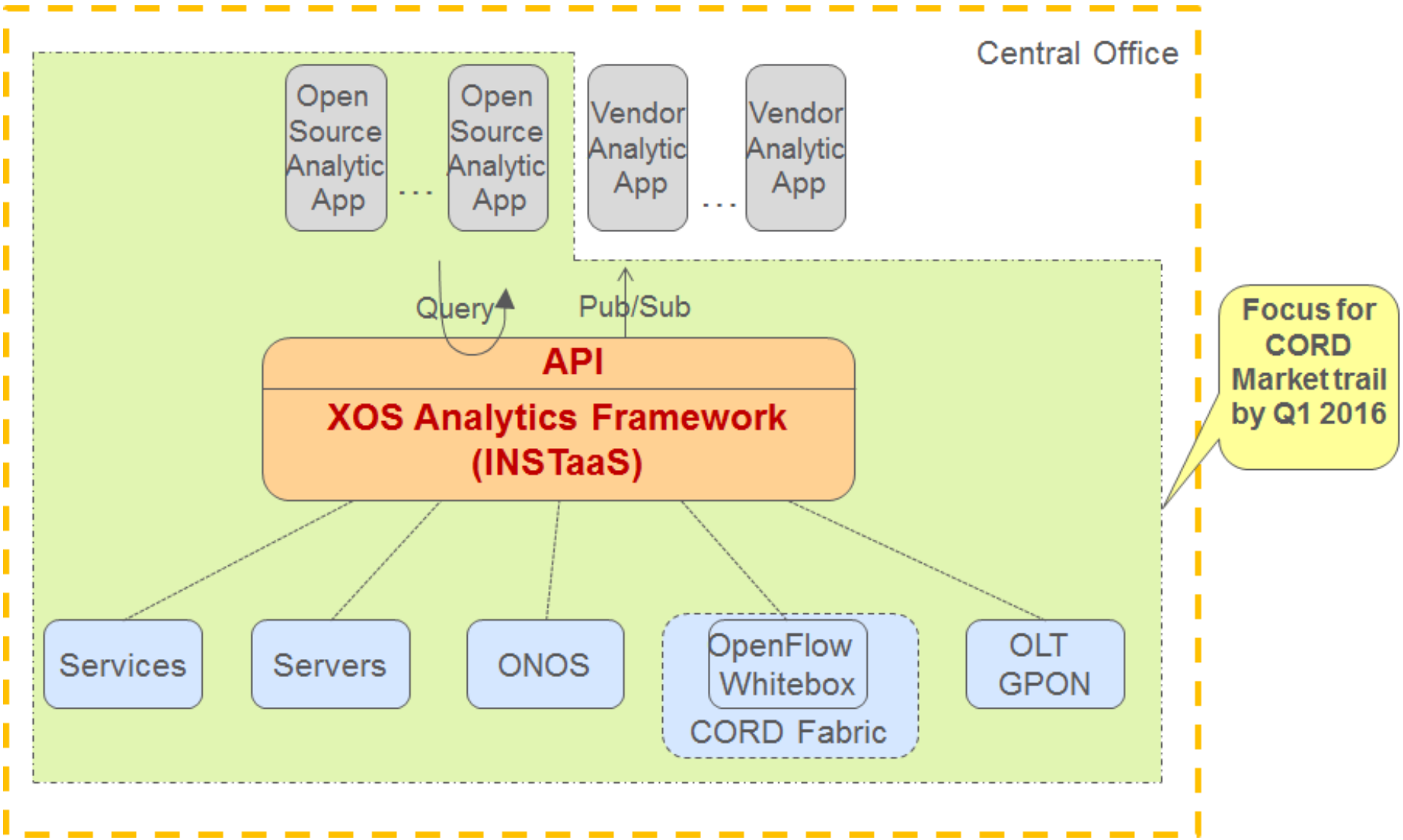
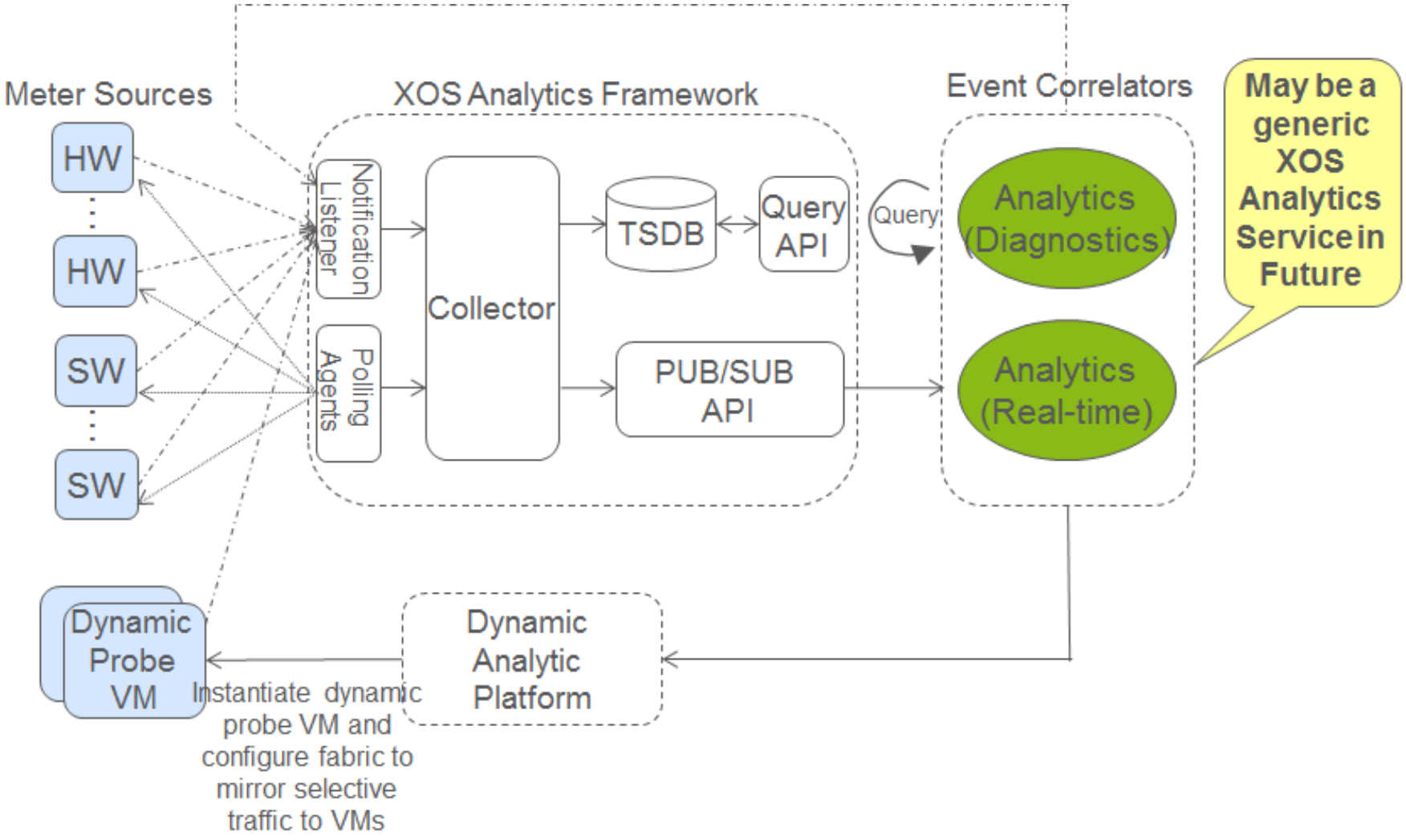
P4-based In-Network Telemetry



ACORD Platform

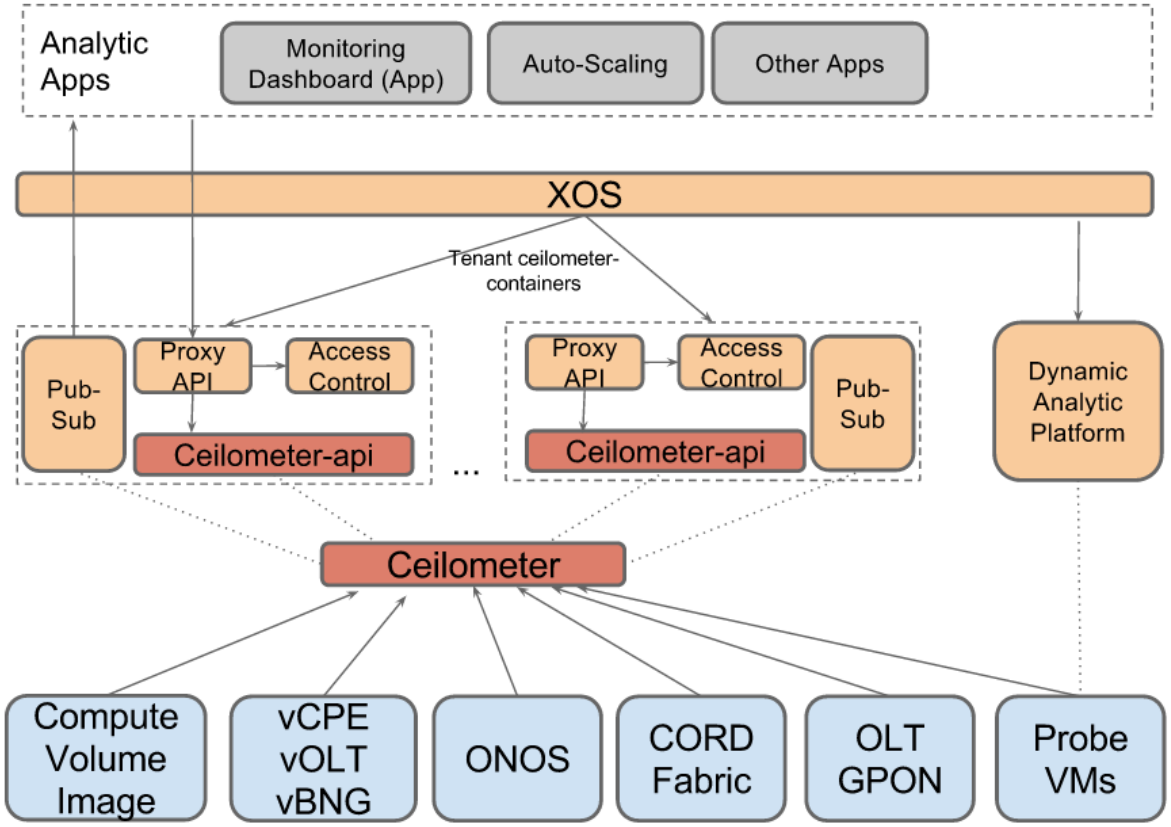


XOS Analytics Framework



ACORD

- Meter agnostic instrumentation framework using Ceilometer with Query API interface
- Low Hanging static meters from compute, ONOS, OLT, CPE, BNG
- Integrate Ceilometer into XOS as a scalable multi-tenant service
- Operator Dashboard visualization
- Performance study (Evaluate the framework in bandwidth intensive environments like Mobility)
- Pub/Sub API interface
- Dynamic control [ON/OFF] meters
- Richer sensors/meters (from Broadcom, OLT GPON…etc)
- Candidate Analytics Use-cases/Apps
  - Auto Scaling
  - Customer care
  - Redirecting Elephant flows in the fabric (Congestion avoidance)



Adaptive Flow Monitoring Motivation

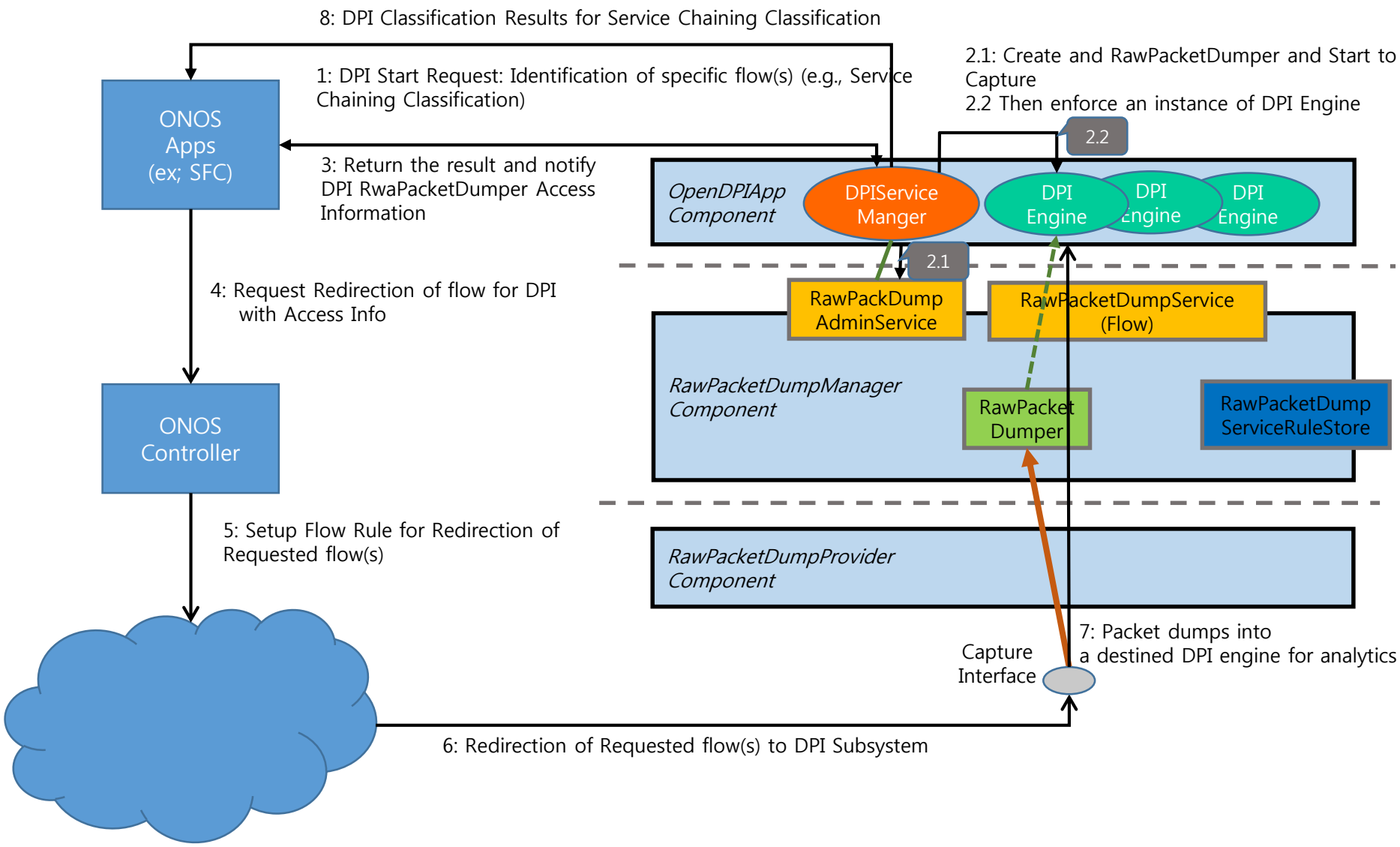
- Default ONOS Flow Monitoring Issues
  - Default FlowRule service collects all flow information from all devices at every time interval (default 10 seconds)
  - This mechanism may cause **performance degradation issue** at each collection time in a large-scale real carrier network due to the number of switches and its associated flows (for example; WAN: ~500 Routers, ~10K ports, ~1-10M flows per port)
  - To overcome performance problem in a simple way, we can maintain collection time interval value with a large number. It then causes another critical issue: **lack of accuracy**
- Our proposal
  - an effective flow monitoring scheme called, **Adaptive Flow Monitoring Service** that can minimize collection computing overhead and provide more accurate flow statistics
    - Re-designing NewAdaptiveFlowStatCollector used in OpenFlowRuleProvider for each corresponding switch
    - Extended StoredFlowEntryWithType from StoredFlowEntry
    - Divides FlowEntries into four groups, i.e., **IMMEDIATE_FLOW, SHORT_FLOW, MID_FLOW, and LONG_FLOW** groups
    - And uses four time intervals, i.e., SHORT_POLL_INTERAVAL, MID_POLL_INTERVAL, LONG_POLL_INTERVAL, ENTIRE_POLL_INTERVAL

Selective-DPI Motivation

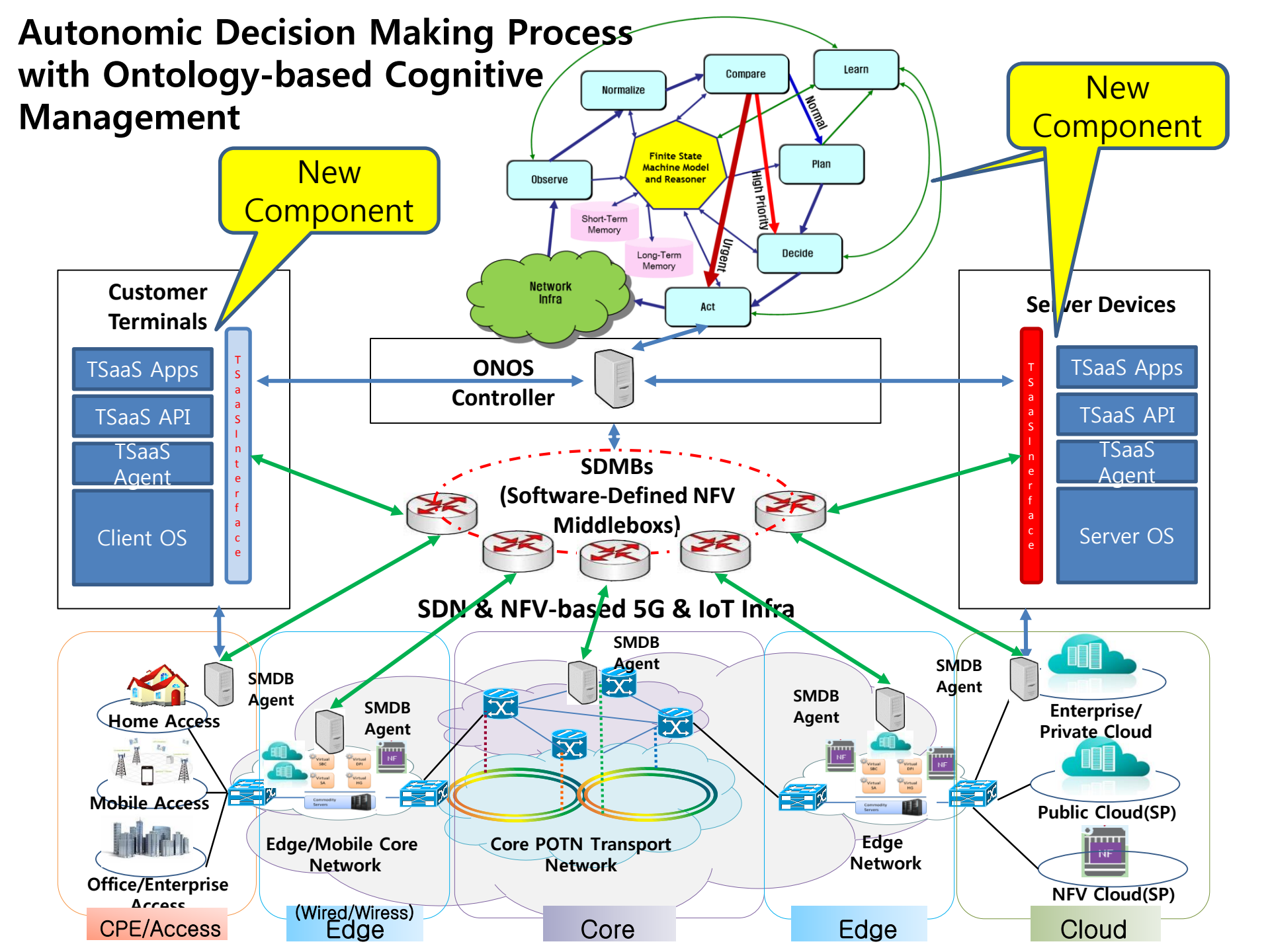
- Default ONOS Application Monitoring Issues
  - Current ONOS flow can be classified and selected by lower-level FlowSelection criteria based on FlowRule entry (eg., ports, ether_type, vlan_id, 5-tuple, etc.)
  - There is **no application classification service** for ONOS data plane user-data

  - We proposed to add a **Selective DPI service** that can filter data plane user-data from controller traffic and classify them with application level granularity by using a open source DPI s/w

OPEN-TAM: DPI Architecture & Use Case



Autonomic Decision Making Process with Ontology-based Cognitive Management



Open Issues for Research

- Some Main Issues to be addressed in research are:
  - How to collect user preferences and resource? (statically, programmably, allow external access or not, etc.)
  - How to carry user preferences? (via cookies, open access API, etc.)
  - How to exchange user preferences? (via protocol (distributed), pull&push (centralized))
  - How to exchange resource status information between customers and providers?
  - How to generate control policies? (statically, dynamically, or autonomically)
  - How to enforce control policies? (in-line embedded in a protocol, centralized by a logically global controller)
  - Can user be involved in control policy enforcement?
  - Is user terminals entities to be controlled as well?

Thank You

Q&A

choits@etri.re.kr