

VoLTE*: A Lightweight Voice Solution to 4G LTE Networks

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HotMobile'16

Voice: Essential Cellular Service

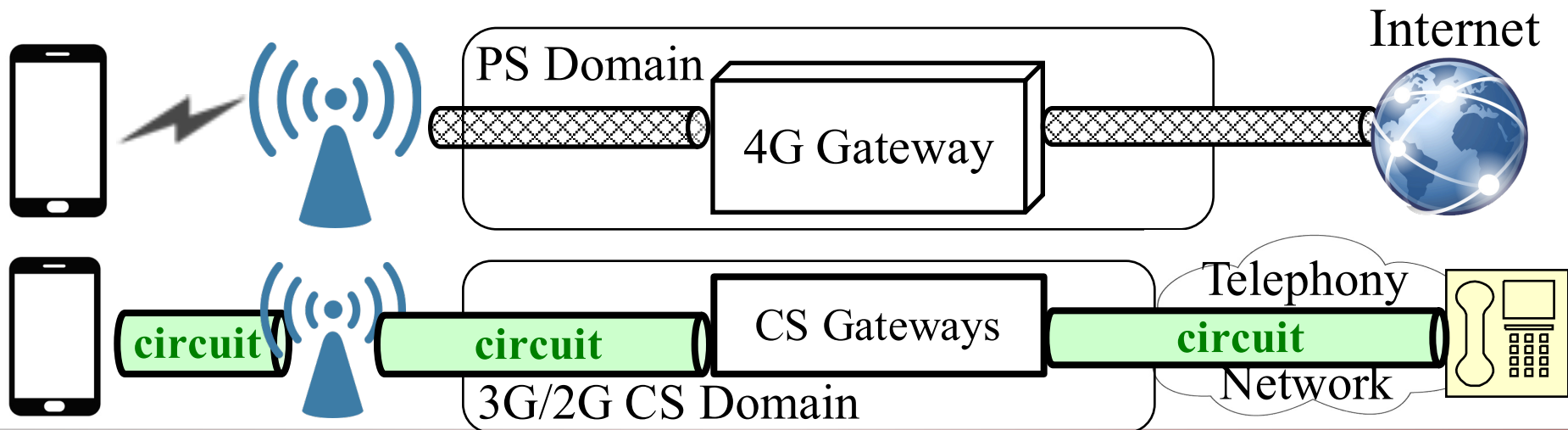


- 30+ years (from 1G to 4G)
- Full coverage:
 - All carriers
 - Almost all users



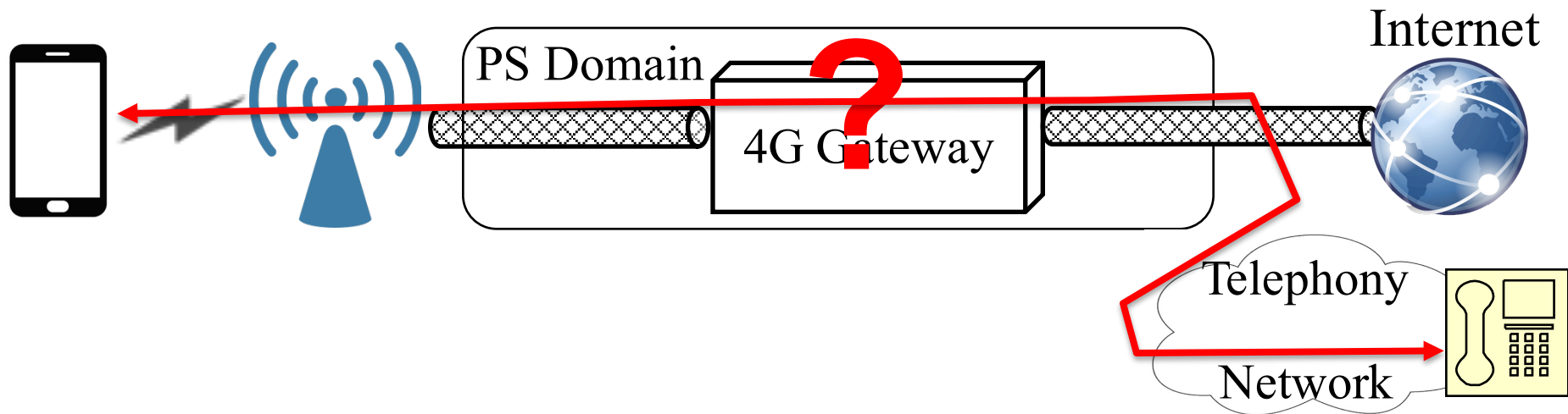
Voice Evolution in 4G LTE

- 4G LTE: packet-switched (PS) only
 - Traditional voice: circuit-switched (CS) for carrier-grade quality



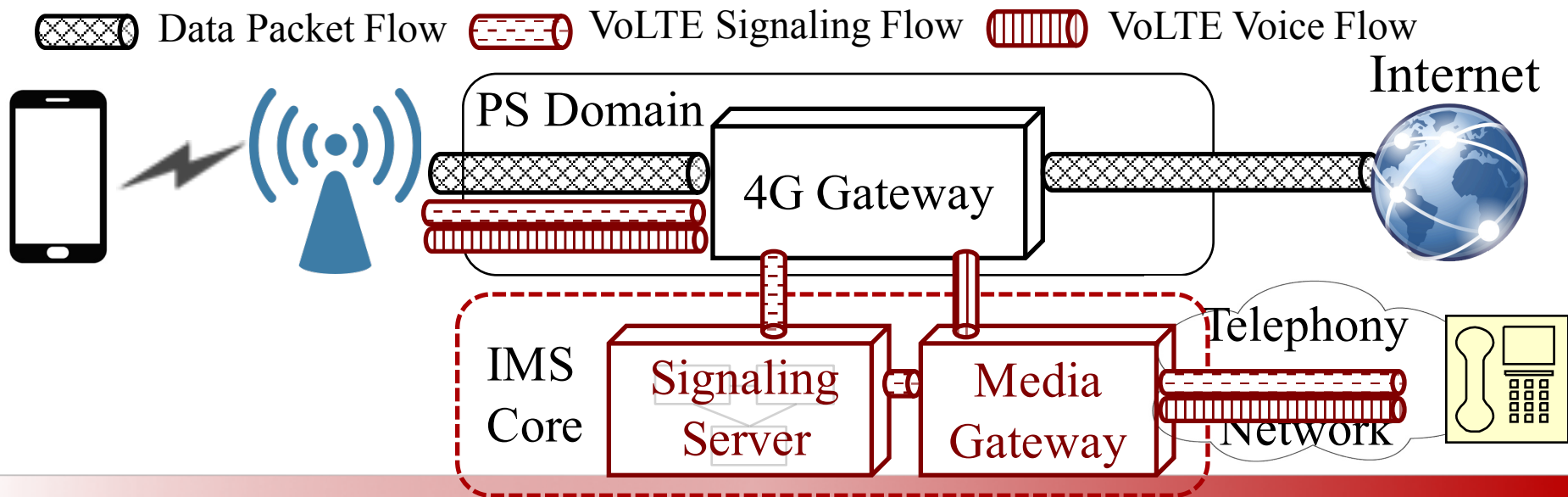
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VoLTE: Voice over LTE

- Standard solution (cellular carrier industry)
- Carry voice in packets (aka. VoIP)



The Good

- Successor of cellular voice for LTE users
 - Comparable carrier-grade quality
- Enable rich communication
 - Voice/video calls, video conferencing, HD voice ...

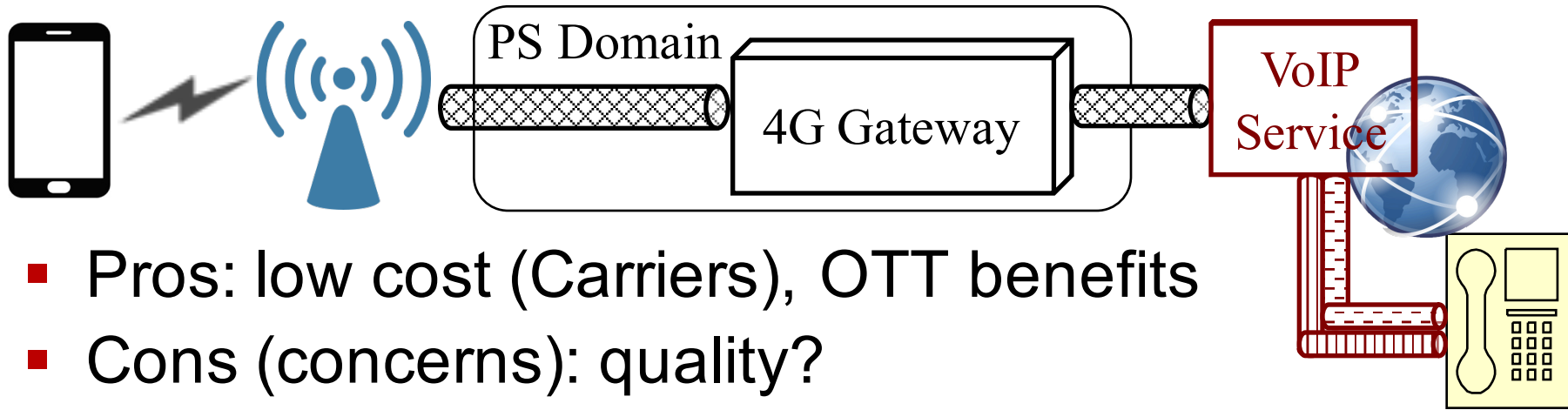
But, The Ugly

- Deployment pain
 - 20 out of 480 LTE carriers support VoLTE (Oct 2015)
 - Delayed rollout until late 2014 in US carriers (AT&T, Verizon, T-Mobile)
 - No nationwide deployment yet
- IP Multimedia Subsystem (IMS): complex and costly
 - Proposed in 2002
 - Little progress until VoLTE



Alternative to VoLTE

- VoIP: on-the-top (OTT) mobile data app
 - Hangouts, Skype, Line, Viber, Whatsapp, ...



- Pros: low cost (Carriers), OTT benefits
- Cons (concerns): quality?

Q1: VoLTE or no VoLTE?

Q2: Alternative lightweight and cost-effective solution?

VoLTE or No VoLTE?

Comparison VoLTE and VoIP over 4G LTE

- Deployment cost
- Operation complexity
- Voice quality

Deployment and Operation

VoLTE

- Deploy IMS
- Upgrade 4G infrastructure
 - BS, PS gateways, and OAM (Operation, Administration, management) subsystem
 - Upgrade firmware/OS of mobile devices to support carrier-specific VoLTE

VoIP over 4G LTE

- + No new deployment/upgrade
 - Reuse 4G PS infrastructure
 - Reuse VoIP service provider's infrastructure
 - Existing Cellular – VoIP translation
 - No upgrade on mobile devices
- Concerns
 - Quality?
 - Compatibility with legacy voice

Voice Call Quality

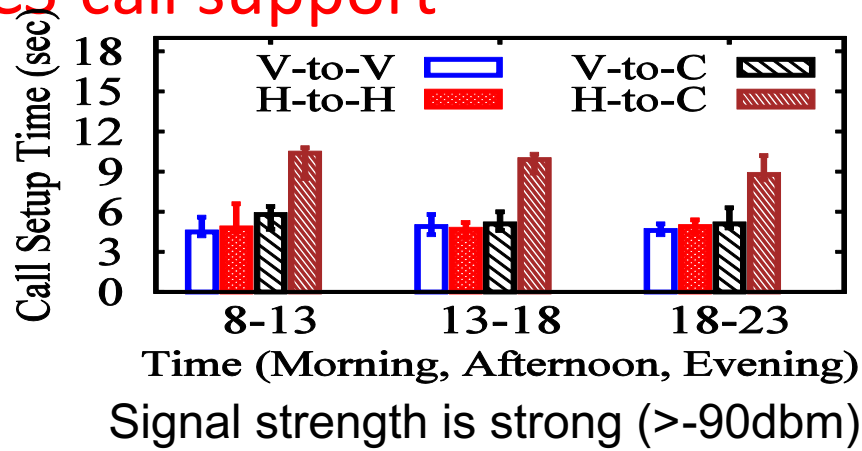
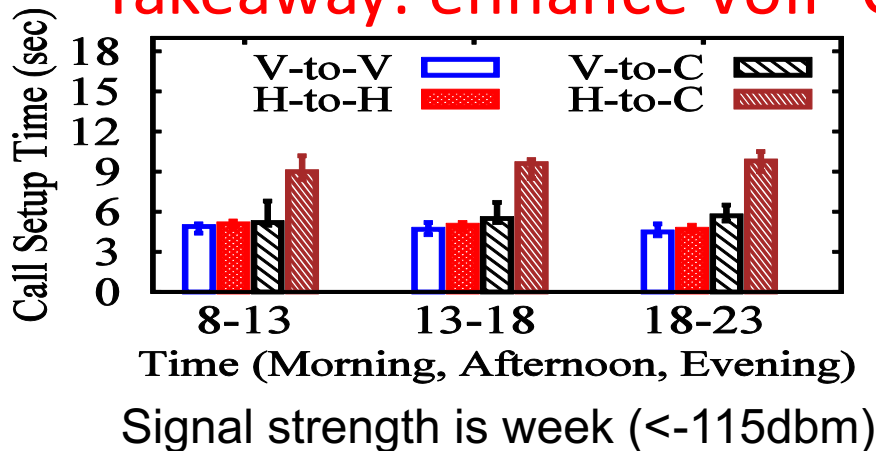
- Small-scale assessment
 - 10 static locations, 20 routes, 50 participants
 - VoIP: Google Hangouts
 - Call setup time
 - Voice call quality (subjective)
 - Call drop rate
- Note: VoLTE at early deployment (12/2014 – 02/2015)

Call Setup time

- **Comparable performance except VoIP-CS case**

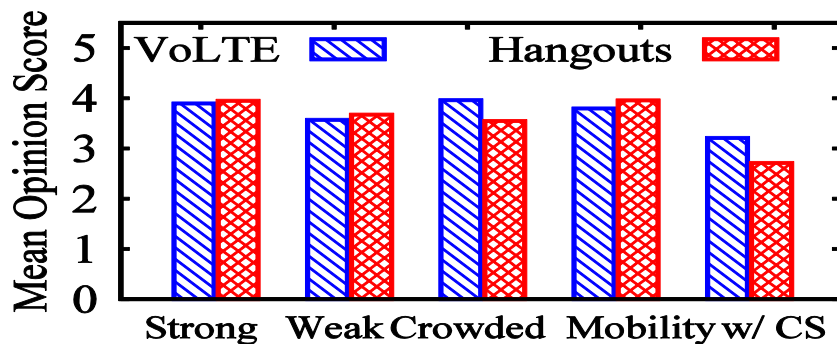
- Caller-to-Callee: V-to-V, V-to-C, H-to-H, H-to-C
- V: VoLTE; C: CS; H: Hangout

- **Takeaway: enhance VoIP-CS call support**

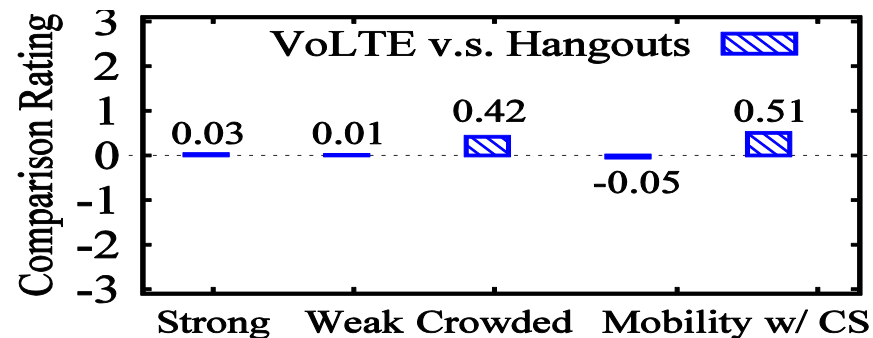


Voice Call Quality

- Record calls and offline listening
 - ITU standard metrics: ACR (Absolute Category Rating) and CCR (Category Rating Comparison)
- Comparable voice quality (VoLTE win: congestion & CS)



ACR: Absolute Category Rating



CCR: Category Rating Comparison

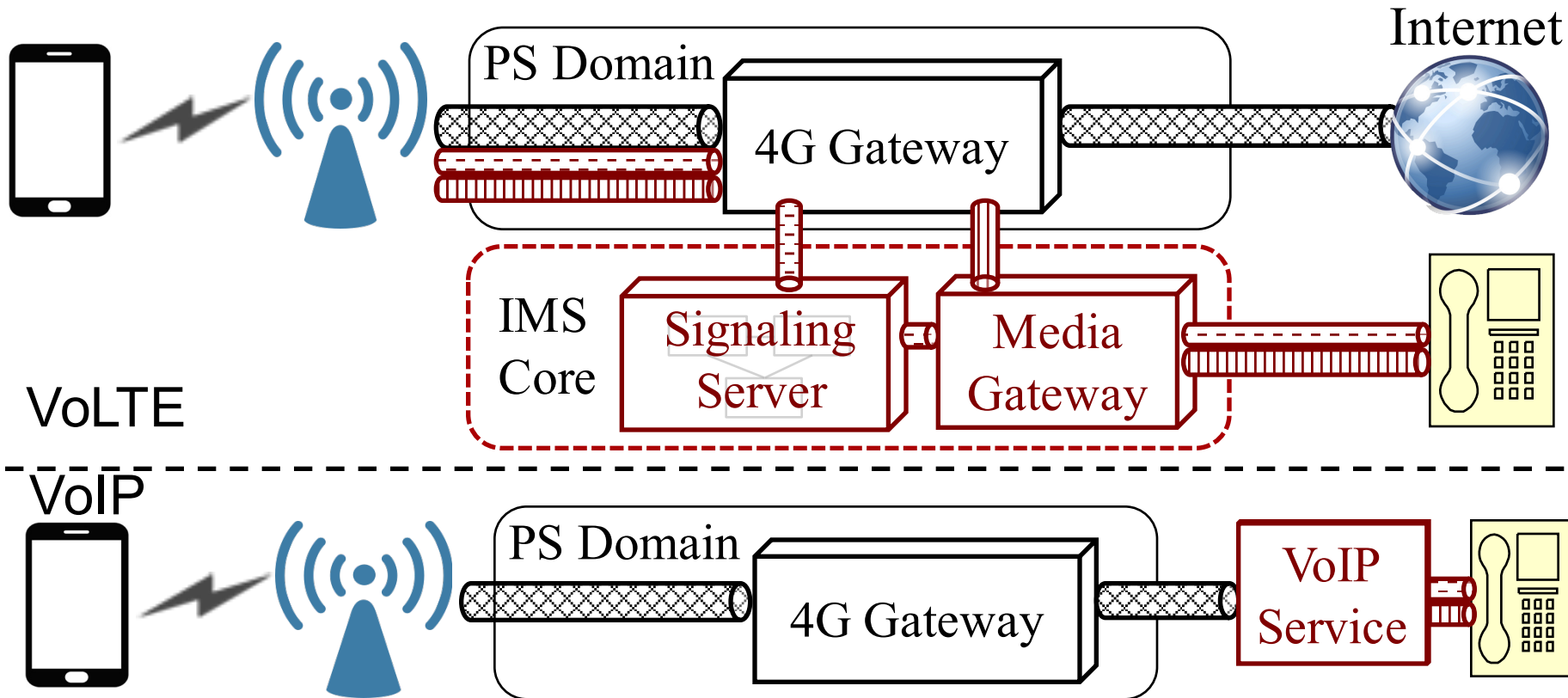
Call Drop Rate

Scenarios	VoLTE	Hangout
Static (strong/weak coverage)	0%	0%
Mobility (4G only, strong → weak)	0%	0.5%
Mobility (4G → 2G/3G)	8%	4%

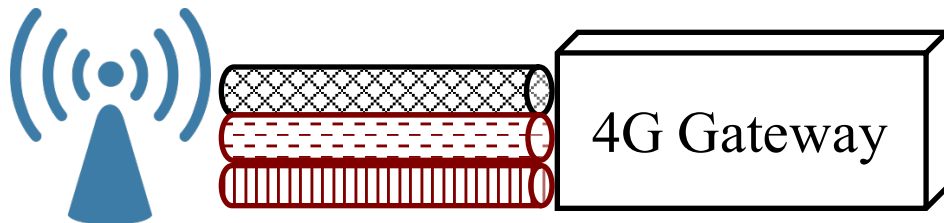
- **Comparable in static and most mobility**
- **VoLTE (4G-2G/3G): even worse** (implementation issues on SRVCC) [mobicom'15]

[mobicom'15] Yunhan Jia, et.al, Performance Characterization and Call Reliability Problem Diagnosis for Voice over LTE

VoLTE's Advantage: High QoS Bearer



VoLTE's Advantage: High QoS Bearer

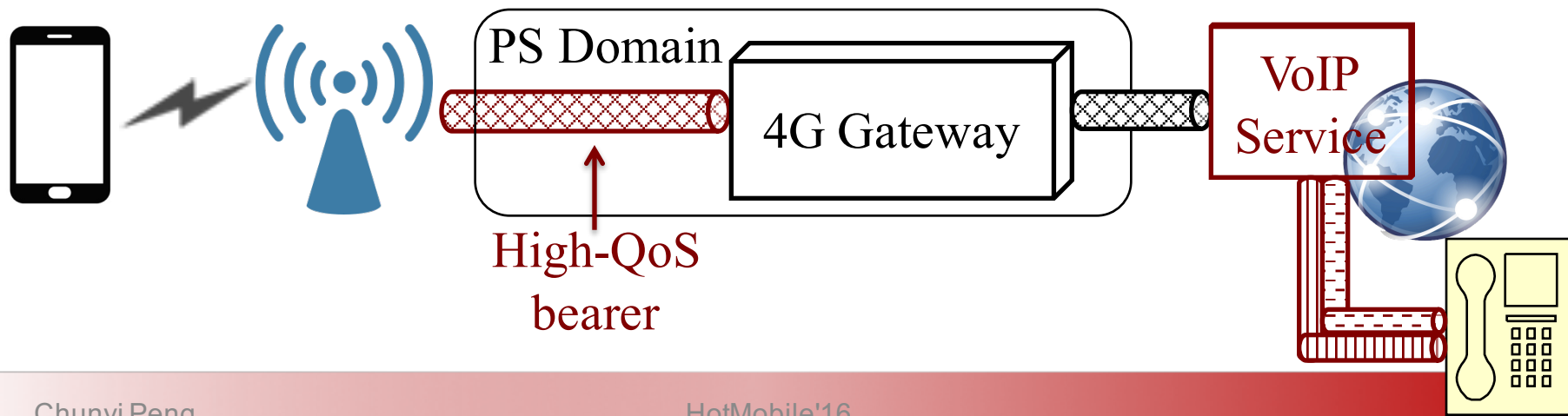


		Delivery	Priority
VoLTE Voice Bearer		Guaranteed-Bit-Rate	2
VoLTE Signaling Bearer		Best Effort	1 (highest)
Data Service Bearer		Best Effort	6-9

VoLTE*: Alternative Solution?

VoLTE*: A Lightweight Voice Solution

- Both good of VoIP and VoLTE
 - VoIP-centric: low cost on deployment and operation
 - High QoS bearer: call quality



VoLTE*: Voice Service Classes

- Apply different QoS profiles to VoIP packets in 4G LTE

Service Class	Description
First	Use highest QoS; quality is similar to VoLTE
Business	Always better than the best-effort QoS profile
Deluxe Economy	Better than best-effort when needed (e.g., congestion occurs)
Economy	best-effort

Modest Support

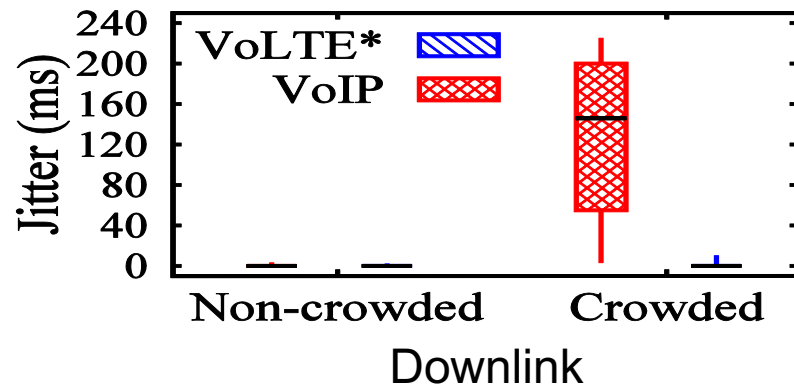
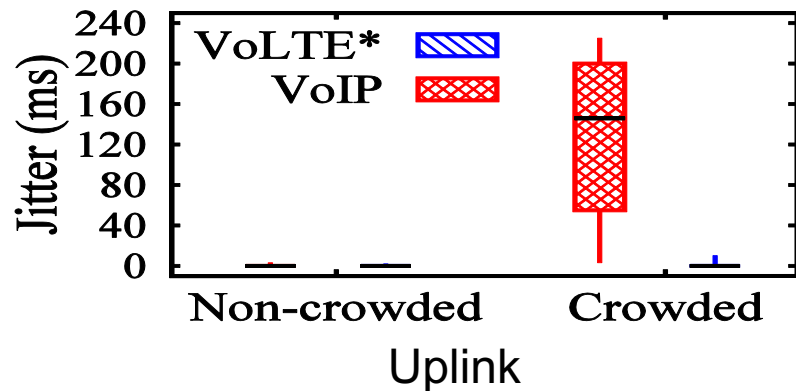
- Device: specify QoS profiles (service classes) for VoIP packets
- VoIP service providers: connect to the existing IPX used by carriers to ensure QoS
- While ***congestion*** occurs,
 - Upgrade QoS of VoIP packets if subscribing the plan (e.g., “Deluxe Economy”)

VoLTE*: Benefit all Parties

- **Carriers:** gain more revenue from priority voice service without deploying and operating IMS core
- **VoIP service providers:** more daily active users – e.g., have more mobile ad. revenue
- **Users:** better service with cheaper fare

VoLTE* Evaluation in Crowded Areas

- Hacking: VoLTE signaling bearer reused to carry VoIP traffic [ccs'15]
- VoLTE*: *congestion-resistant + lightweight*



[ccs'15] Chiyu Li, et.al Insecurity of Voice Solution VoLTE in LTE Mobile Networks

Possible Downsides

- Technical drawbacks (LTE Radio)
 - No VoLTE-like energy-saving mechanism
 - No VoLTE-like coverage enhance mechanism
- Non-Technical drawbacks (business concerns)
 - Carriers may not want to share customers with VoIP service providers
 - Carriers may not easily deploy new multimedia services

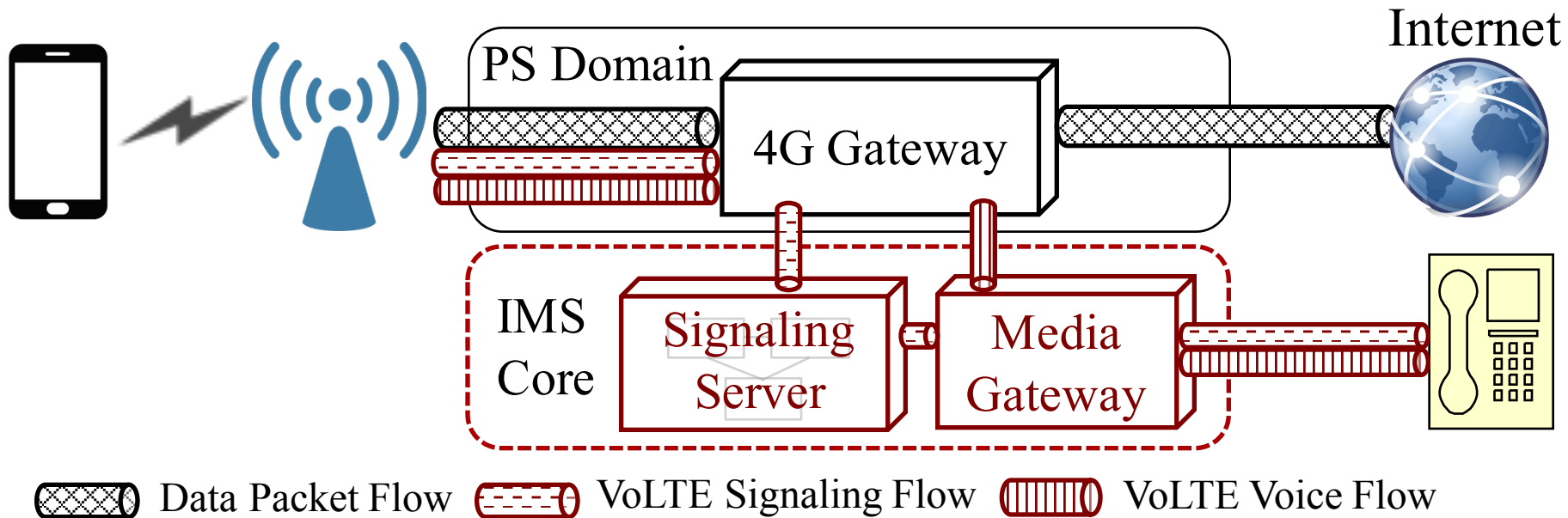
Summary

- VoLTE*: Both good of VoIP and VoLTE
 - VoIP: Easy deployment/upgrade and low cost
 - VoLTE: call quality
- VoLTE (vs. VoIP)
 - Comparable or slightly better quality
 - But, may not worth the efforts
- Promises of VoLTE* deployment
 - Room for VoLTE (not replacement)
 - Roles of VoIP provider and cellular carriers

Thank you! Questions?

Open Issues in VoLTE*

- Interplay of VoIP (external) and cellular CS domain
 - API, translation
- Migration from 4G to 2G
 - Poor support for data (VoIP) in 2G
- Voice billing (different QoS)



VoLTE*: Four Service Classes

- Apply different QoS profiles to VoIP packets in 4G LTE

Service Class	Description
First	Use highest QoS; quality is similar to VoLTE
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Deluxe Economy	Better than best-effort when needed (e.g., congestion occurs)
Economy	best-effort

VoLTE*: Only Requires Essential Support from Infrastructure

- Allow devices to specify QoS profile for VoIP packets
 - It is a operational policy issue not a technical problem
 - QoS negotiation is a mandatory procedure by standards
- Allow VoIP service providers to connect to the existing IPX used by carriers in practice
 - To ensure QoS
- While **congestion** occurs,
 - 4G infrastructure will upgrade QoS of VoIP packets if users subscribe the service class “Deluxe Economy”

VoLTE*: Benefit all Parties

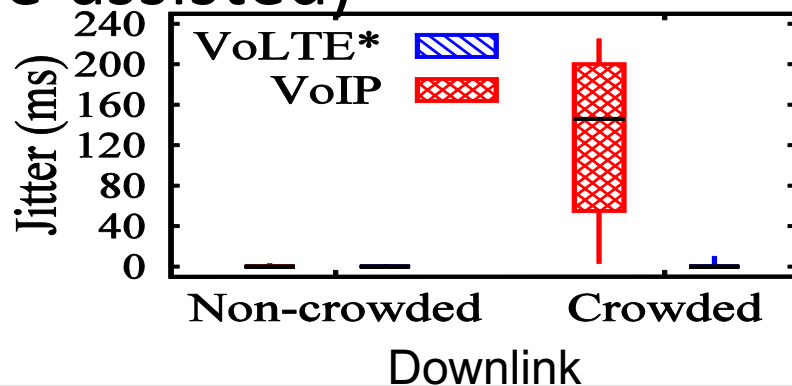
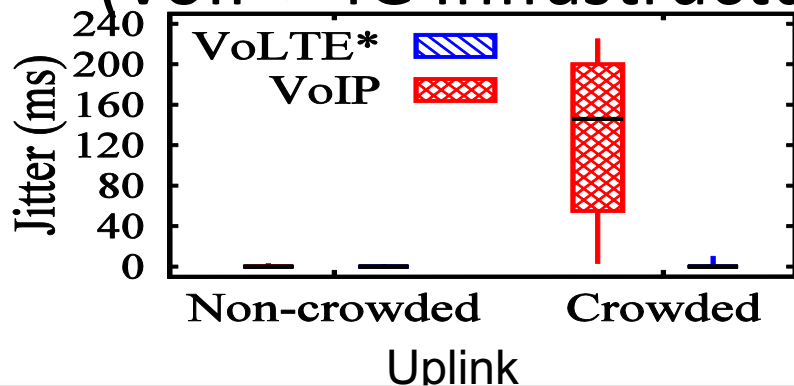
- **Users** have better service with cheaper fare

Charge (cent/min)		T-Mobile	AT&T	Verizon	Sprint
Cellular Call	450 mins	6.7	8.9	7.8	6.7
	900 mins	3.3	4.4	3.9	3.3
Hangouts	450/900 mins	1.2	1.2	0.6	0.9

- **Carriers** get more revenue from priority service without deploying and operating IMS core
 - **VoIP service providers** have more daily active users – e.g., have more mobile ad revenue
- (Surveyed on Sep. 2015)

Evaluation of VoLTE* in Crowded Areas

- Comparison of Jitter of normal VoIP and VoLTE* (VoIP+ 4G Infrastructure-assisted)



- VoLTE* is a **congestion-resistant** voice service, similar to VoLTE; but VoLTE* is **lightweight and benefit all parties**