Software Defined *Cellular* Networks

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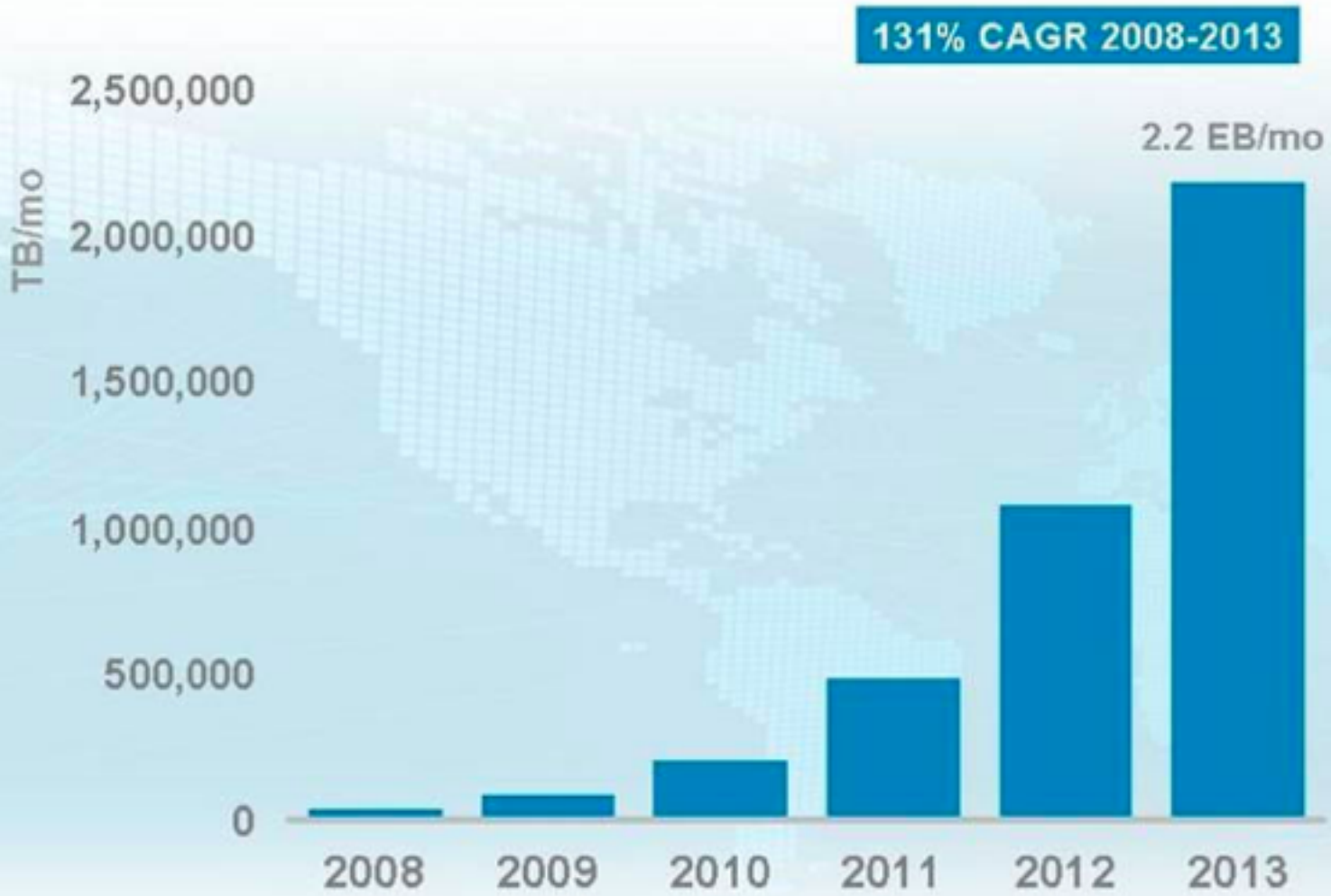
Global Mobile Data Traffic Growth

Mobile data traffic will increase 66X from 2008 to 2013



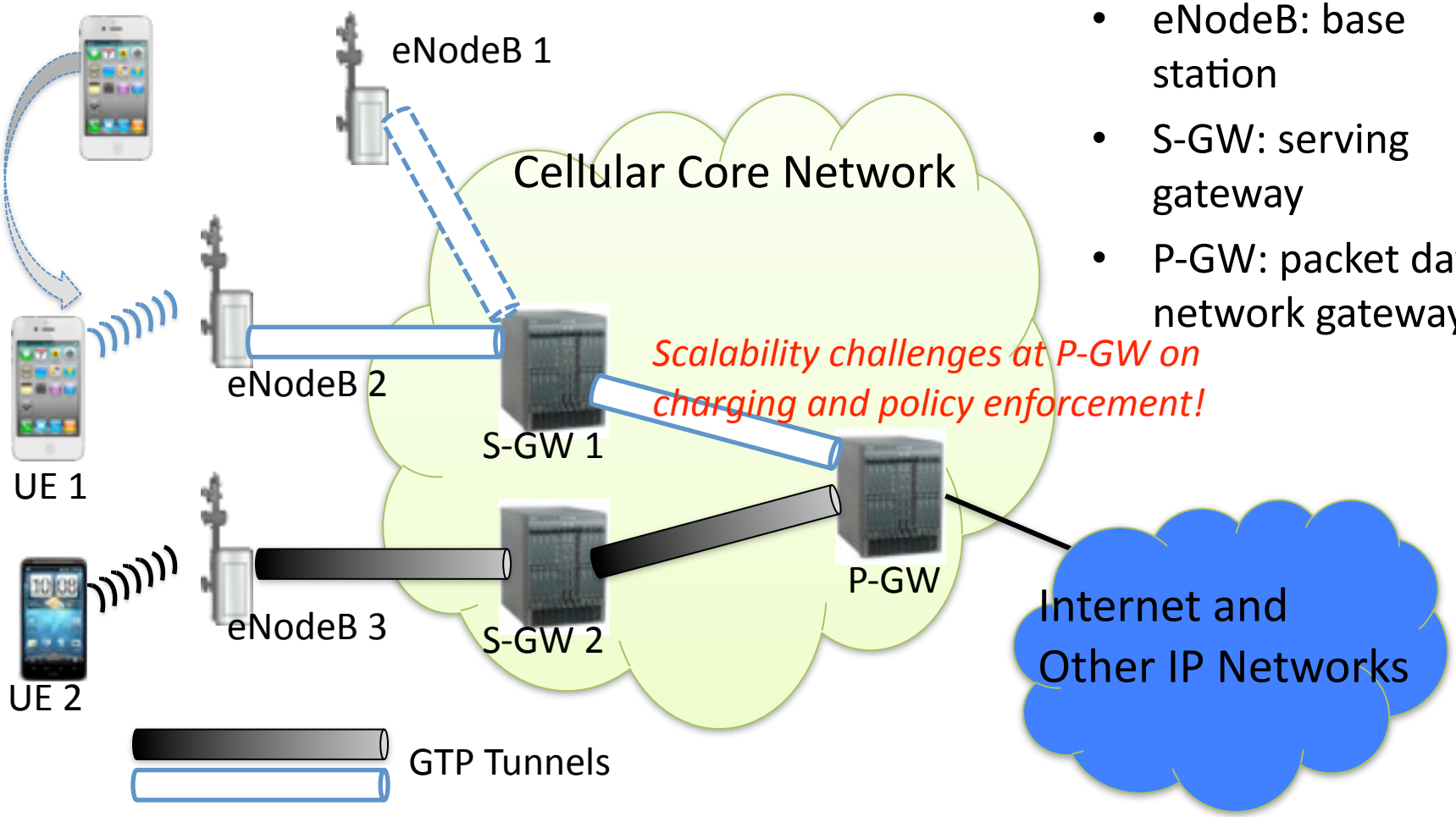
Source: Cisco Visual Networking Index – Forecast, 2008-2013

Outline

- Critiques of LTE Architecture
- CellSDN Use Cases
- CellSDN Architecture
- Related Work
- Conclusion and Future Work

LTE Data plane is too centralized

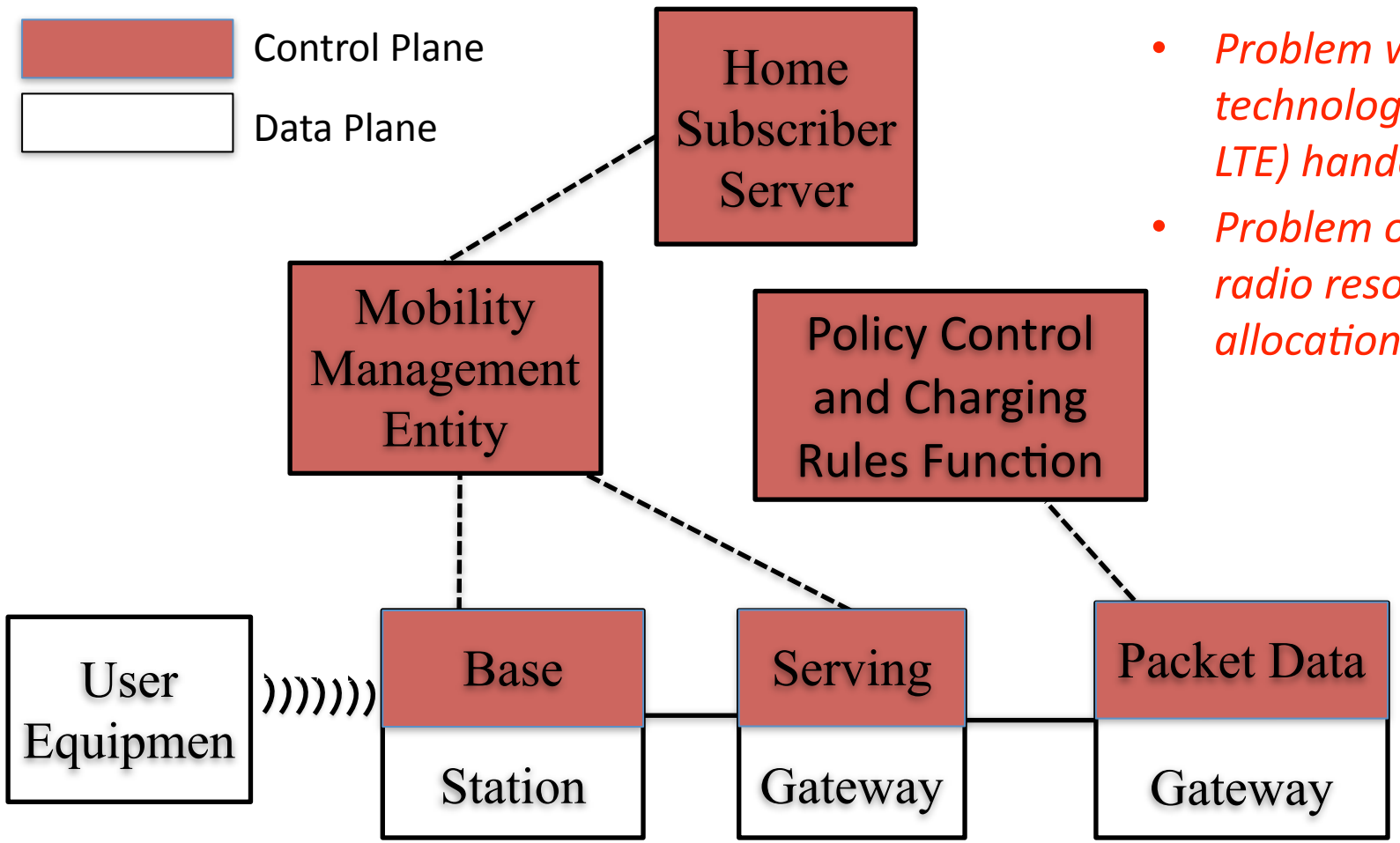
- Data plane is too centralized



- UE: user equipment
- eNodeB: base station
- S-GW: serving gateway
- P-GW: packet data network gateway

LTE Control plane is too distributed

- No clear separation of control plane and data plane



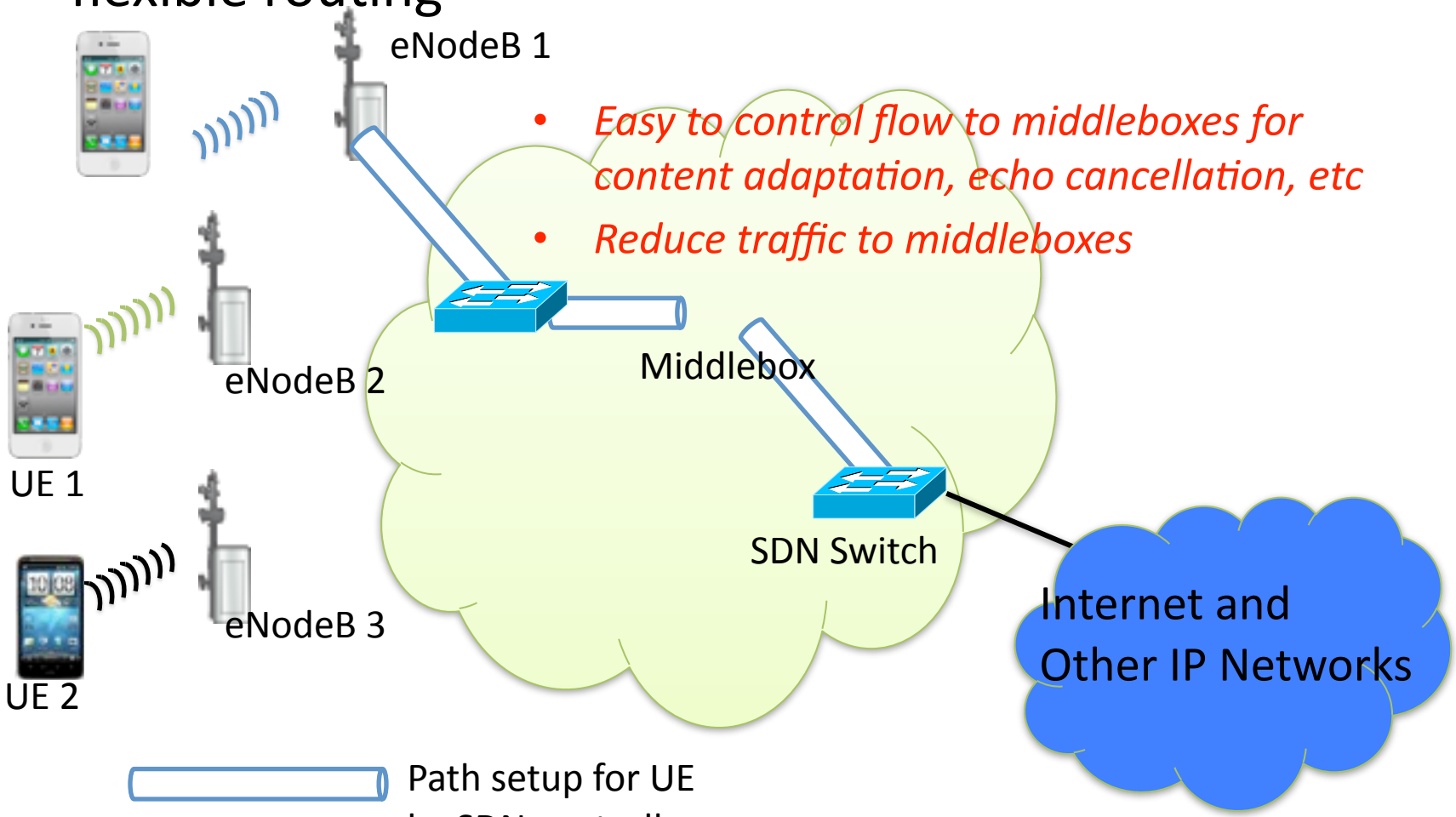
- *Problem with Inter-technology (e.g. 3G to LTE) handoff*
- *Problem of inefficient radio resource allocation*

Advantages of SDN for Cellular

- Advantage of logically centralized control plane
  - Flexible support of middleboxes
  - Better inter-cell interference management
  - Scalable distributed enforcement of QoS and firewall policies in data plane
  - Flexible support of virtual operators by partitioning flow space
- Advantage of common control protocol
  - Seamless subscriber mobility across technologies
- Advantage of SDN switch
  - Traffic counters enable easy monitoring for network control

Flexible Middlebox Support

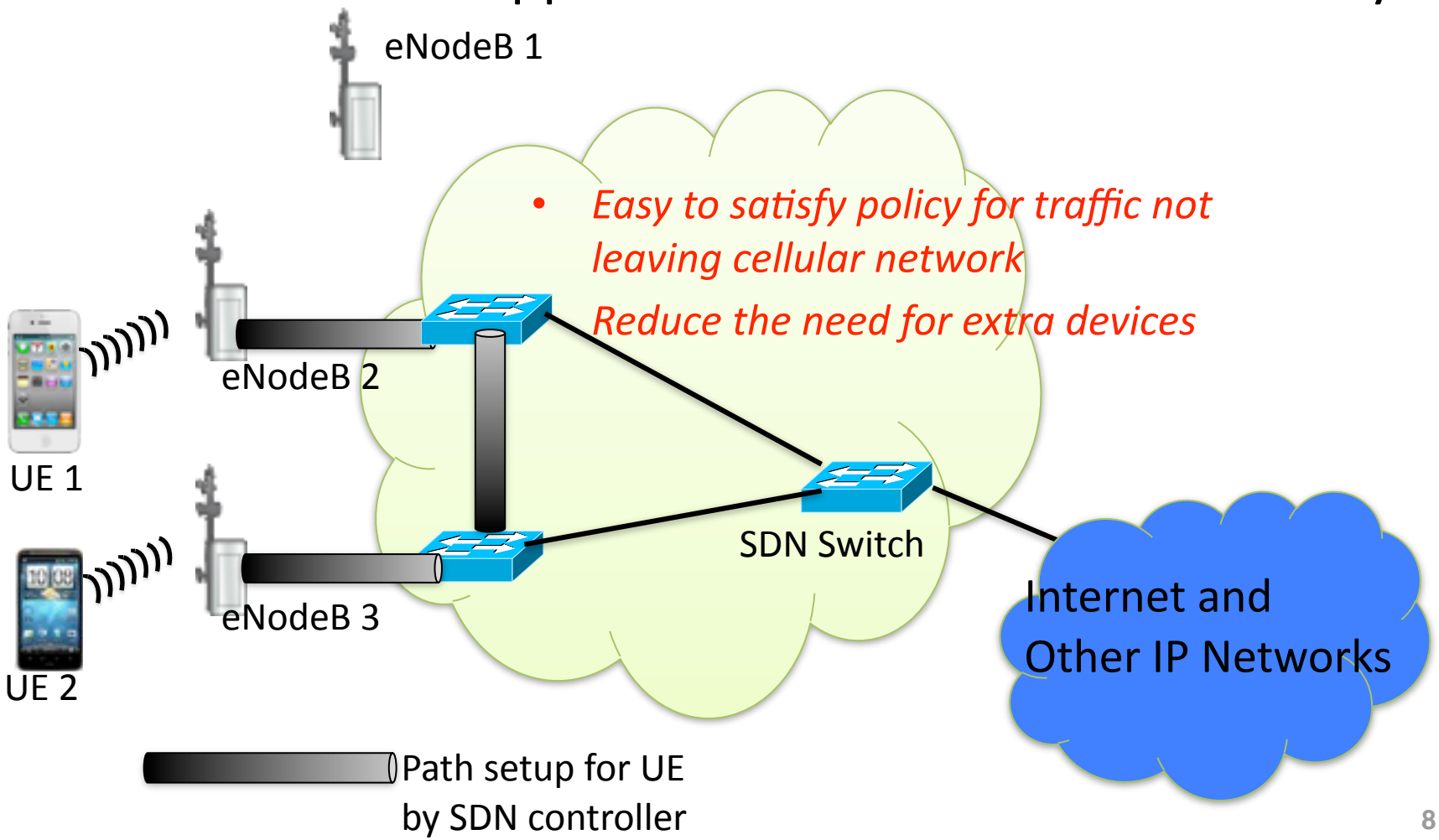
- SDN provides fine grained packet classification and flexible routing



- *Easy to control flow to middleboxes for content adaptation, echo cancellation, etc*
- *Reduce traffic to middleboxes*

Flexible Middlebox Support (Cont'd)

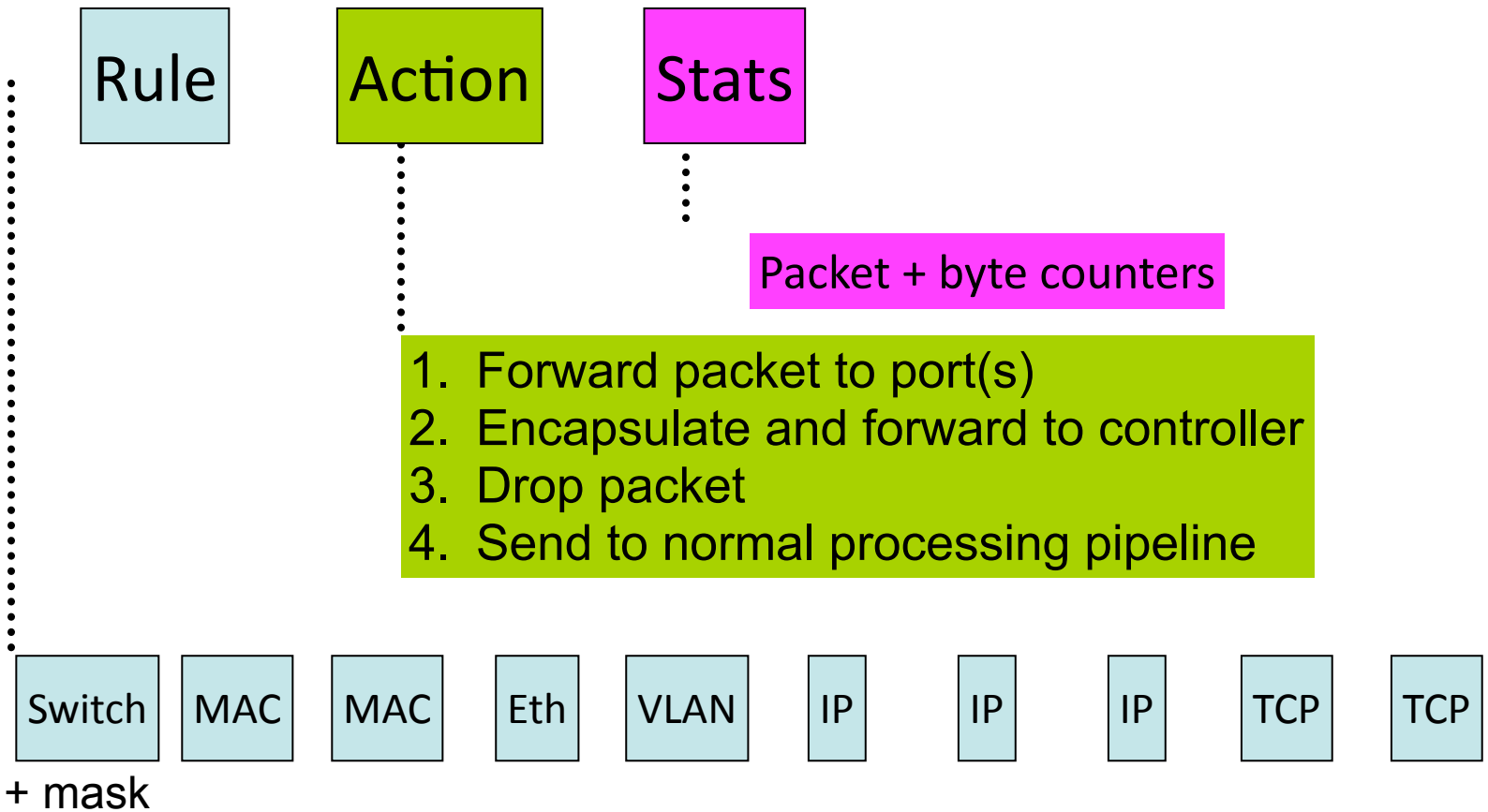
- SDN switch can support some middlebox functionality



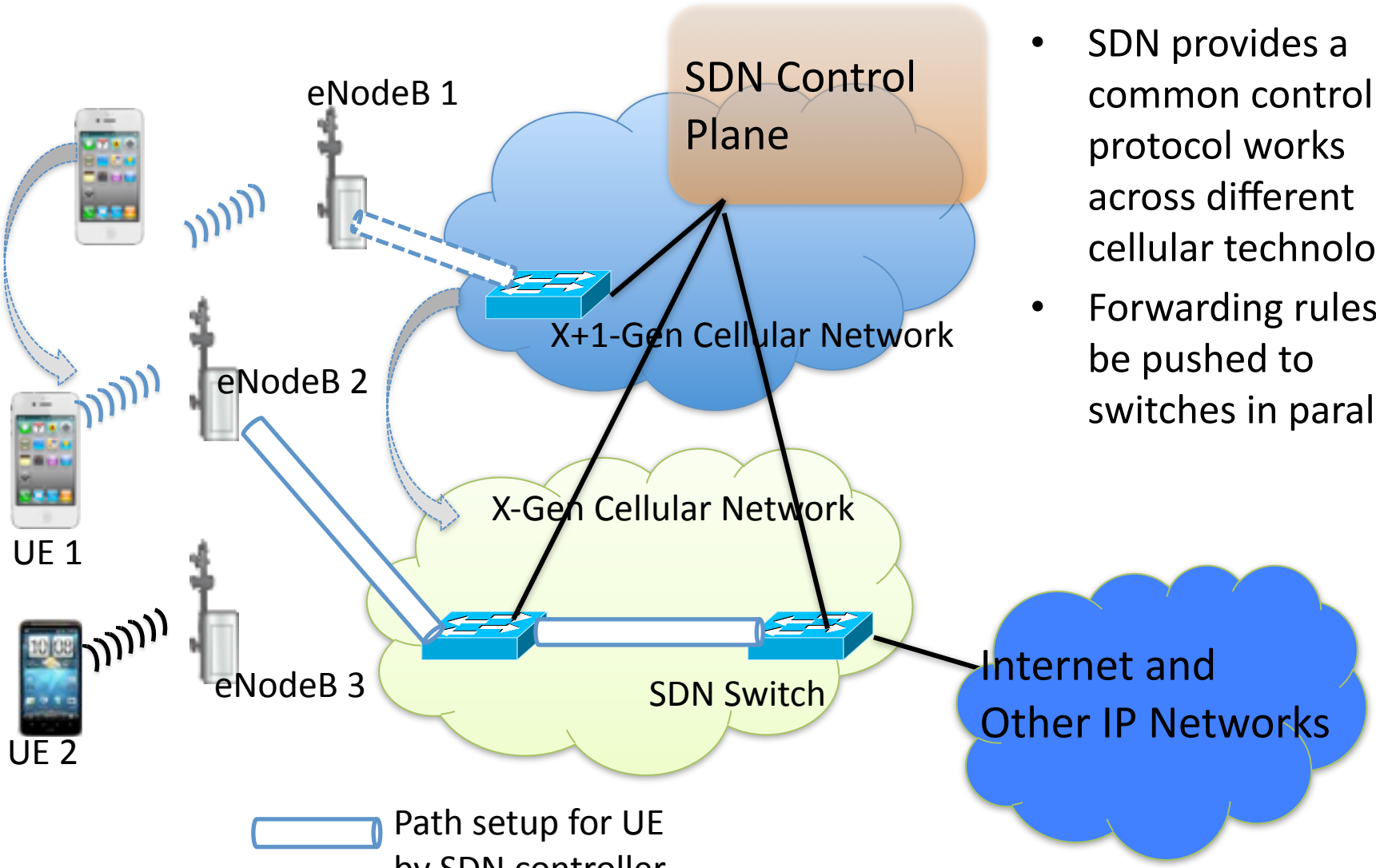
- *Easy to satisfy policy for traffic not leaving cellular network*
- *Reduce the need for extra devices*

Monitoring for Network Control & Billing

- Packet handling rules in SDN switches can efficiently monitor traffic at different level of granularity

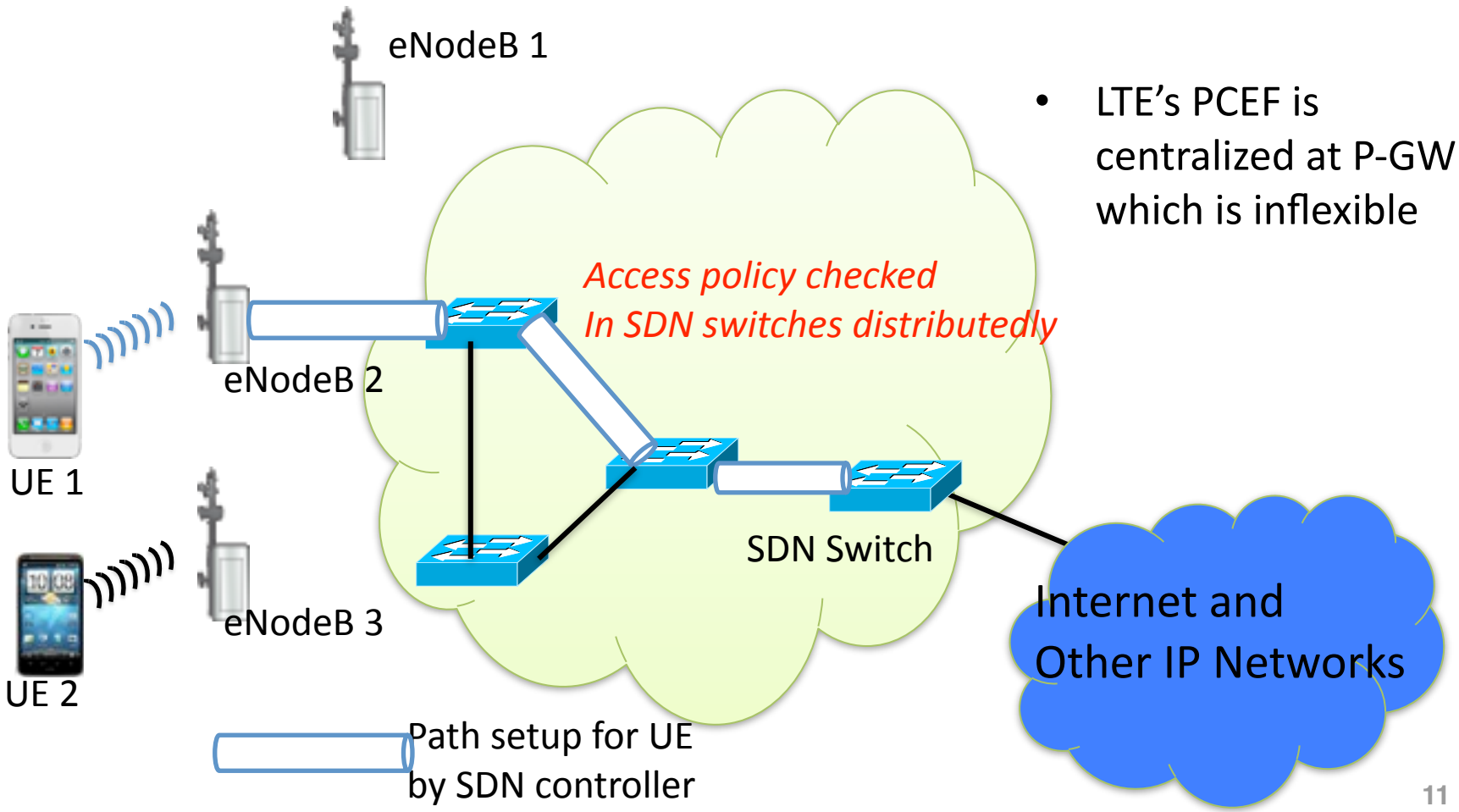


Seamless Subscriber Mobility



- SDN provides a common control protocol works across different cellular technologies
- Forwarding rules can be pushed to switches in parallel

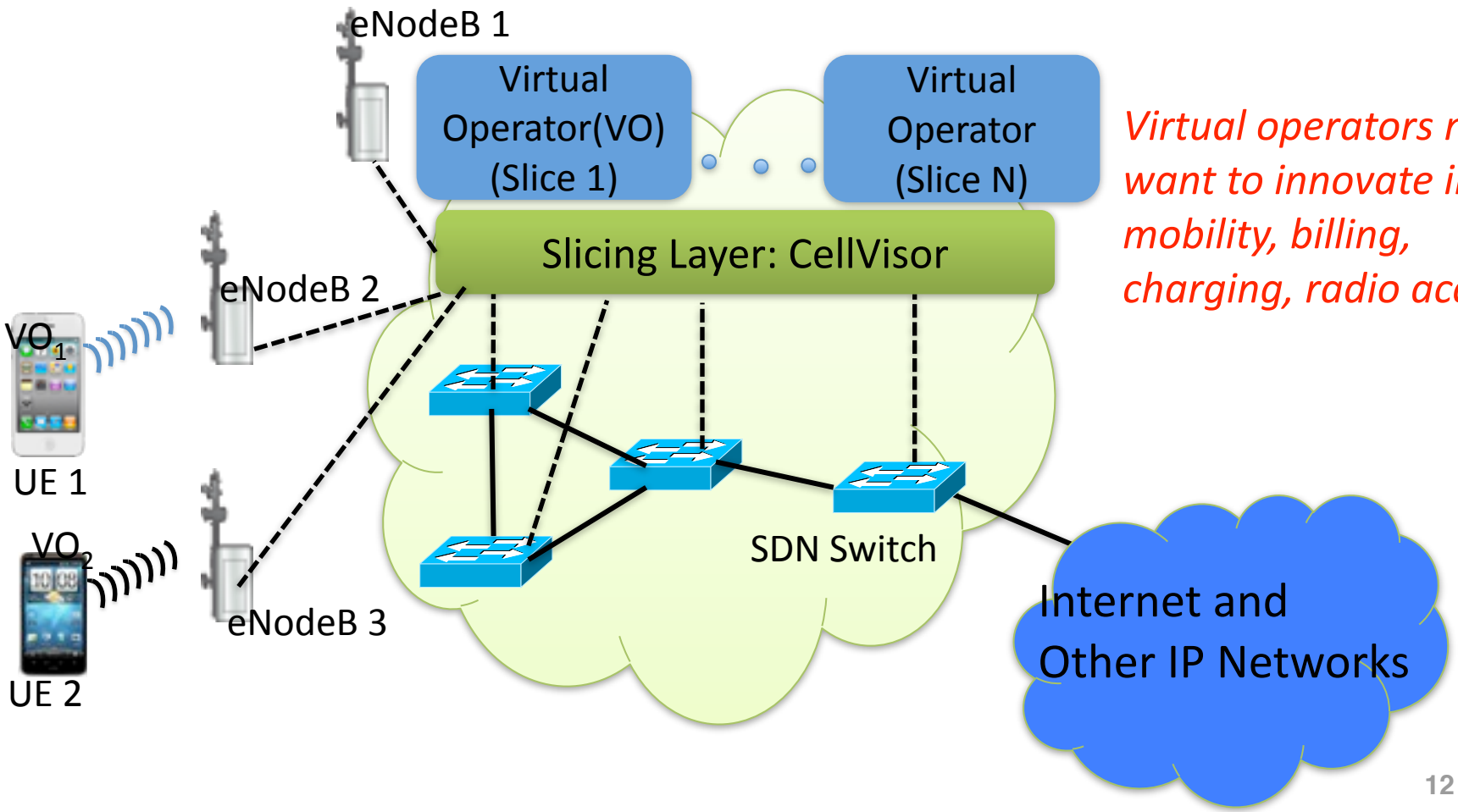
Distributed QoS and ACL Enforcement



- LTE's PCEF is centralized at P-GW which is inflexible

Virtual Operators

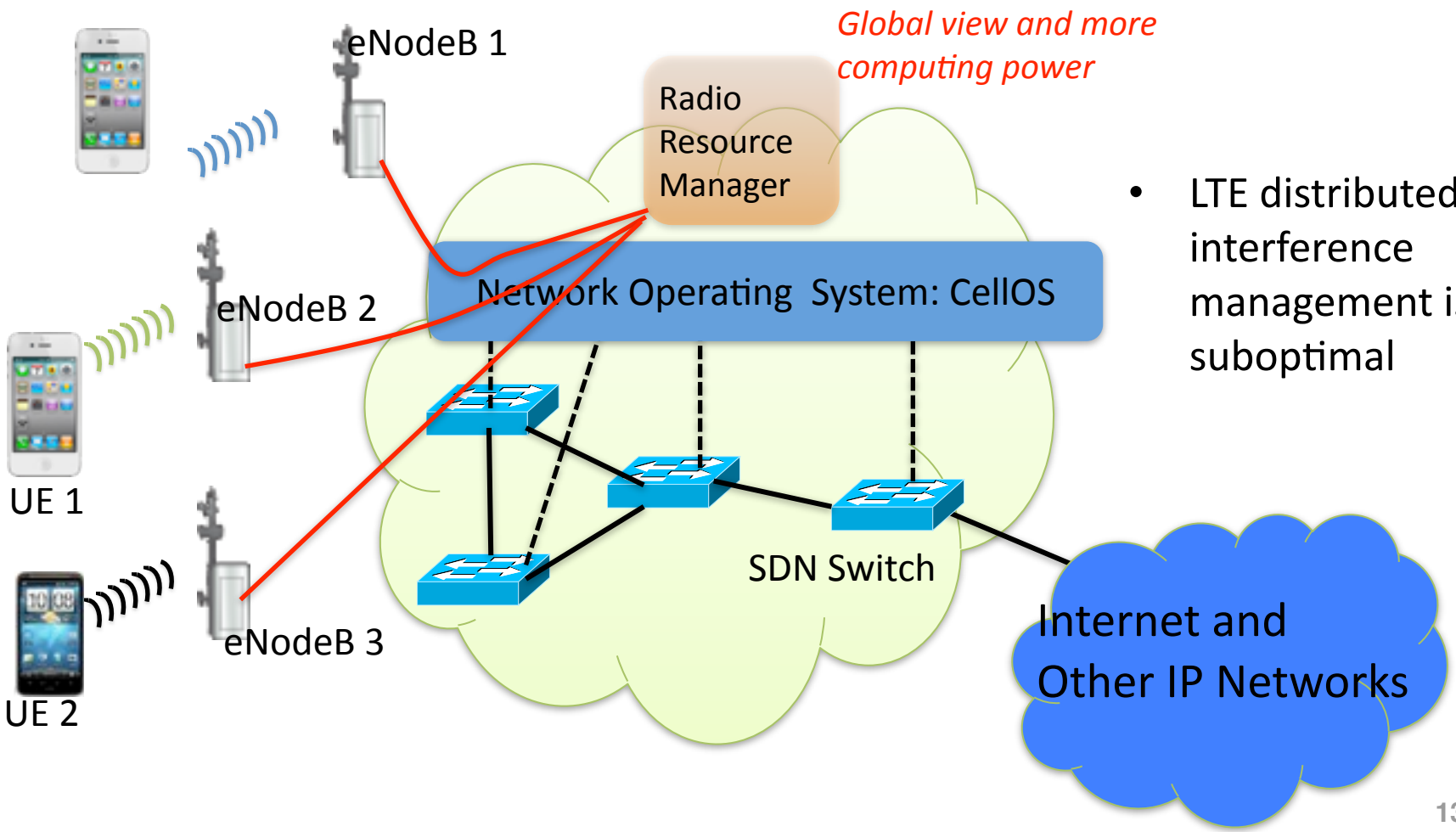
- Flexible network virtualization by slicing flow space



Virtual operators may want to innovate in mobility, billing, charging, radio access

Inter-Cell Interference Management

- Central base station control: better interference management

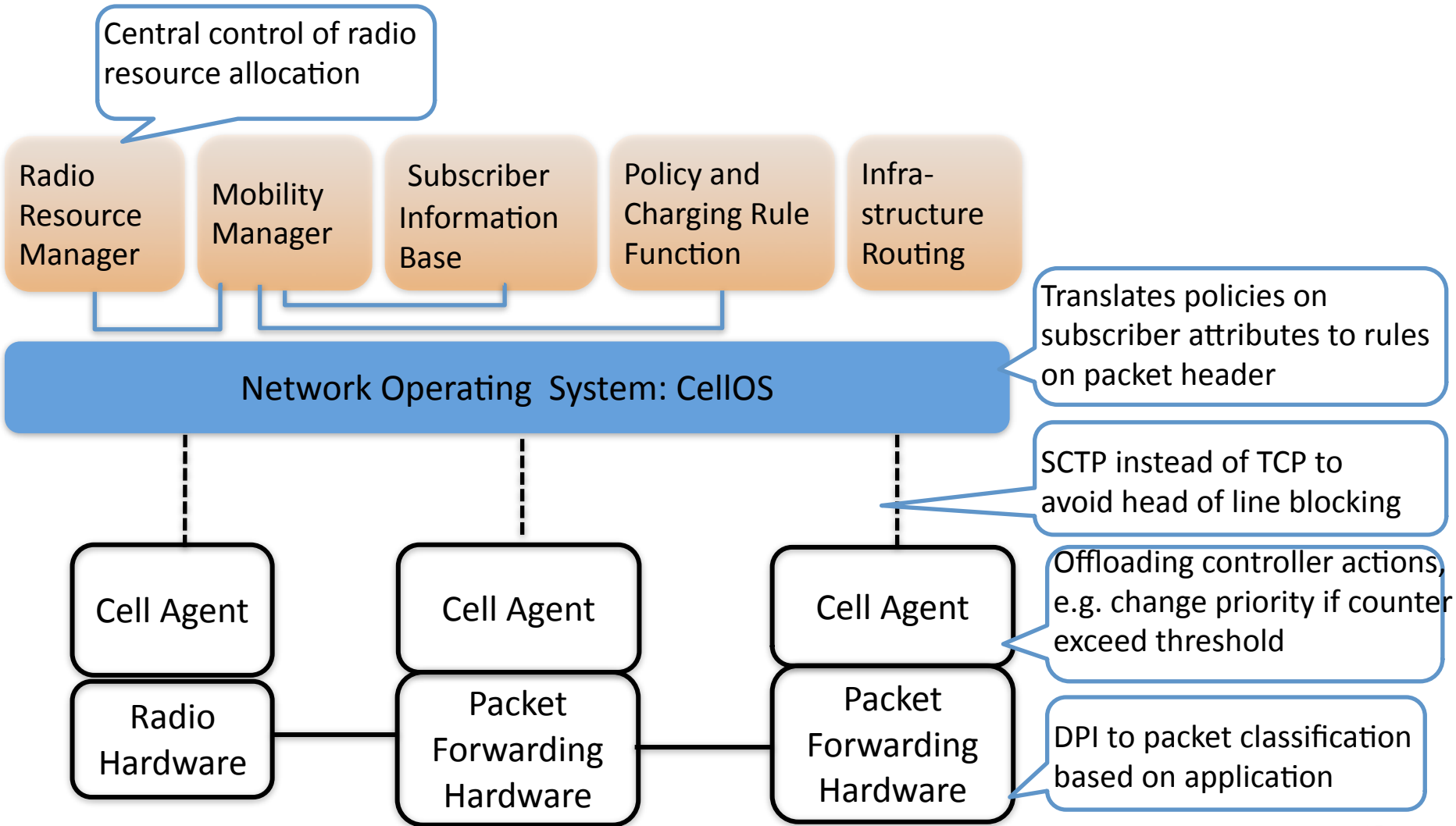


- LTE distributed interference management is suboptimal

CellSDN Architecture

- CellSDN provides scalable, fine-grain real time control with extensions:
  - Controller: *fine-grain* policies on subscriber attributes
  - Switch software: local control agents to improve control plane *scalability*
  - Switch hardware: *fine-grain* packet processing to support DPI
  - Base stations: remote control and virtualization to enable flexible *real time* radio resource

CellSDN Architecture (Cont'd)



Related Work

- Stanford OpenRoads
  - Introduced openflow, FlowVisor, SNMPVisor to wireless networks
- Stanford OpenRadio
  - Programmable cellular data plane
- NEC base station virtualization
  - Slicing radio resources at the MAC layer
- Ericsson CloudEPC
  - Modify LTE control plane to control openflow switches

Conclusion and Future Work

- CellSDN advantages:
  - Simple and easy to manage
  - Simple and easy to introduce new services
  - Easy to inter-operate with other wireless technologies
- Future work: detailed CellSDN design

Thank you!

CellSDN Virtualization