

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

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HotMobile'16

# Voice: Vital Cellular Service

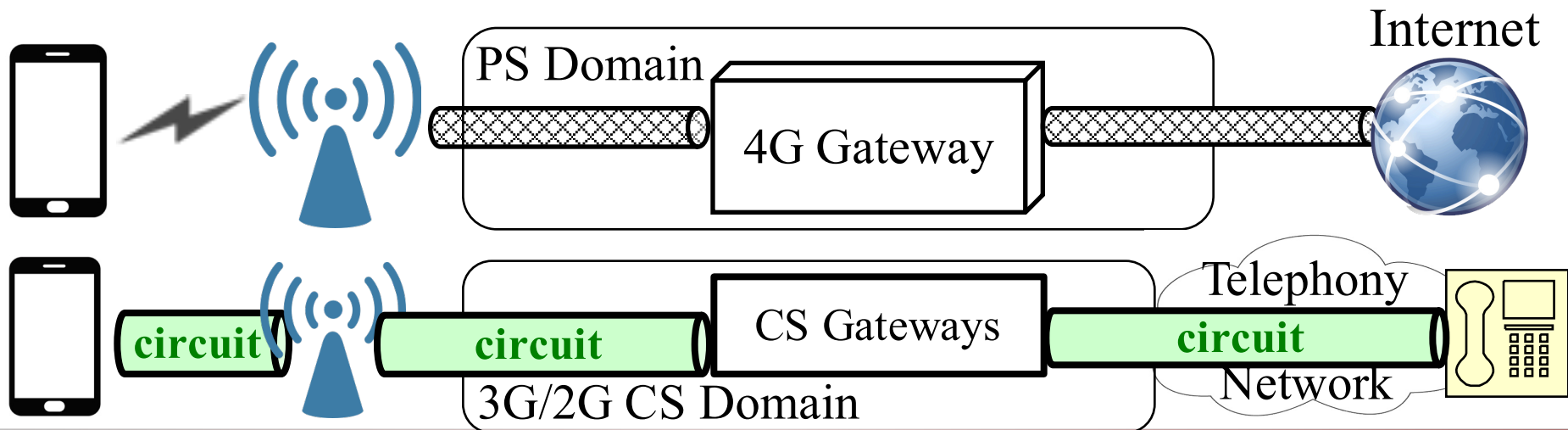


- 30+ years (from 1G to 4G)
- Full coverage:
  - All carriers
  - Almost all users



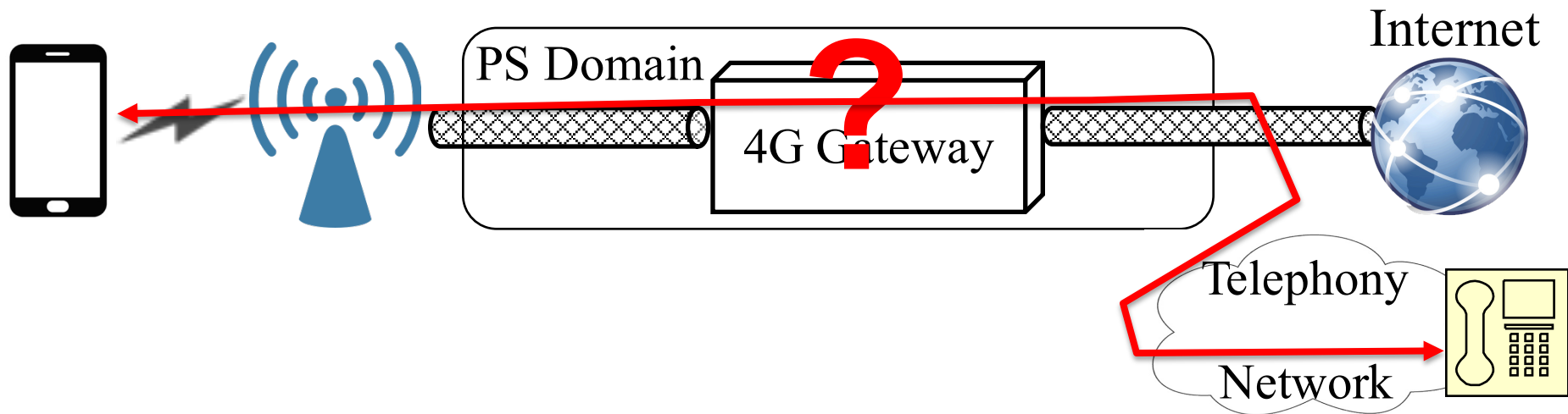
# Voice Revolution in 4G LTE

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



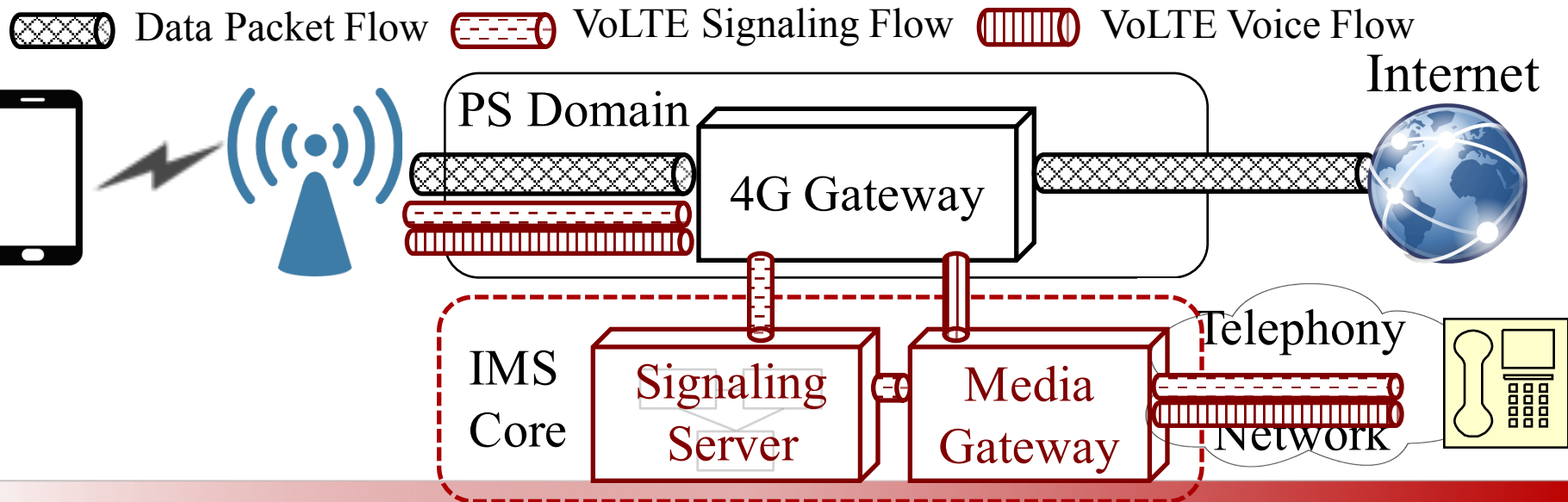
# Voice Evolution in 4G LTE

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



# VoLTE: Voice over LTE

- Standard solution (industry)
- Basic idea: carry voice in packets (aka. VoIP)



# The Good and The Ugly

- Continue to offer cellular voice for 4G LTE
  - Comparable quality, compatible with CS calls
- Enable rich communication (video conferencing, HD voice)
- But, strenuous deployment
  - 20 out of 480 LTE carriers support VoLTE (Oct 2015)
  - Delayed rollout until late 2014 in US (AT&T, Verizon, T-Mobile)
    - No nationwide deployment yet
  - Deployment cost and operation complexity

# This Talk

- Q1: VoLTE or no VoLTE?
- Q2: Alternative voice solution?

# VoLTE or No VoLTE?

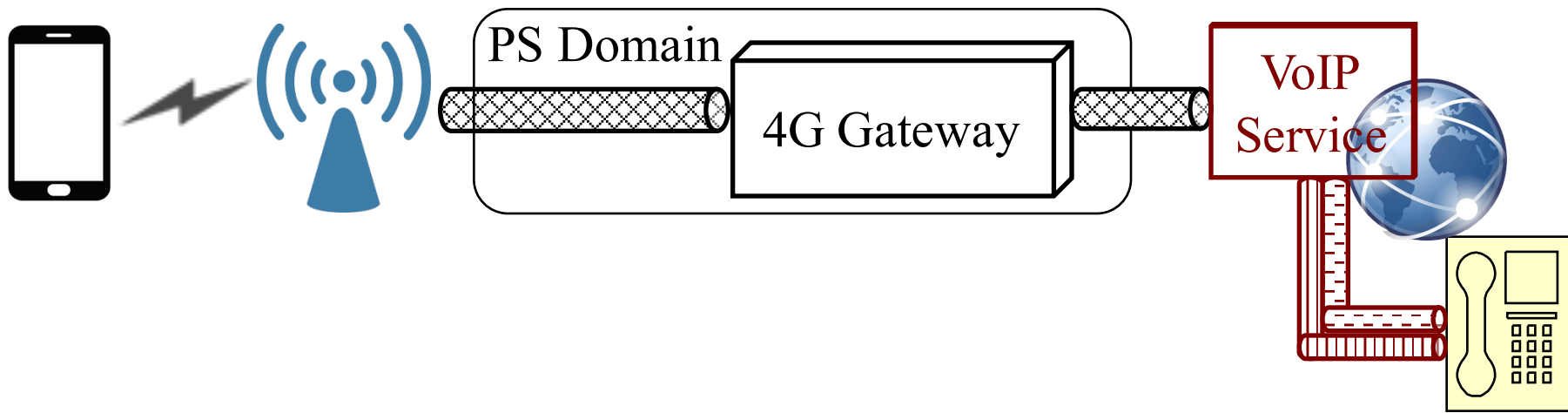
## Comparison VoLTE and VoIP over 4G LTE

- Deployment cost
- Operation complexity
- Voice quality



# VoIP: Alternative to VoLTE

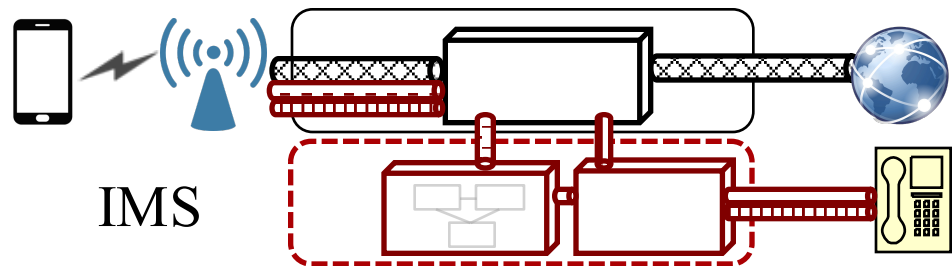
- VoIP: on-the-top (OTT) mobile data app
  - Hangouts, Skype, Line, Viber, Whatsapp, ...



# Deployment and Operation

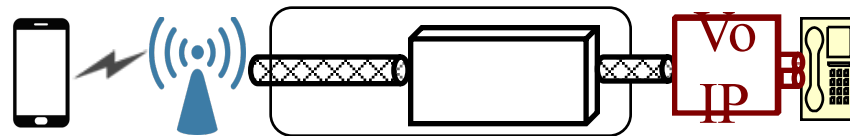
## VoLTE (high cost)

- Deploy IMS
- Upgrade 4G infrastructure
- Upgrade device firmware/OS
- Require complex operations



## VoIP over 4G LTE (low cost)

- + No new deployment/upgrade
  - Reuse 4G PS infrastructure
  - Reuse VoIP service provider's infrastructure
  - No upgrade on mobile devices
- + Operations like PS data



# But, VoIP's Cons

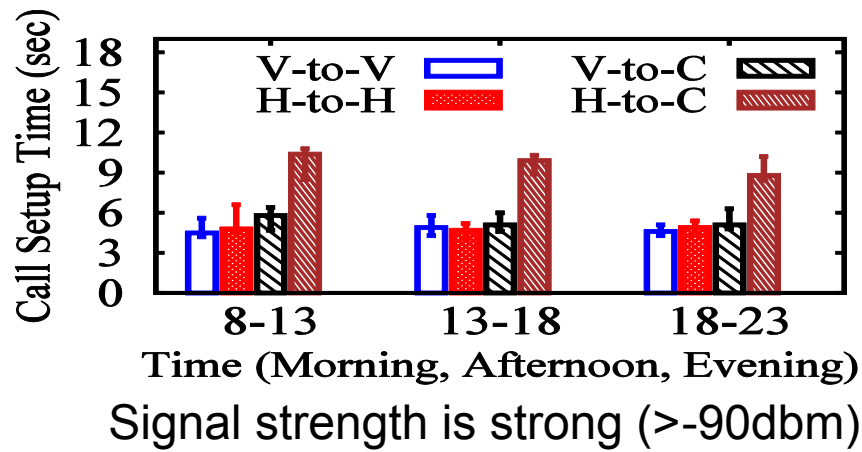
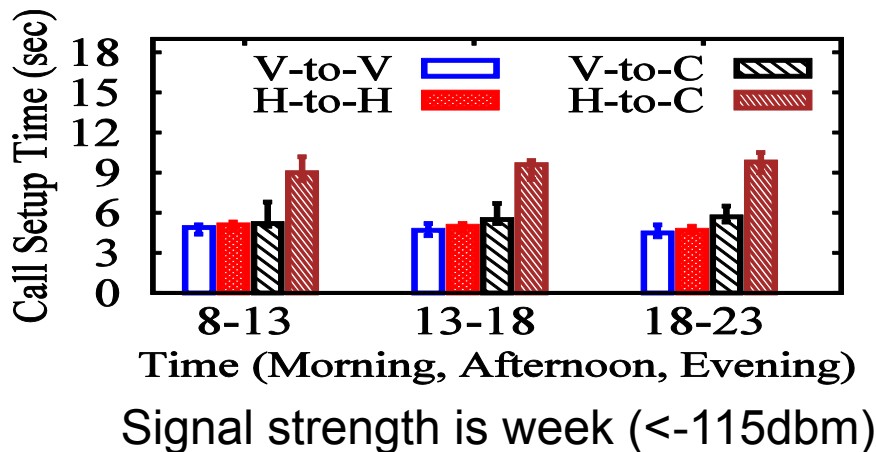
- Voice call Quality?
- Compatibility with legacy cellular voice?

# Voice Call Quality

- Small-scale assessment
  - 10 static locations, 20 routes, 50 participants
  - VoIP: Google Hangouts
  - VoLTE over US carriers (at early rollout)
- Metrics
  - Call setup time
  - Voice call quality scores (subjective)
  - Call drop rate

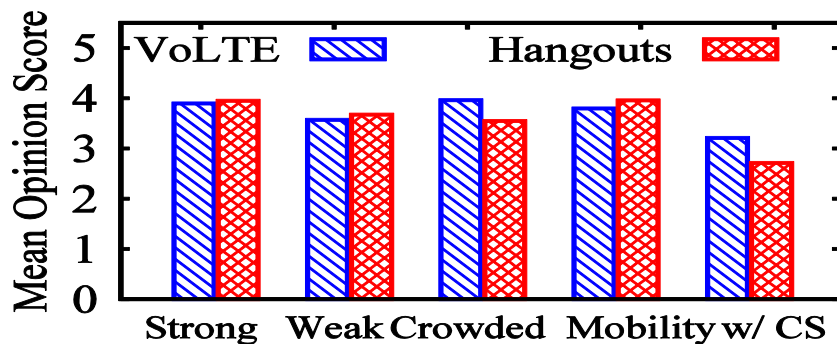
# Call Setup time

- **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

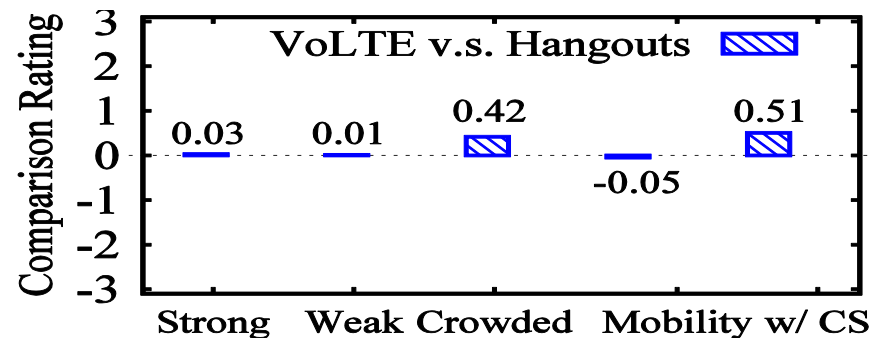


# Subjective Voice Call Quality

- Record calls and offline listening (50 participants)
  - ITU standard metrics: ACR (Absolute Category Rating) and CCR (Category Rating Comparison)
- Comparable voice quality (VoLTE wins: heavy load & CS)



ACR: Absolute Category Rating



CCR: Category Rating Comparison

# Call Drop Rate

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

- **Comparable in static and most mobility cases**
- **VoLTE (4G-2G/3G): surprisingly worse** due to implementation issues [mobicom'15]

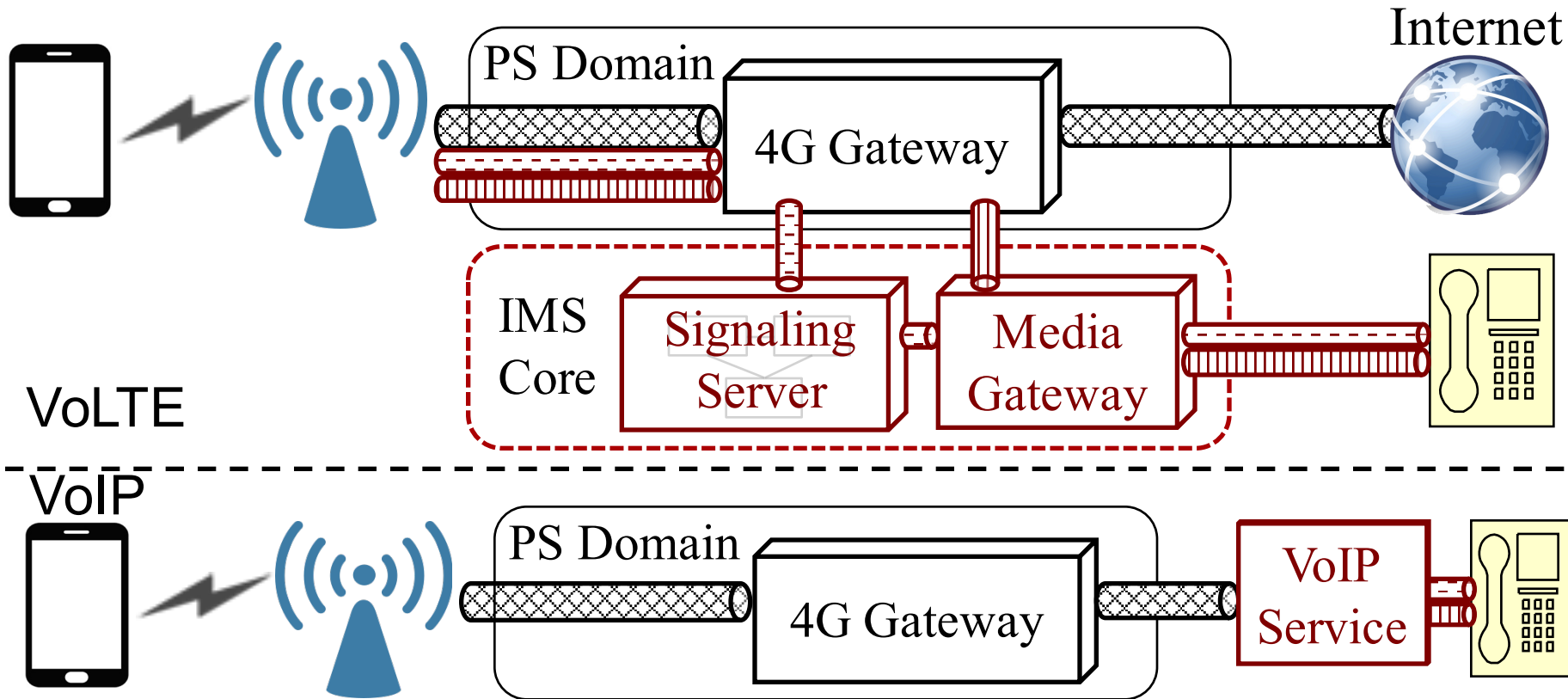
[mobicom'15] Yunhan Jia, et.al, Performance Characterization and Call Reliability Problem Diagnosis for Voice over LTE

# VoLTE\*: Alternative Lightweight Solution?

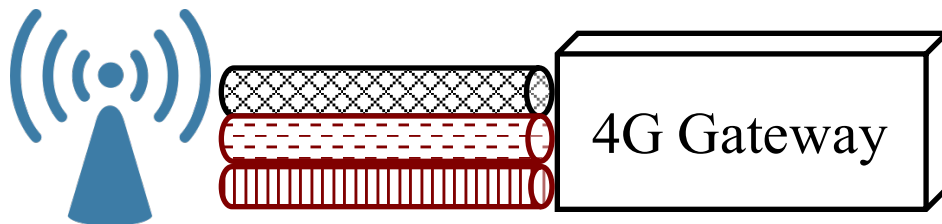
Tradeoff between cost and quality



# VoLTE's Weapon: High QoS Bearer



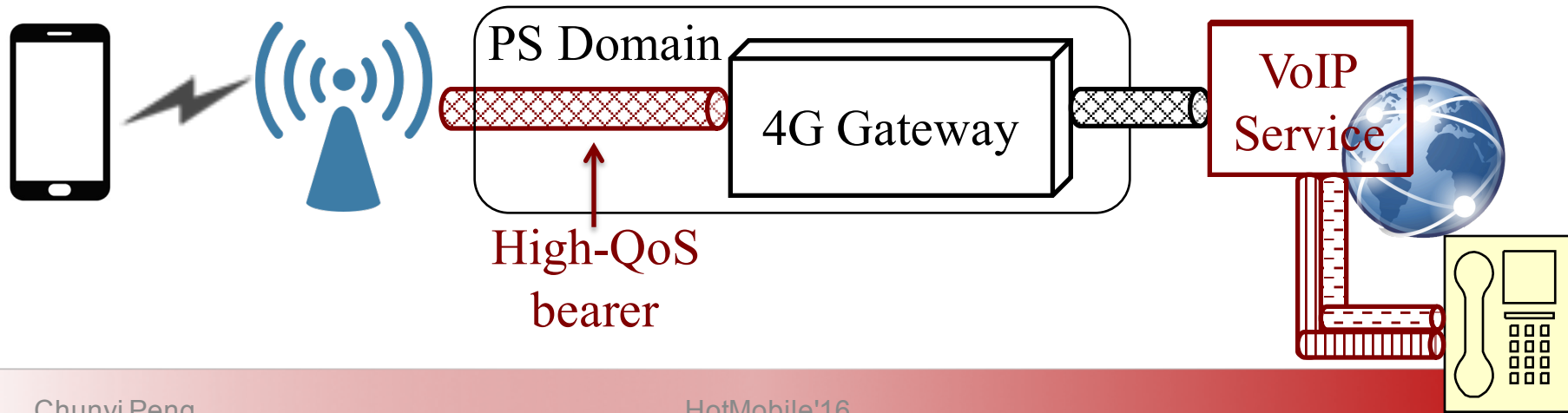
# VoLTE's Weapon: High QoS Bearer



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

# VoLTE\*: A Lightweight Voice Solution

- Both good of VoIP and VoLTE
  - Reduce cost without deploying IMS (VoIP)
  - Boost call quality with high QoS bearer (VoLTE)



# VoLTE\*: Voice Service Classes

- Assign different QoS profiles to VoIP packets

Service Class	Description
<b>First</b>	Use highest QoS (Quality similar to <b>VoLTE</b> )
<b>Business</b>	Always better than the best-effort QoS profile
<b>Deluxe Economy</b>	Better than best-effort when needed (e.g., congestion occurs)
<b>Economy</b>	best-effort ( <b>OTT VoIP</b> )

# Modest Support Required

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

# VoLTE\*: Benefit all Parties

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

# Downsides in VoLTE\*

- VoLTE\* complements not replaces VoLTE
- Technical drawbacks (little low-layer optimization)
  - No VoLTE-like energy-saving mechanism
  - No VoLTE-like coverage enhance mechanism
  - Still need extra efforts for CS-call compatibility
- 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 (vs. VoIP)
  - Comparable or slightly better quality but at higher cost
- VoLTE\*: Both good of VoIP and VoLTE
  - VoIP: Easy deployment/upgrade and low cost
  - VoLTE: call quality
- Promises of VoLTE\* deployment
  - Still room for VoLTE (not replacement)
  - Revisit roles of VoIP service providers and cellular carriers



Thank you! Questions?

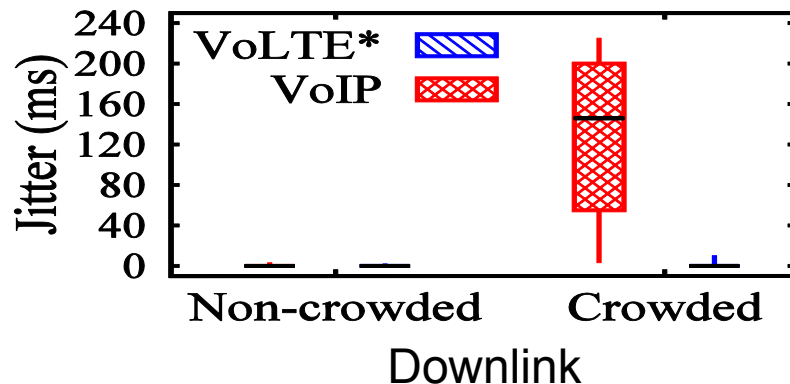
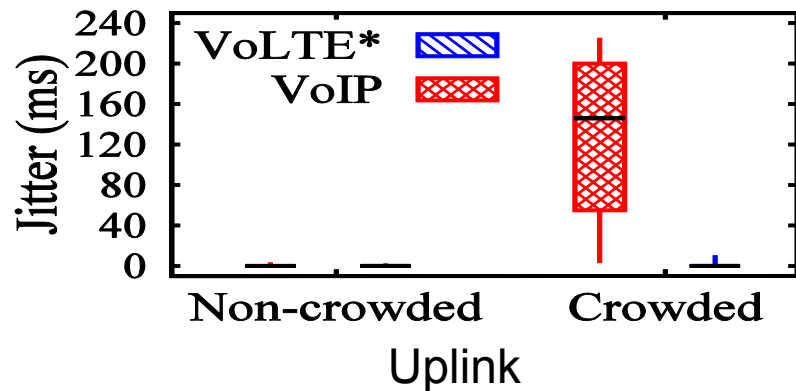
# Security: Another Downside of VoLTE

- Vulnerabilities due to complexity (more changes) in VoLTE [ccs'15]
  - VoLTE signaling/voice bearer abused to carry normal PS
  - Free data access attack (almost fixed now)
  - Overbilling attack (almost fixed now)
  - Voice/Data DoS attack (not yet)

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

# VoLTE\* Evaluation in Crowded Areas

- **Hacking VoLTE**: VoLTE signaling bearer exploited 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

# Other Issues in VoLTE\*

- Benefits for a universal voice solution
  - L3 solution (weaken the dependence on L2)
  - Flexibility
  - Integration with WiFi calling and other voice solutions
- Interplay of VoIP (external) and cellular CS domain
  - API, IPX design
- Migration from 4G to 2G
  - Poor support for data (VoIP) in 2G
- Voice billing (same/different charges for different QoS)

# 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)