Priority, Pre-Emption, and Quality of Service

http://www.pscr.gov

Public Safety Communications Research Program
Department of Commerce – Boulder Labs

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By

FirstNet

DHS Office of Interoperability and Compatibility

DHS Office of Emergency Communications

NIST

Overview of Priority, Pre-Emption, QoS

- Priority, Pre-emption, and QoS showed up in 3GPP standards in the Release 8 timeframe
  - Just because it's in the standards, doesn't mean it's in the product
  - Just because it's in the product, doesn't mean it meets public safety's needs

Let's take a look at the fundamental priority, pre-emption and QoS mechanisms.

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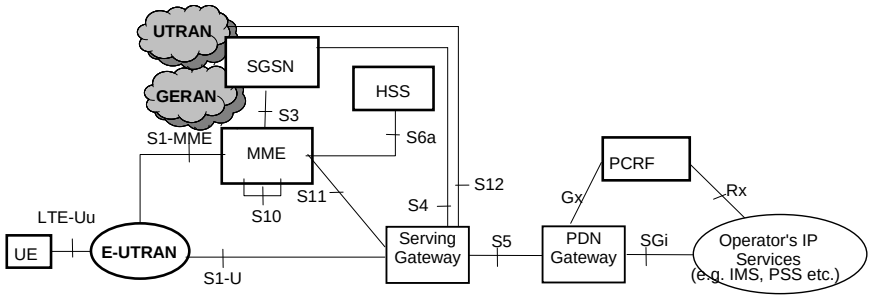
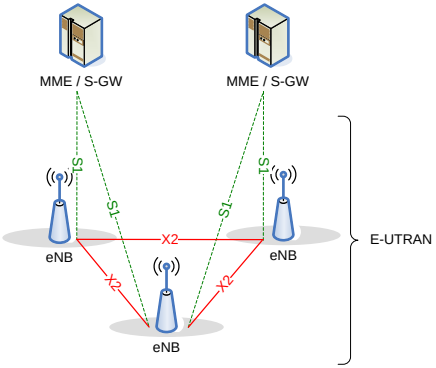
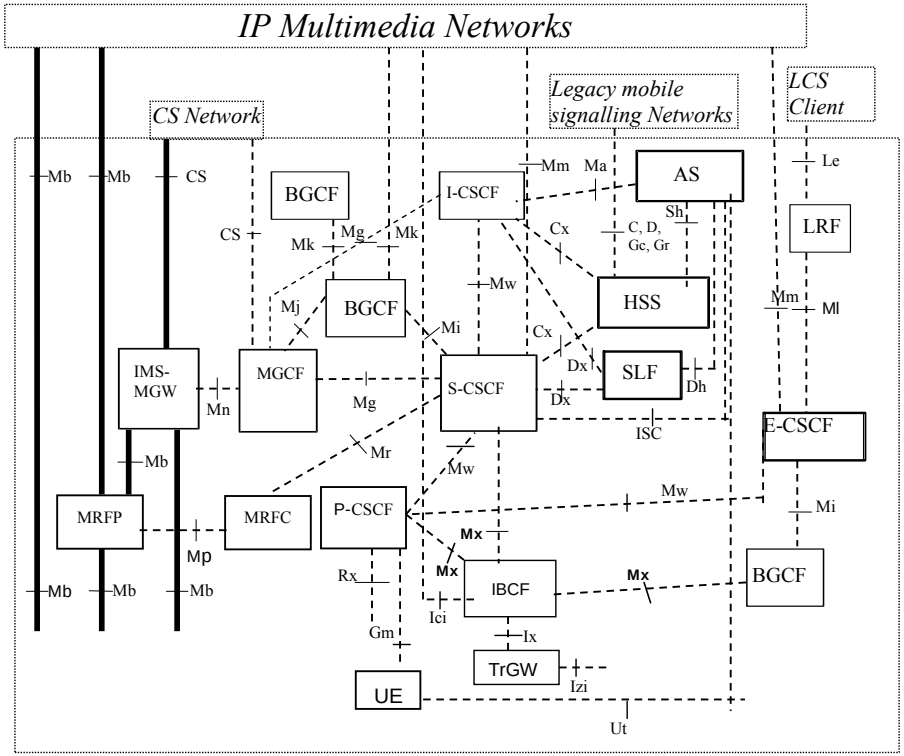
The "Network"



Evolved Packet Core



Evolved UMTS Terrestrial Radio Access Network



IP Multimedia System

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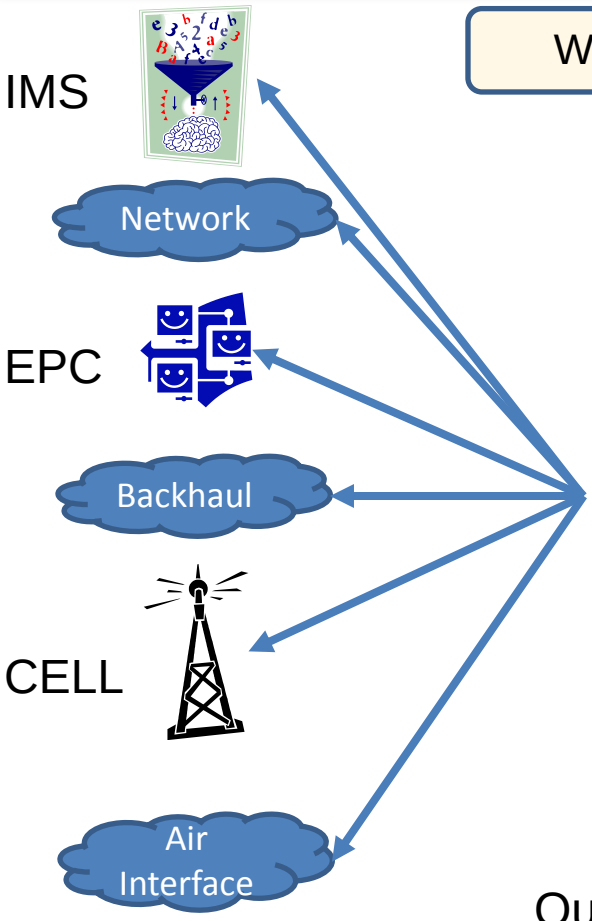
The Simple Network

Why is QoS such a big deal?



Your network will become congested.

Quality of Service allows public safety to confidently use LTE when the network becomes congested.

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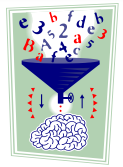
Today's Discussion



Network

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Air Interface

Provide an End User perspective on QoS functionality

1. QoS can improve access to the network (or cell)
2. QoS can improve allocation of network resources
3. QoS can improve end user experience
4. Give a brief update on the FirstNet QoS evaluation

Why does QoS seem so complicated?

- It is End to End
- It is highly customizable
- It is a collection of "mechanisms"
- It can be applied to many areas

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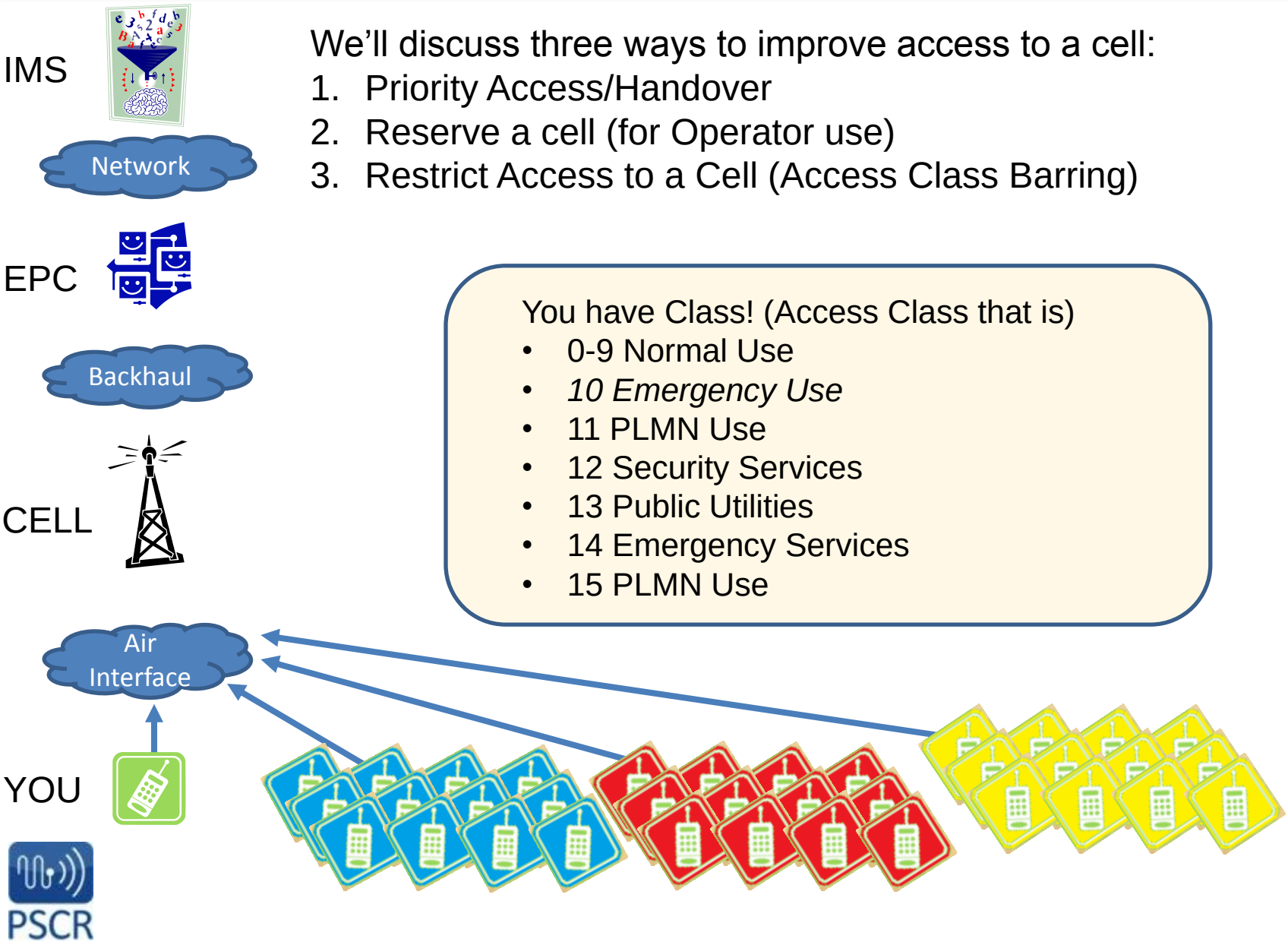
Improving Access



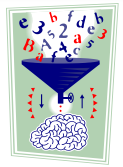
We'll discuss three ways to improve access to a cell:

1. Priority Access/Handover
2. Reserve a cell (for Operator use)
3. Restrict Access to a Cell (Access Class Barring)

You have Class! (Access Class that is)

- 0-9 Normal Use
- *10 Emergency Use*
- 11 PLMN Use
- 12 Security Services
- 13 Public Utilities
- 14 Emergency Services
- 15 PLMN Use

Priority Access/Handover



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1. Priority access means you can access the cell during times of congestion.

Yikes!

You can also get priority on handover

When requesting a connection, you can send a High Priority Establishment Cause

Air Interface

Air Interface

YOU

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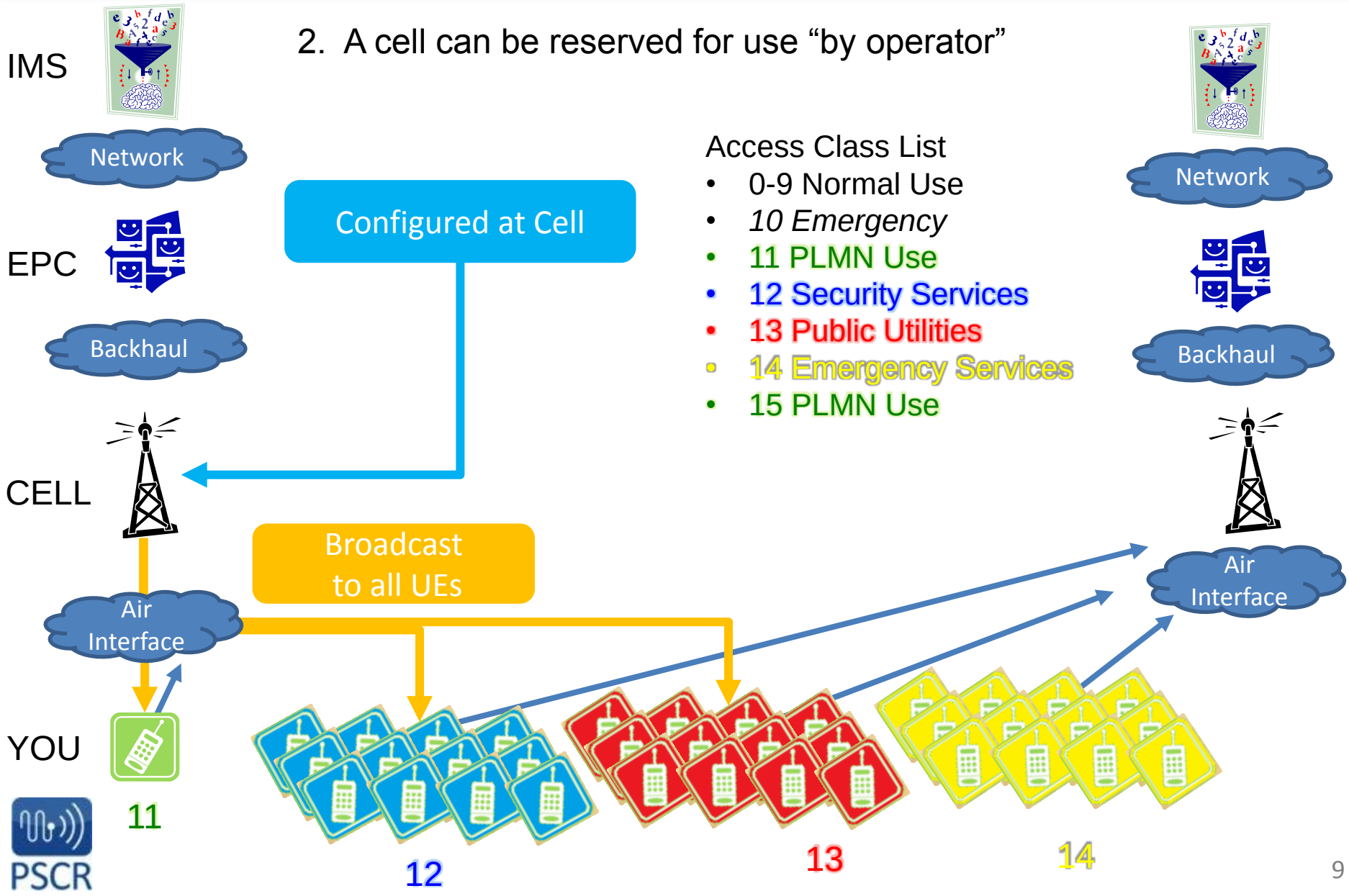
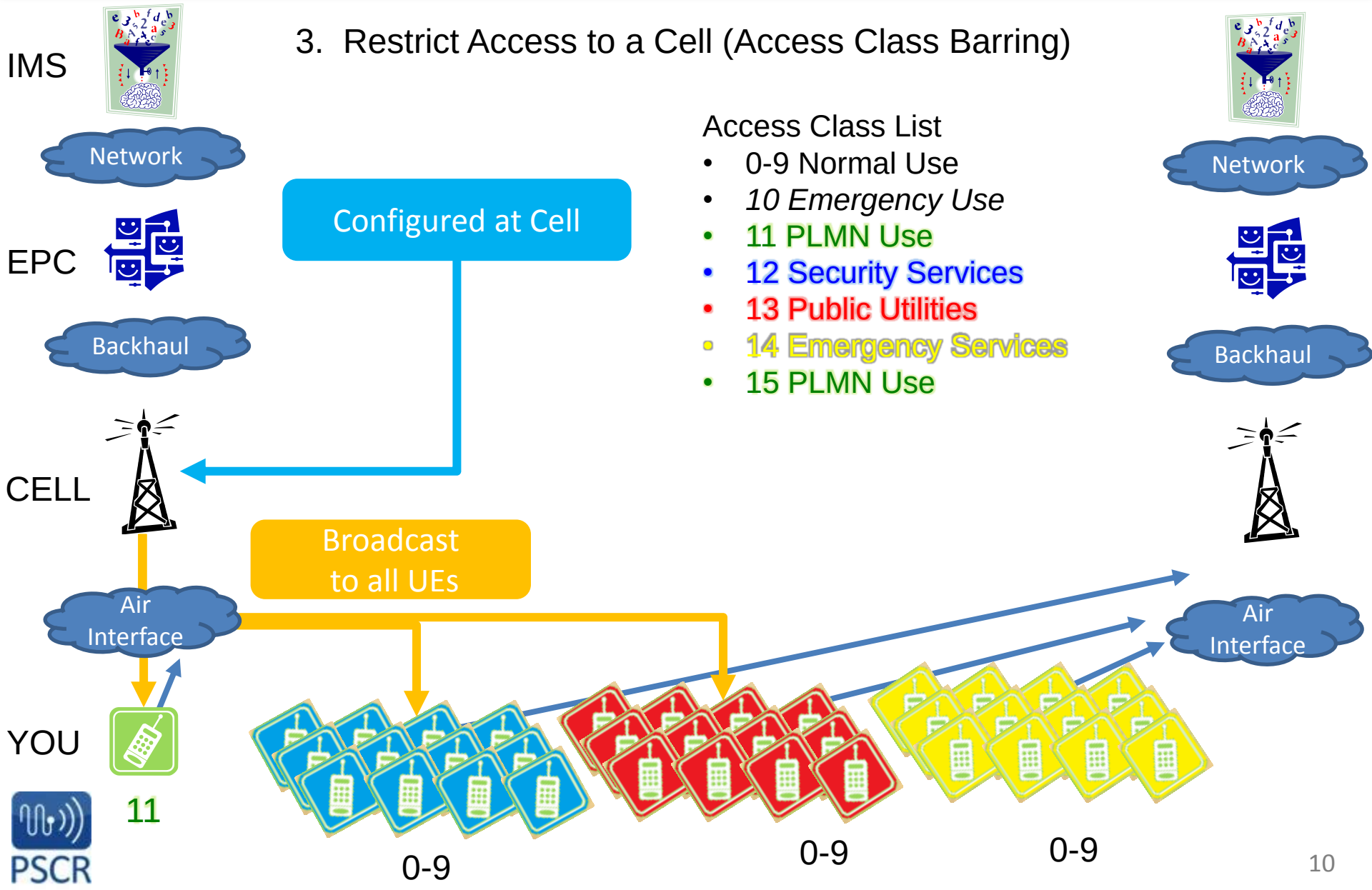
Reserve a Cell

2. A cell can be reserved for use “by operator”



Restrict Access to a Cell



3. Restrict Access to a Cell (Access Class Barring)

Access Class List

- 0-9 Normal Use
- *10 Emergency Use*
- 11 PLMN Use
- 12 Security Services
- 13 Public Utilities
- 14 Emergency Services
- 15 PLMN Use

Improving Allocation of Resources

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First, let's look at the device and how it sends/receives data.

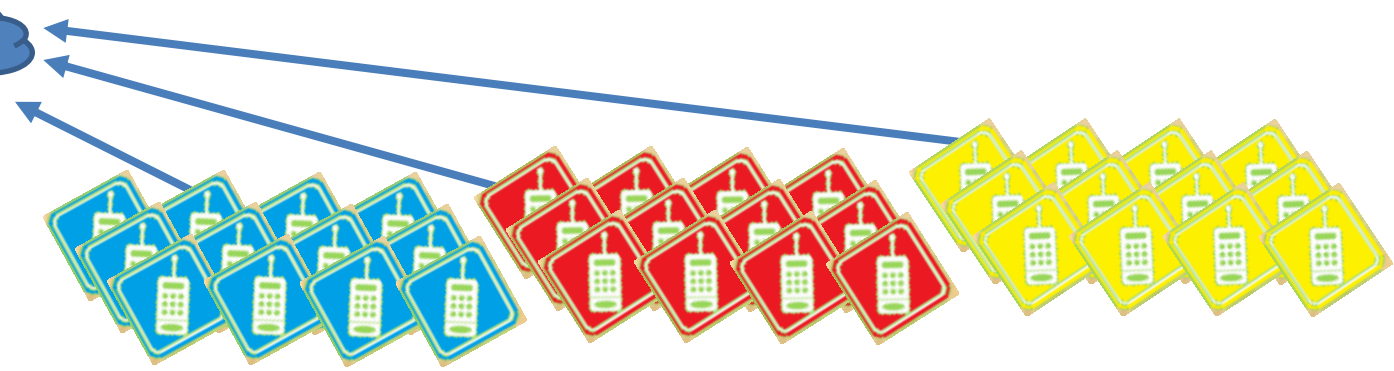
"Call or Session"

Your Device can do lots of stuff

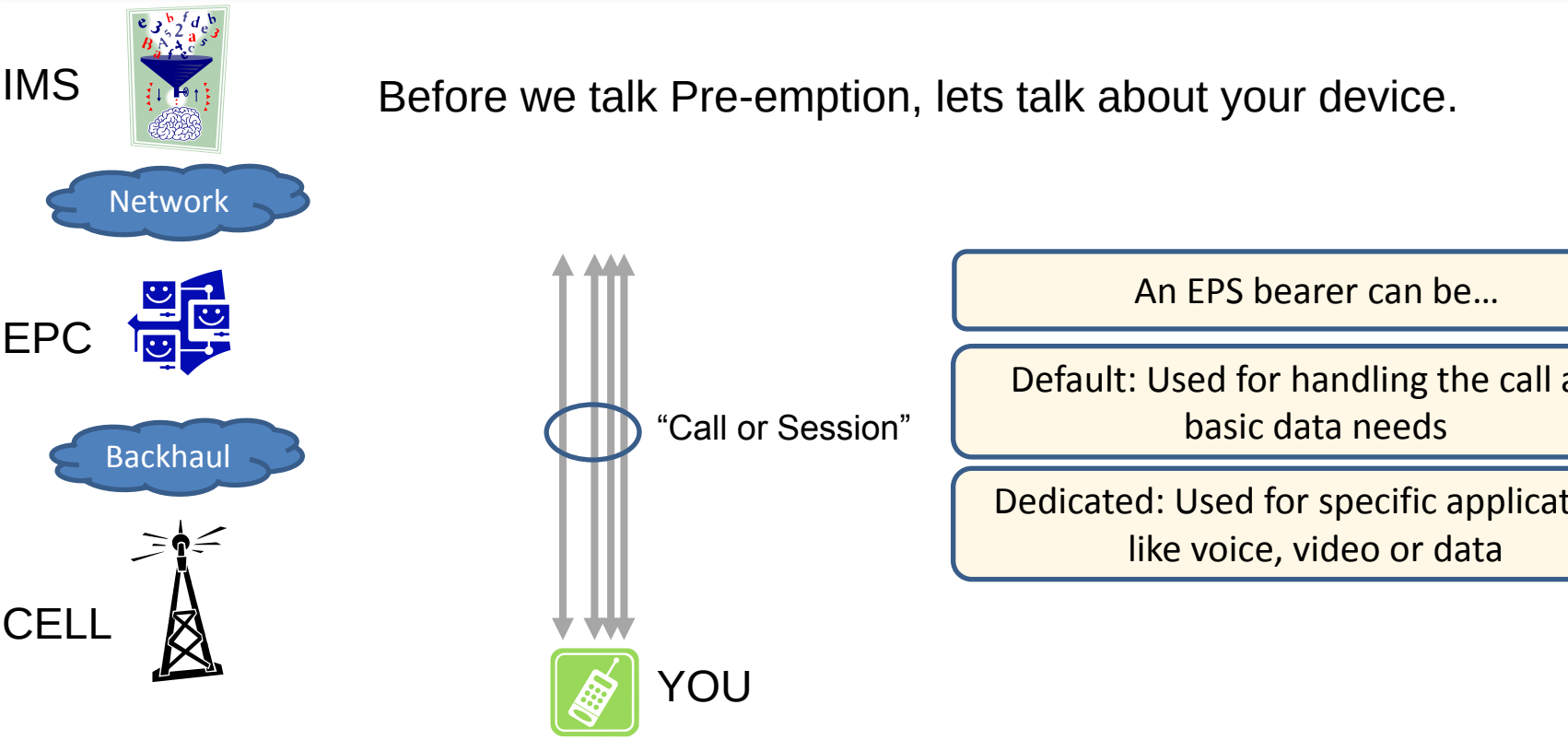
- Voice
- Video
- Data

To do this your device creates EPS bearers

It can even do multiple things at once!



Improving Allocation of Resources



Before we talk Pre-emption, lets talk about your device.

An EPS bearer can be…

Default: Used for handling the call and basic data needs

Dedicated: Used for specific applications like voice, video or data

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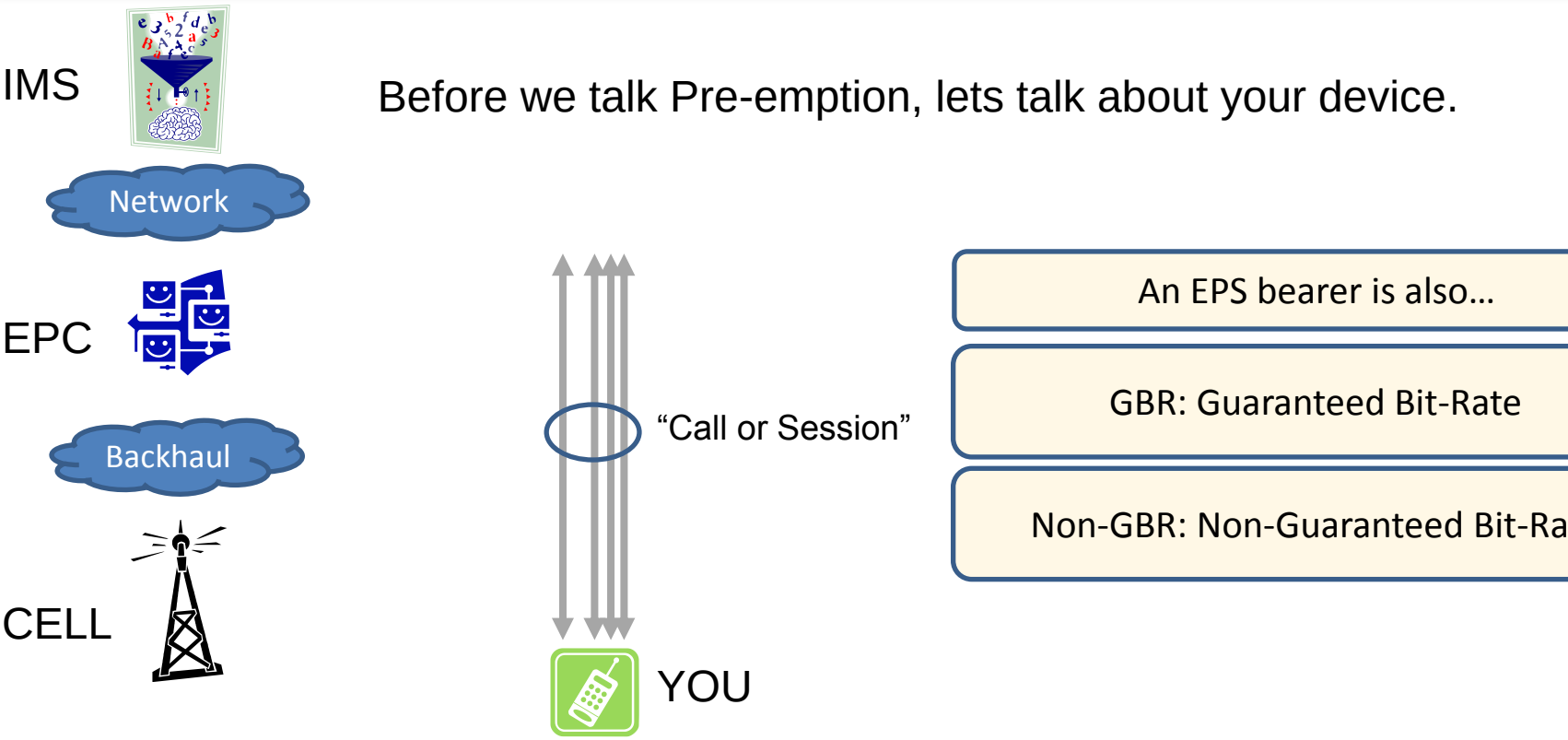
Improving Allocation of Resources



Before we talk Pre-emption, lets talk about your device.

An EPS bearer is also…

GBR: Guaranteed Bit-Rate

Non-GBR: Non-Guaranteed Bit-Rate

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Improving Allocation of Resources

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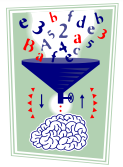
Now…. Imagine every one doing that at the same time!

Allocation and Retention Priority (ARP) gives priority access to bearer resources when the network is congested.
(Get, Change or Take)

Yikes!

Finally… Pre-emption



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Let's look at a simple example.

Your Configuration:
ARP=1
Pre-empt Capable: TRUE
Pre-empt Vulnerable: FALSE

My Configuration:
ARP=15
Pre-empt Capable: FALSE
Pre-empt Vulnerable: TRUE

Bang!

Yikes!

You

Me

I have a new app called "BWKiller"
- Low Priority, Preempt vulnerable

You request priority resources to handle something like Incident Command.

Your request is accepted, and because you have a higher priority you can pre-empt my bearer.

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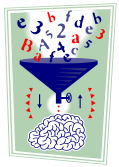
Improving End User Experience



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Let's take another look at your device

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QoS maps LTE priority to packet priority markings that routers can treat the packets with priority as well (DSCP)

QoS configuration establishes the priority and maximum bit rate for your network.

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Dedicated Bearer (GBR)

VoIP

Local Database or Service

Default Bearer (Non-GBR)

Web Traffic

Email

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QoS configuration establishes the priority and maximum bit rate parameters for the pipe.

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QoS configuration establishes the priority and maximum bit rate parameters for you and your device.

QoS configuration also establishes the priority, maximum bit rate and traffic flow parameters for the flows.

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Improving End User Experience

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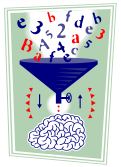

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QoS Parameters – Because every presentation needs an eye chart

Packet Transport Priority

QCI	Resource Type	Priority	Packet Delay Budget	Packet Error Loss Rate	Example Services
1	GBR	2	100 ms	10E-02	Conversational Voice
2		4	150 ms	01E-02	Conversational Video (Live Streaming)
3		3	50 ms	01E-02	Real Time Gaming
4		5	300 ms	10E-06	Non-Conversational Video (Buffered Streaming)
5	Non-GBR	1	100 ms	10E-06	IMS Signalling
6		6	300 ms	10E-06	Video (Buffered Streaming) TCP-based (e.g., www, e-mail, chat, ftp, p2p file sharing, progressive video, etc.)
7		7	100 ms	10E-06	Voice, Video (Live Streaming), Interactive Gaming
8		8	300 ms	10E-06	Video (Buffered Streaming) TCP-based (e.g., www, e-mail, chat, ftp, p2p file sharing, progressive video, etc.) *Also used for Default bearer for non-priority subscribers.
9		9			

Bit Rates
- Bearer and Flow
- Aggregate Max Rate
- Max Rate
- Guaranteed Rate

Traffic Flow Templates
- Map Data to Flows
- Map Flows to Pipes
- Customizable

Network Transport Priority
- 7 Classes of Service
- Differentiates between services in a class (DSCP)
- Addresses things like assured forwarding, drop probability when traversing the network routers.

QoS – What do we expect?

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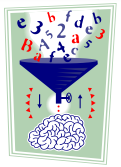

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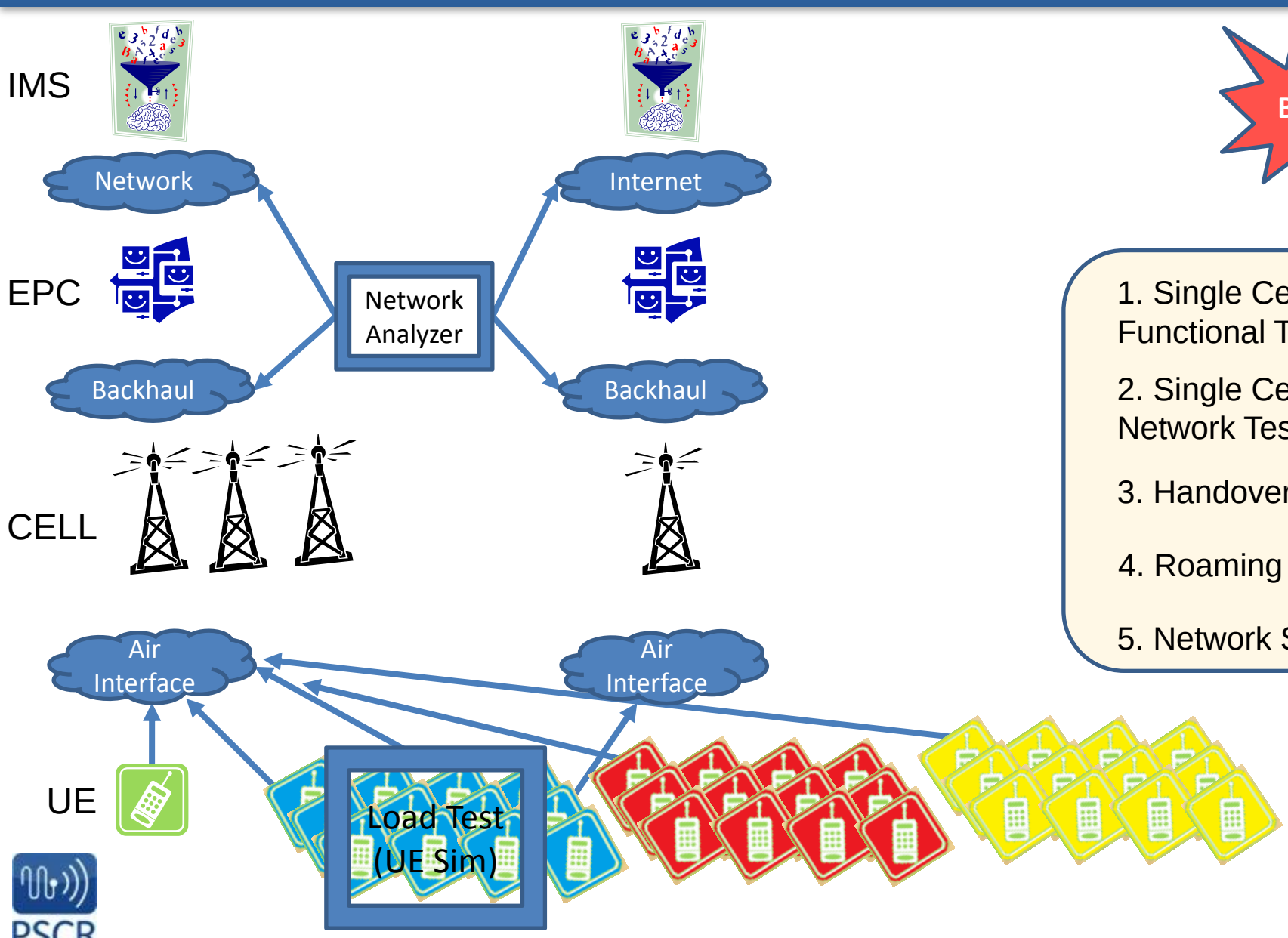
QoS Mechanisms

- MPS Identifier
- QCI, MBR, GBR, AMBR
- DSCP Mapping
- Traffic Flow
- ARP
- Establishment Cause
- Access Class
- Multi-APN Support

QoS Capabilities

- MPS Priority
- Enhanced Access Class Barring
- Advanced Priority
- Priority CSFB
- Paging Priority
- Priority Signaling and Processing
- Overload Exemption
- Priority Queuing
- Rebalancing Exemption
- Reservation Priority
- Priority Bearer Establishment
- Priority Bearer Pre-emption
- Priority Bearer Modification
- Over Allocation

QoS Testing Strategy



1. Single Cell Functional Testing
2. Single Cell Network Testing
3. Handover
4. Roaming
5. Network Sharing

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FirstNet Update

- What's happened in the last 3 months?
  - CRADA Partners have been working hard
  - RAN Load Test Research
  - FirstNet Preliminary Deliverables
    - Lab Capability, 3GPP QoS, Future Plans
    - Initial Use Case, more to come

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FirstNet Update

- What's next?
  - Test Case Creation
  - Functional Testing, Initial results by July
  - Lab Evolution

- Key Challenges
  - Need to shore up BC14 UE area
  - Upstream (above RAN) loading

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Acronym Soup

General Acronyms
- 3GPP: Third Generation Partnership Project
- Bearer: An information transmission path
- CSFB: Circuit Switched Fall Back
- EPC: Evolved Packet Core
- EPS: Evolved Packet System
- E-UMTS: Evolved Universal Mobile Telephone Service
- E-NodeB: Evolved Node B
- IMS: Internet Protocol Multi-Media Service
- LTE: Long Term Evolution
- PLMN: Public Land Mobile Network
- RAN: Radio Access Network
- UE: User Equipment

Quality of Service Related Acronyms
- AMBR: Aggregate Maximum Bit Rate
- APN: Access Point Name
- ARP: Allocation and Retention Priority
- DSCP: Differentiated Services Code Point
- GBR: Guaranteed Bit Rate
- MBR: Maximum Bit Rate
- MPS: Multi-media Priority services
- PCI: Pre-emption Capability Indicator
- PVI: Pre-emption Vulnerability Indicator
- TFT: Traffic Flow Template
- QCI: Quality Class Indicator
- QoS: Quality of Service

Interactive Terms and Definitions Database (Very Useful!)

http://webapp.etsi.org/Teddi/

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LTE RAN Load Testing

http://www.pscr.gov

Public Safety Communications Research Program
Department of Commerce – Boulder Labs

Presentation by:
Jon Cook
Electronics Engineer– NIST

Reasons for Testing QoS, Priority, Preemption

- Verify QoS, Priority and Preemption features function correctly before first responders use them
  - Features need to be verified before lives and property are in peril
- Provide an opportunity for network equipment vendors and UE vendors to debug unproven features
- Verify that pieces of equipment from various vendors interoperate properly
- RAN testing is the first portion of load testing that PSCR will look at

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RAN Load Tester Research

- How can we generate radio access network congestion?
  - Hundreds of users needed

- We could hire 800 people to drive around Boulder with band 14 UEs

- Fortunately, there are devices that simulate hundreds of users
  - Movement through the coverage area can also be simulated

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RAN Load Tester Research

- RAN load tester vendors were invited to demonstrate their capabilities
- They were given a list of 18 features desired for testing LTE band 14 QoS, priority, and preemption
- Four vendors brought their equipment to PSCR labs between December, 2013 and April, 2014
- PSCR staff gained knowledge on current capabilities of RAN load testing
- RAN load test vendors gained knowledge of public safety needs

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RAN Load Tester Research

- PSCR staff had several discussions to decide which RAN load test features are necessary based on FirstNet needs and current capabilities
- Multiple vendors can provide the needed capabilities
- Key features for a RAN load tester focused on public safety needs were identified

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RAN Load Tester Research

- Some key features for current needs
  - 2 simultaneous cells
  - 400 simulated UEs per cell
  - Traffic generation capabilities
  - QoS, ARP test capabilities
  - RAN sharing test capabilities
  - Detailed statistics reporting
  - RF fading within and between cells
- Expandability of RAN load tester for future needs is a key requirement

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Lab Operations and Engineering

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Presentation by:
Todd Bohling
Electronics Engineer– NIST

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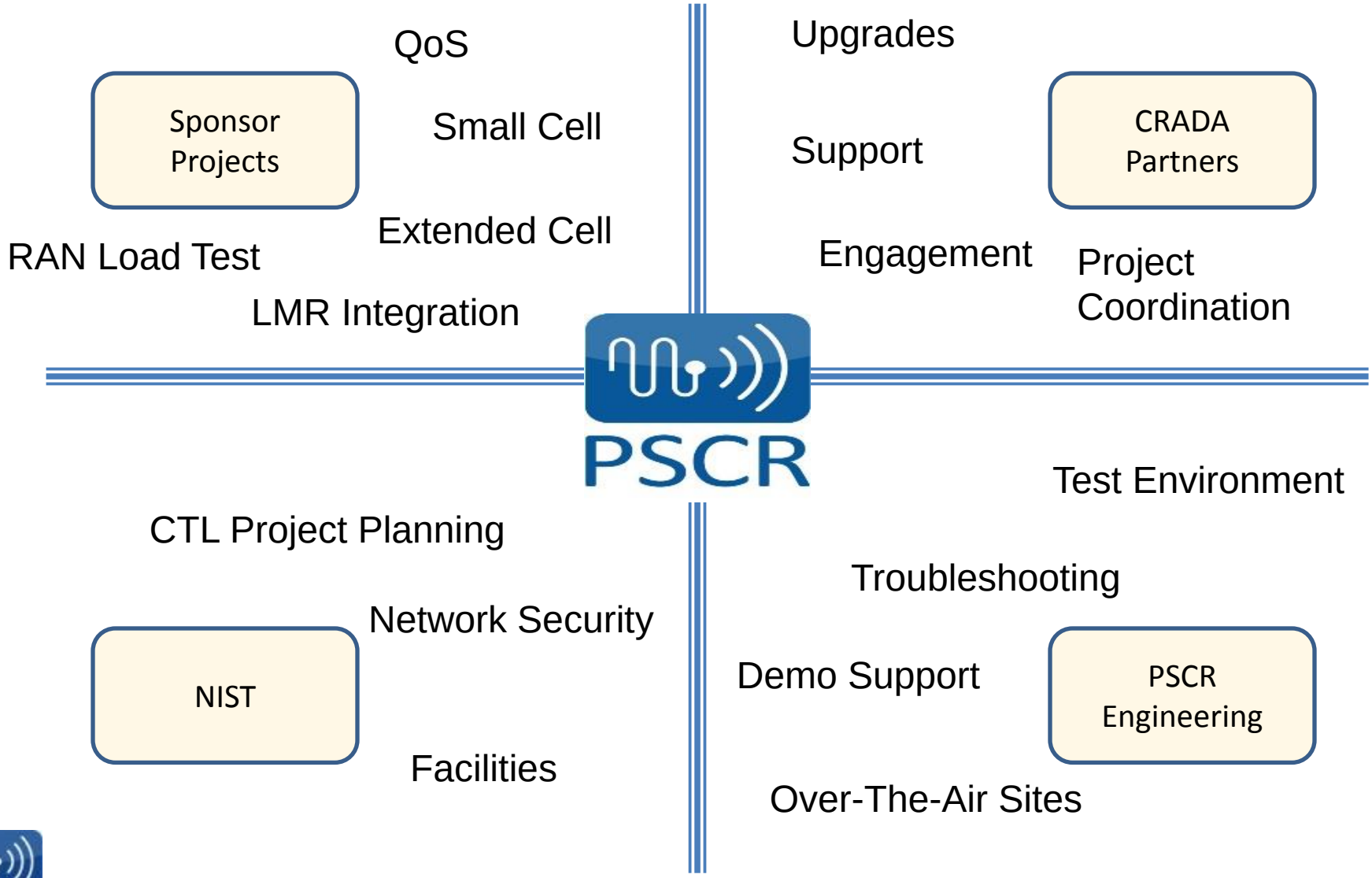
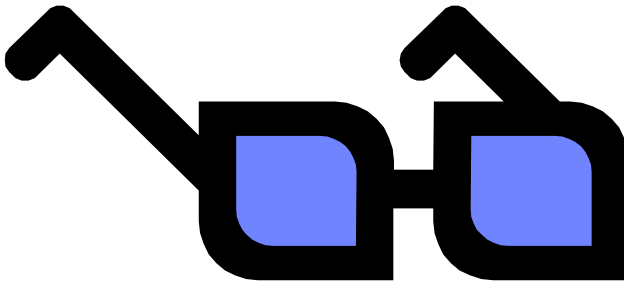


PSCR Lab Operations

- Develop best practices in multi-vendor LTE lab environment that is **Focused** on Public Safety
- Future proofing the Lab will retain the labs value in to the distant future
- Research and Implement Operational Support Systems (OSS)
- The future is so bright we gotta wear shades!!!



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Thank You!

Questions?