# Software Defined Networking

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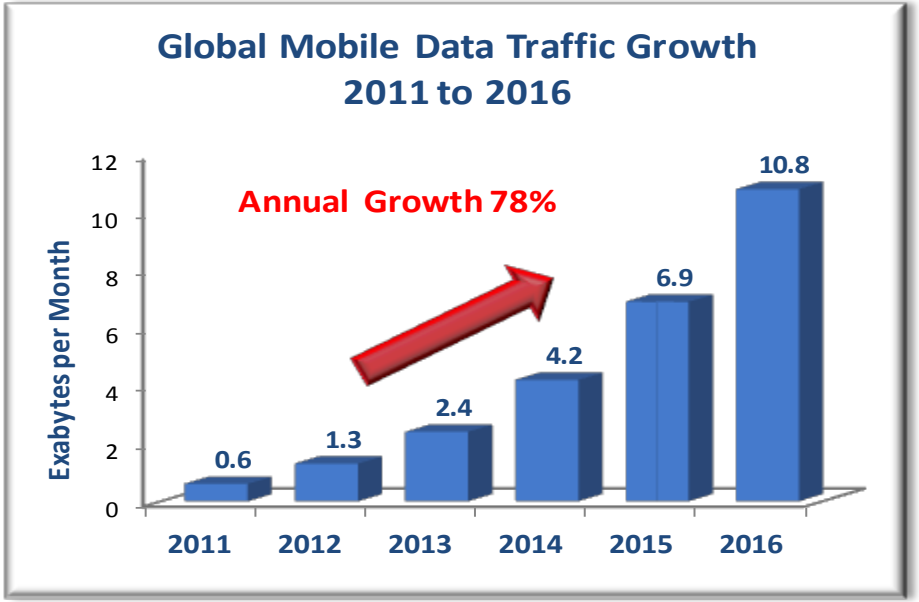
*In this course, you will learn about software defined networking and how it is changing the way communications networks are managed, maintained, and secured.*

# Wireless Data Growth

- AT&T
  - Wireless data growth 20,000% in the past 5 years

***Question: How to substantially improve wireless capacity?***

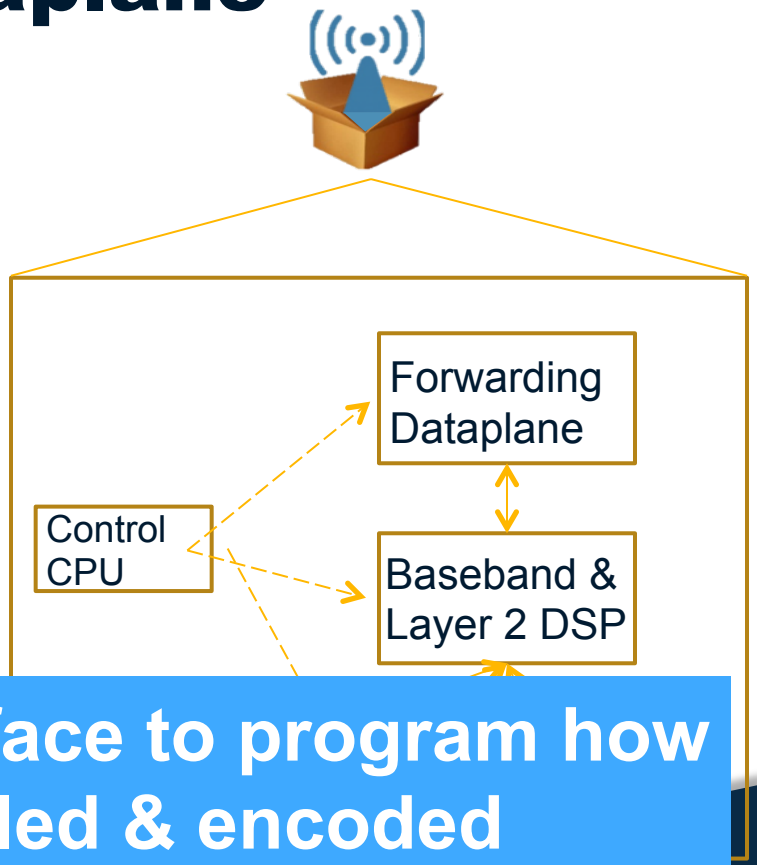



Source: CISCO Visual Networking Index (VNI) Global Mobil Data Traffic Forecast 2011 to 2016

# OpenRadio: Access Dataplane

OpenRadio APs built with merchant DSP & ARM silicon

- Single platform capable of **LTE, 3G, WiMax, WiFi**
- OpenFlow for Layer 3
- Inexpensive ($300-500)




**Exposes a match/action interface to program how a flow is forwarded, scheduled & encoded**

# Opening Up the Radio

## Why?

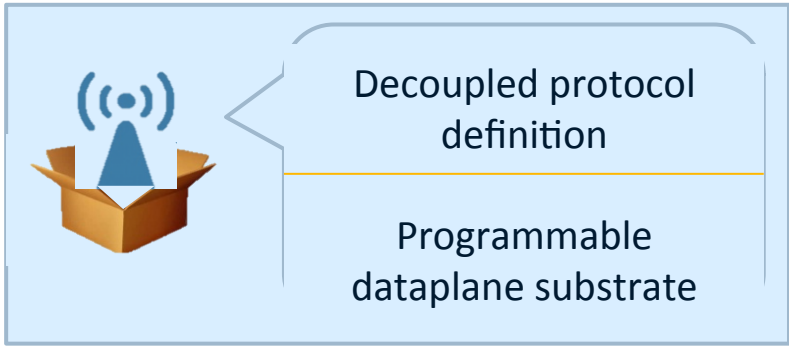
- Evolving protocols
- Diverse applications
- Network growth and Diverse scenarios

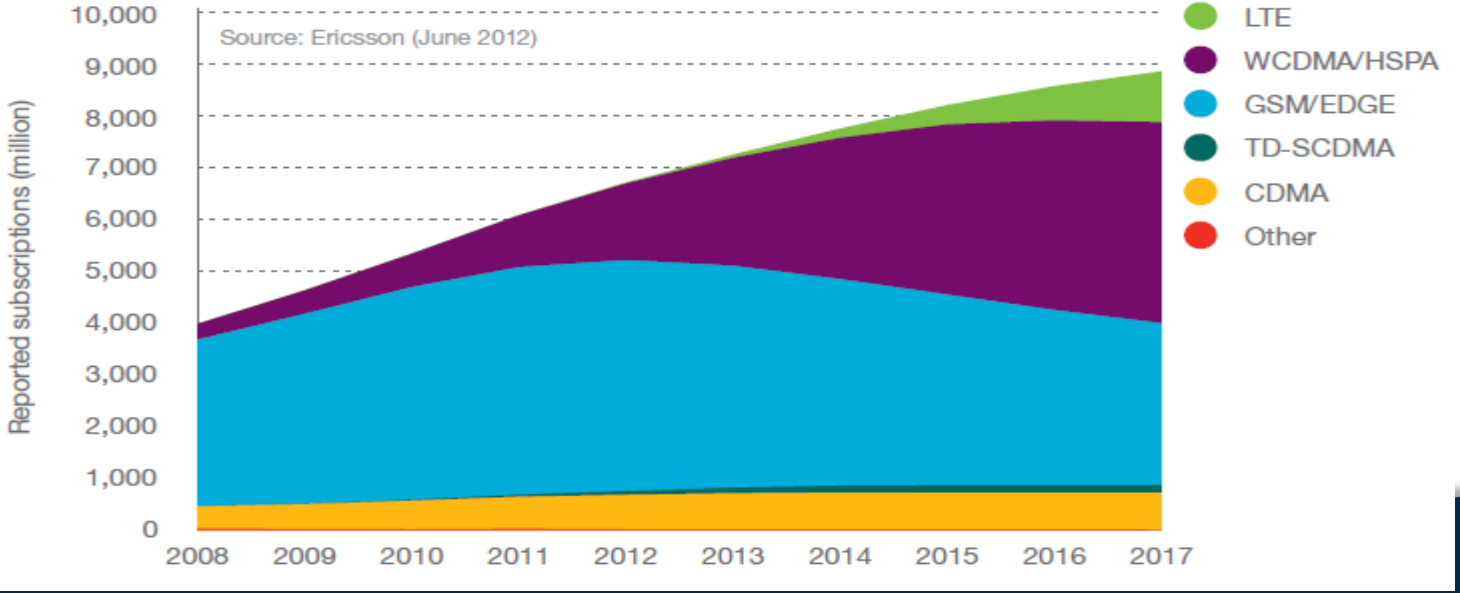
## How?

- Decouple functionality and HW
- Judicious split of protocols
- High-level abstractions

# Evolving standards

- Major 3GPP LTE releases every 18 months
- Continuous minor updates
- Old standards don't die
  - Multi-mode basestation radios
- Can we deploy once and keep updating?



# OpenRadio: SDN for Wireless

- Wireless network architecture that provides software interfaces to:
  - Query wireless networks about availability, quality, speed, user location …
  - Control granularly how individual user or application traffic is handled by the network

# Problems With Wireless Networks

- Wireless networks are complex & closed
- Do not expose network state
  - Hard to know available APs, their speeds, load etc.
- Do not provide external control
  - Hard to request flow specific services from network

# OpenRadio Control Interface

- **Match:** Identify and tag flows of individual users and/or applications

- **Action:** Control how packets are routed, what speeds & priorities they get, and how they are scheduled at the AP

# OpenRadio: Control Plane

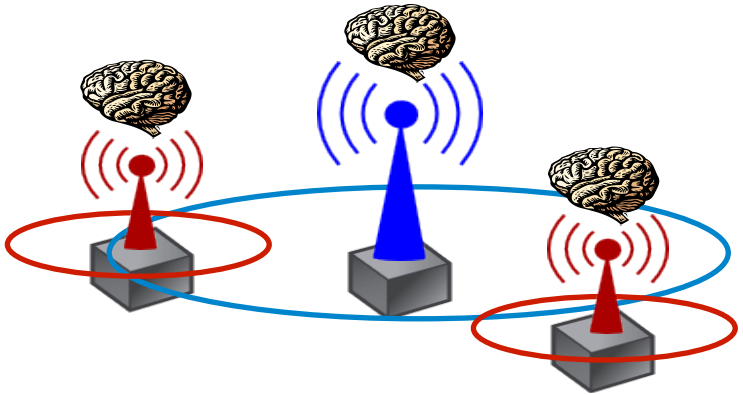
- Network OS that provides software abstractions to simplify development of new services:
  - Hides network heterogeneity (WiFi, 3G, LTE)
  - Hides complexity of finding network state
  - Hides complexity of controlling flow behavior

# Application: Different Traffic Classes

- Can do better than one-size-fits-all radio stack
  - Unequal error protection (UEP) for video
- LTE specifies several traffic classes
  - How do I implement them?
  - Future traffic classes?
- How about a programmable infrastructure?

# Application: Coordination

- Reducing cell-sizes to meet capacity demands
  - Smaller macro-cells → less users per cell
  - Picocells (open), femtocells (closed) just thrown in
  - Interference dominates, mobility is harder
- How can we make base stations coexist?
  - Dynamic scenario-specific adaptation
  - Decoupled control plane, programmable dataplane



# Design goals and challenges

- Programmable wireless dataplane
  - Customize remotely after deployment
  - Modularity to provide ease of programmability
    - Only modify affected components, reuse the rest
    - Hide hardware details and stitching of modules
  - Built using off-the-shelf components

# Other Emerging Areas

- Radio Access Networks
  - Coordination to antenna direction and power to minimize interference [SoftRAN]
- Cellular Networks
  - Placement of software functions near basestations to optimize backhaul, facilitate billing [SoftCell]
- Programmable APs [Odin]

# Conclusion

- A programmable wireless data plane
  - Rich programming interface for wireless radios
  - Principled design for efficient implementation
  - Built using off-the-shelf components
- Balance of flexibility, performance and modularity