ATIS 5G Symposium

5G Network Aspects and Service Enablers

Cisco Systems

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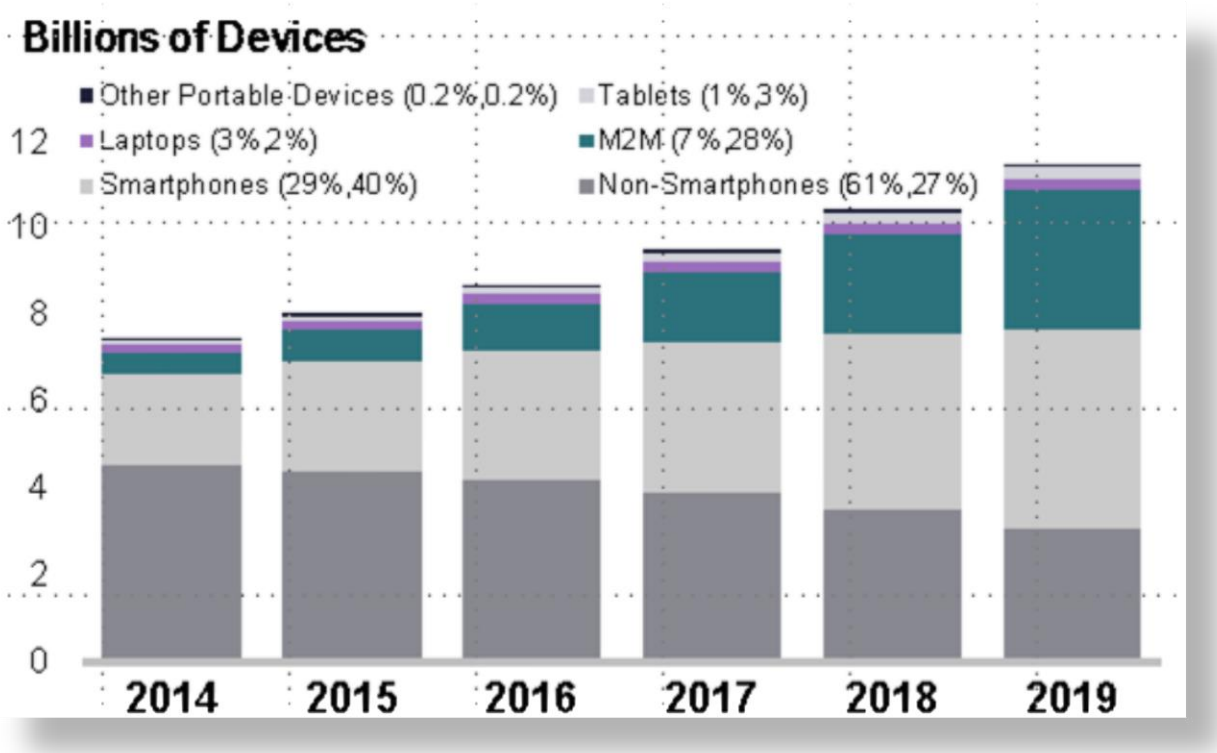
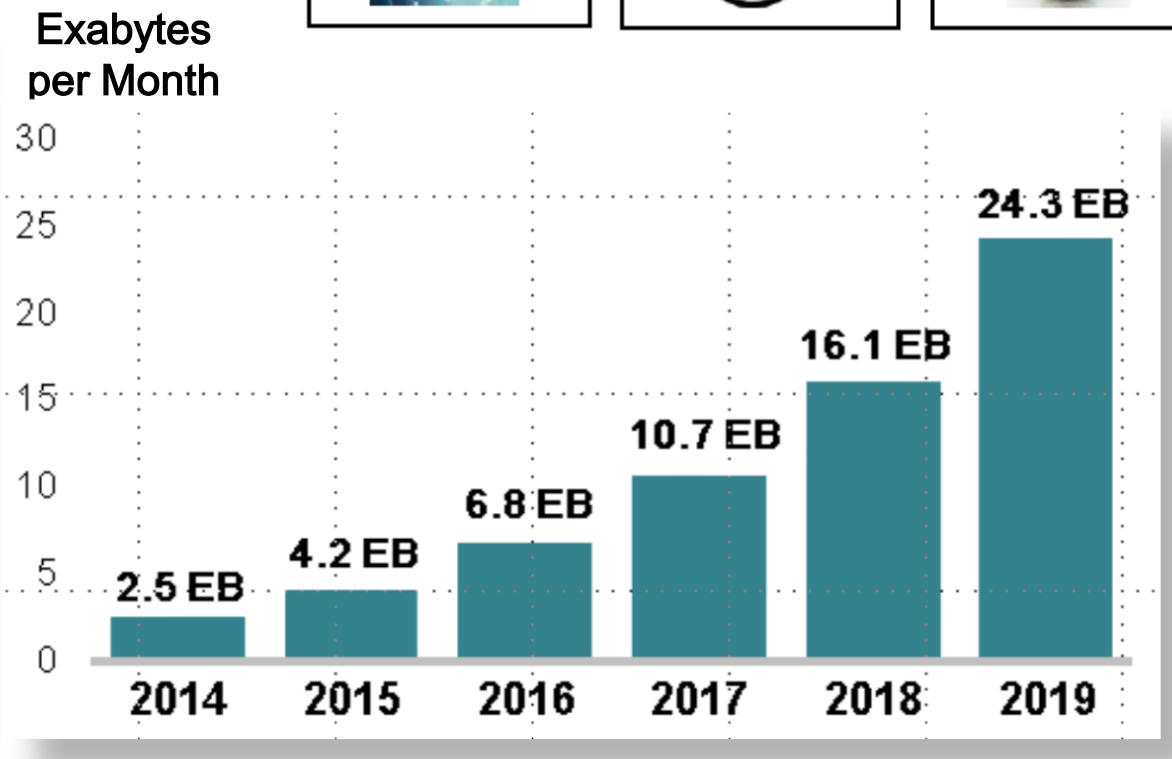
The 5G Drivers
When won't 4G be enough?

Massive Internet of Things	Broadband access everywhere	Broadband access in dense areas
SENSOR NETWORKS	50+ MBPS EVERYWHERE	PERVASIVE VIDEO



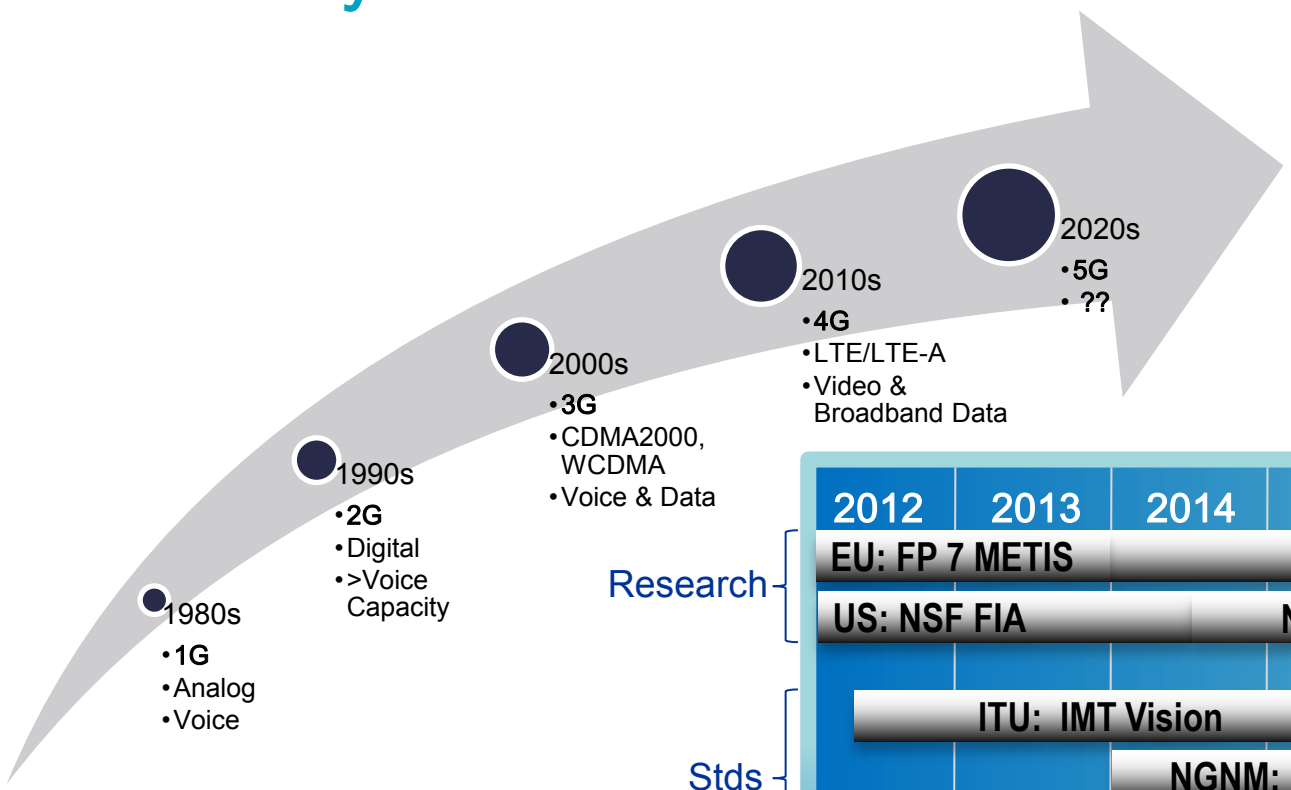


The Truth: 5G will become a market reality when 4G can no longer *economically* support the applications and use cases the market demands

Source: Cisco VNI Global Mobile Data Traffic Forecast, 2014–2019

So why another G?

- Growth: new devices, diverse applications and usage models, more traffic
- One generation / decade since mid-80s; clearly defined use cases market demand
- 2000-2010 transition for voice centricity to data centricity
- >2020 needs to be more than greater data capacity and coverage

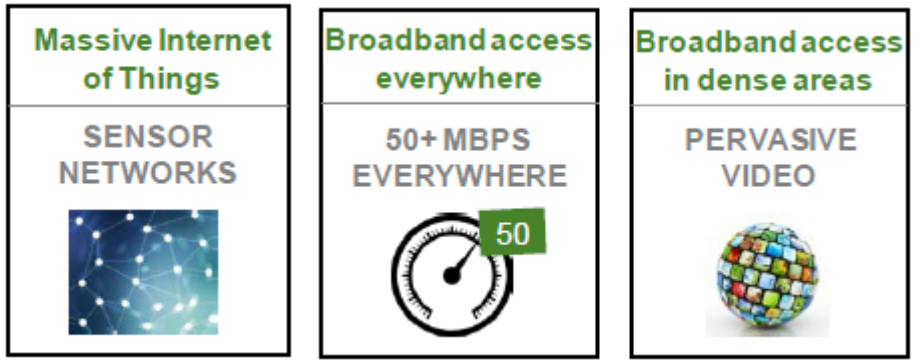


Despite the market hype, the industry is in the early stages of defining "5G"
Cisco is pushing radical thinking

5G Technologies
The usual suspects

	Technology	Description	Target Benefits
Access	**Millimeter-wave technology**	Using 30 - 60 GHz frequency range for short range access	More Spectrum ➔ more capacity, higher data rates
	Lots of signal processing, High-order MIMO	Interference management and cancellation Many antenna elements (>16) in active array	Greater spectral efficiency ➔ more capacity, higher data rates (mainly low mobility)
	Adaptive air interfaces	Throughput, duty cycle, connectivity, signaling	Better support for new devices (ie IoE, M2M)
	Ultra Wideband Radios	Radios that span multiple bands	Flexible spectrum utilization; multi-operator sharing
	Cloud-RAN (C-RAN)	Move basestation L1-3 processing functions to cloud.	Lower opex. Improve performance via broader option set for inter-cell coordination, Mu-MIMO, etc. Increased flexibility for air-interface evolution/disruption. Potentially reshape the RAN ecosystem.
	Device to Device (D2D)	Direct communication between cellular devices	
Mobility Core	**Network Function Virtualization (NFV)**	Pooling of processing across many sites (starting in 4G and more widespread in 5G)	Cost Reduction Agility gain
	Software Defined Networking (SDN)	Logically centralized control of access, transport and core	Cost reduction Improved flexibility to meet needs of different services/mobility

5G Technologies
Not-so-usual suspects (Cisco Focus)



Technology	Description	Target Benefits
Simplified small cells	Make smalls cells more like wifi; Eliminate complexity derived from macro-cell heritage Move processing complexity to network cloud	Easy to deploy, simplified operations, lowest cost; Enable multi-operator sharing
Information-Centric Networking **Named-Data-Networking (NDN)** **Content-Centric Networking (CCN))**	New communication model for internet designed for information delivery rather that data transport; Mobility, Security, Storage become 1st class citizens	Simple, Fast, efficient, secure, authorized retrieval of information and content

Cisco thinking….. hide complexity, expand functionality, emphasize simplicity

RAN Evolution towards 5G

- RAN evolution to 5G will continue to investigate higher complexity technologies (e.g. massive MIMO, New Waveforms, Advanced Internode Communication, etc.), but…
- …there may be more benefit if 5G RAN is SIMPLER with the goal of lowering TCO
  - 70-80% of TCO in RAN is OPEX for running, managing and maintaining the RAN, so focus on reducing OPEX
  - What technologies should be looked at for lowering RAN TCO for 5G?
- Current trends towards centralizing and virtualizing portions of the traditional RAN architecture (for both macro and small cell) is one area

Summary of RAN Vision Towards 5G

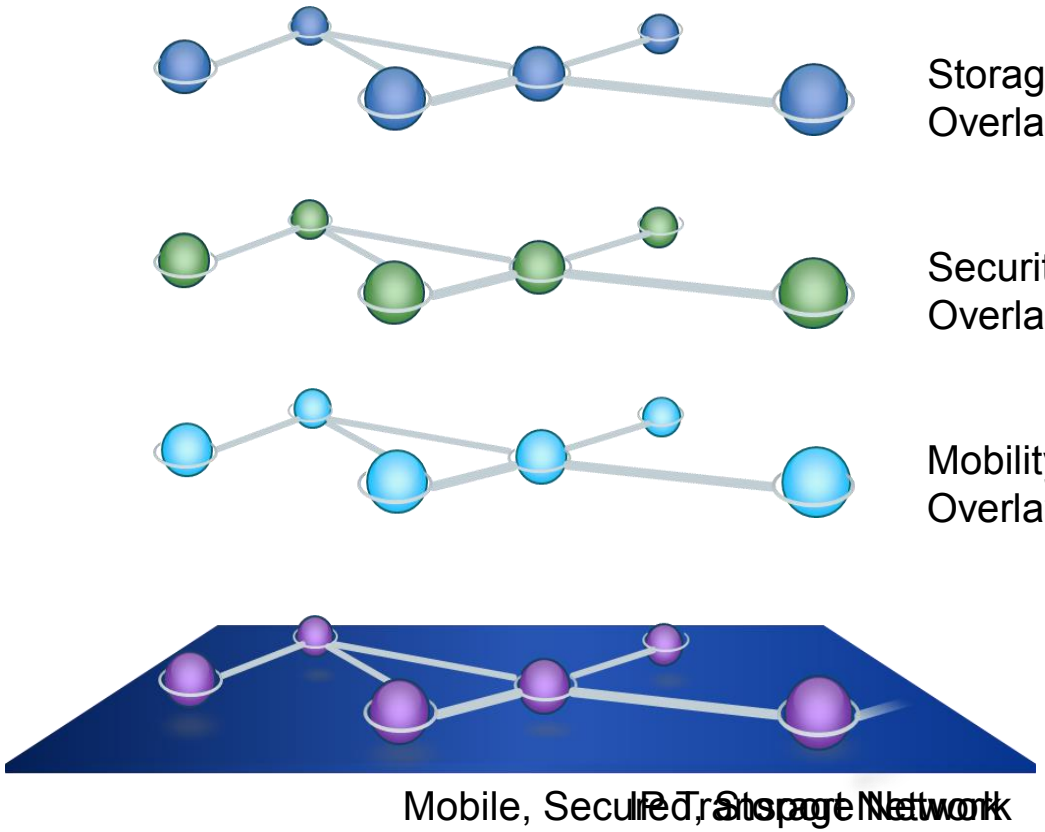
- 5G RAN will include the usual suspects
  - mmWave but tied to LTE network through DC or MP-TCP and assisted by SON
  - Possibly new waveforms/adaptive air interface for mmWave & M2M/IoT
  - D2D for certain IoT applications
- Evolution of the LTE will continue to be based on LTE-adv
- Lower TCO neutral host small cells should be important part of the vision towards 5G
  - Evolution to CRAN can help
  - Likely multiple split point ecosystems

5G Core Network – Goals

The core is the convergence point of all use cases:

- Simplification
- Only loosely-coupled to the access network
- Inherent mobility – fundamentally converging fixed and mobile at the network layer
- Intrinsic security
- Orchestrated virtualization is a fundamental building block

Information Centric Networking
Providing a New Foundation for 5G



A new model for modern Internet usage

Builds on the latest "*Future-Internet*" architecture research

New networking paradigm:

- **Mobility** – eliminate need for special mobility overlays
- **Security** – guarantee the integrity of every data object
- **Storage** – dynamic placement of information anywhere in the network

NDN / CCN Architecture

Underlying Principle

Model for information retrieval –

ask the network for a chunk of named content

not a connection to where the content is located

Hierarchical (and perhaps human-readable) *ContentName*

eg /conf/papers/NDN.pdf

nb variable-length content names are routable entities—

- conventional routing protocols operate on structured content names rather than structured IP addresses
- ensures scalability

Two basic types of packets:

Interest

Data

Request / response model ←→ data delivered over request path

Information Centric Networking
The Principles

- Name-based network operations
- Receiver-driven data delivery - Request-based multipath connectionless transport (multiple sources/paths)
- Symmetric routing
- Stateful forwarding ➔ in-network control
- In-network storage – temporary caching for reuse and repair
- In-network processing
- Object-oriented security (not connection-oriented)

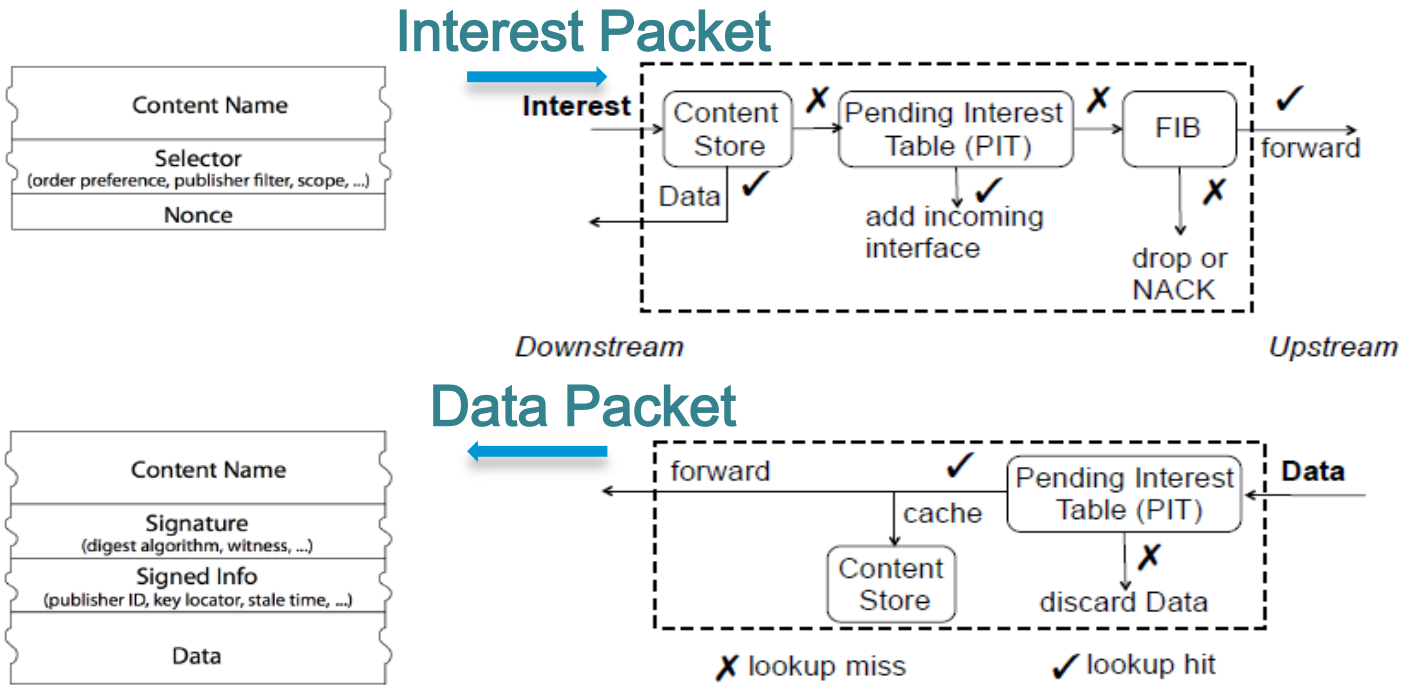
Information Centric Networking
The Objectives:

- Move from *vertically-integrated silo* of network assets to a *horizontal architecture* that loosely-couples the access technologies to the core
- Simplified mobile architecture – eliminate the need for mobile tunnels (user mobility support intrinsic to architecture – for any device)
- Intrinsic security (integrity, privacy and confidentiality) – rather than an overlay
- Seamless multi-homing at per-flow granularity
- Traffic-load reduction, latency enhancement via in-network caching (also for live streaming)
- Edge computing
- Per-application service differentiation

NDN Routing–Basic Concepts

NDN Routers comprise three components (rather than one)

i. FIB: Forwarding Information Table—can have multiple forwarding entries per prefix
ii. PIT: Pending Interest Table—return route state for outstanding requests
iii. Content Store: Integral content cache in networking layer



Security – Trust the Content
(not the connection)

- For data received, the user can verify:
  - Integrity: Is data intact and complete?
  - Origin: Who asserts this data is an answer (Provenance)?
  - Correctness: is this an answer to my question (Relevance)?
- Key concept: Secure the content rather than the container (eg router, host) or the communication channel
- ContentObject := *Name; SignedInfo; Signature; Content*
  - Name, some additional bits of information (the *SignedInfo*), a digital signature of the other three elements, and arbitrary binary data (representing the content)
  - *SignedInfo* identifies the publisher that signed the content and includes the public key of the publisher
  - *Signature* verifies authenticity of the Name, SignedInfo and Content
- Separate Actions – ensure privacy, confidentiality

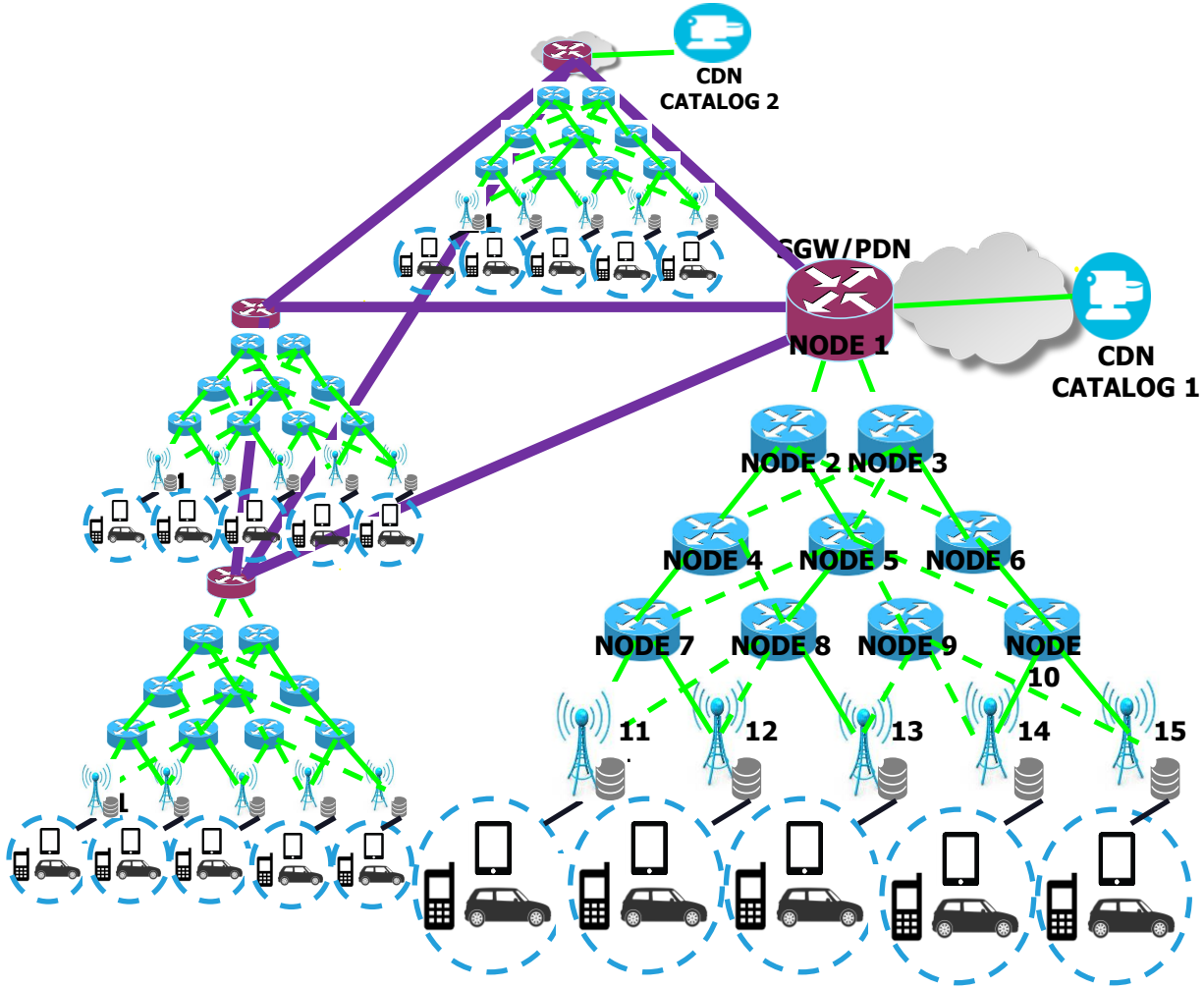
First look at ICN Improvement of Mobile Backhaul
Latency and Bandwidth Utilization

Experimental investigation of ICN usage in mobile backhaul network:

- over ~100 nodes
- Realistic backhaul topology
- realistic workload

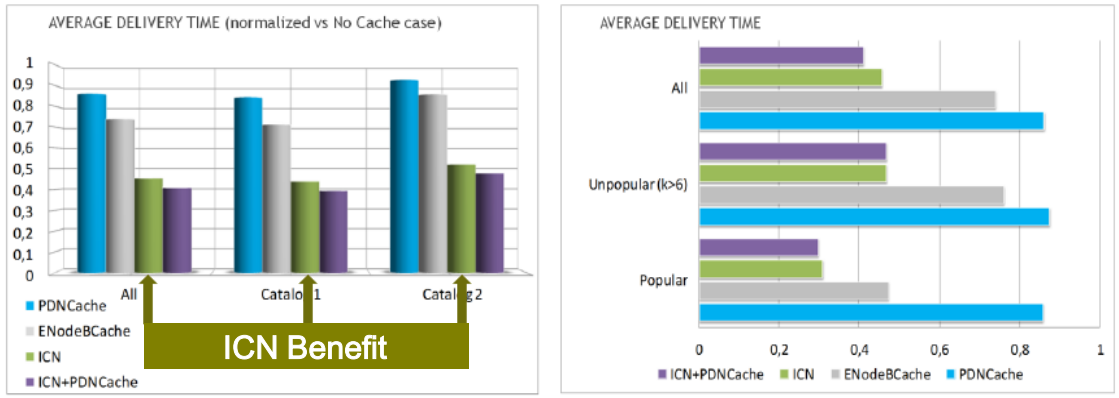
Test basic ICN capabilities:

- multipath transport
- in-network caching
- latency-aware hop-by-hop forwarding on names



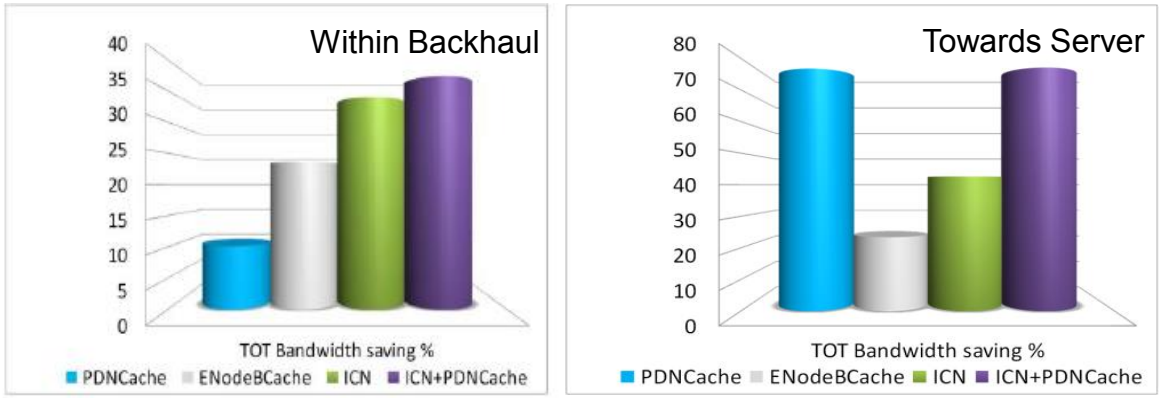
First look at ICN Improvement of Mobile Backhaul
Latency and Bandwidth Utilization

- Significant reduction in information delivery time:
  - In-network caching
  - Implicit multipath transfer
  - <1/2 average latency for all content
    <1/3 average latency for popular content



Average Delivery Time

- Significant improvement in bandwidth utilization:
  - Up to 40% BH bandwidth savings



Bandwidth Saving (%)

Ref: Proc. ICNRG Sep2014 http://www.ietf.org/proceedings/interim/2014/09/27/icnrg/proceedings.html

Key Points:

- On timing, Cisco believes 5G will emerge when 4G strains to support the applications and the use-cases the market demands at the ***desired economic cost points*** (>2020)
- 5G is about putting the network on a ***new economic cost curve for SPs*** to follow after they've pushed 4G to its limit in supporting the breadth of use cases in mobile broadband, IoE, M2M, etc
- 5G is about transforming the architecture from a ***vertically-integrated silo*** of network assets to a ***horizontal architecture*** that loosely-couples the access layer to the mobility core
- Cisco envisions a new core networking framework that incorporates ***Mobility, Security and Storage*** as fundamental players in the networking layer as the means to achieve the 5G economic objective. We believe that ***Information Centric Networking*** (ICN) will play a key role in enabling 5G to meet this objective.
- We must provide an ***economically sound transition from 4G to 5G*** that continues to protect the SP's prior network investment and maintains sound operations.

Thank you.