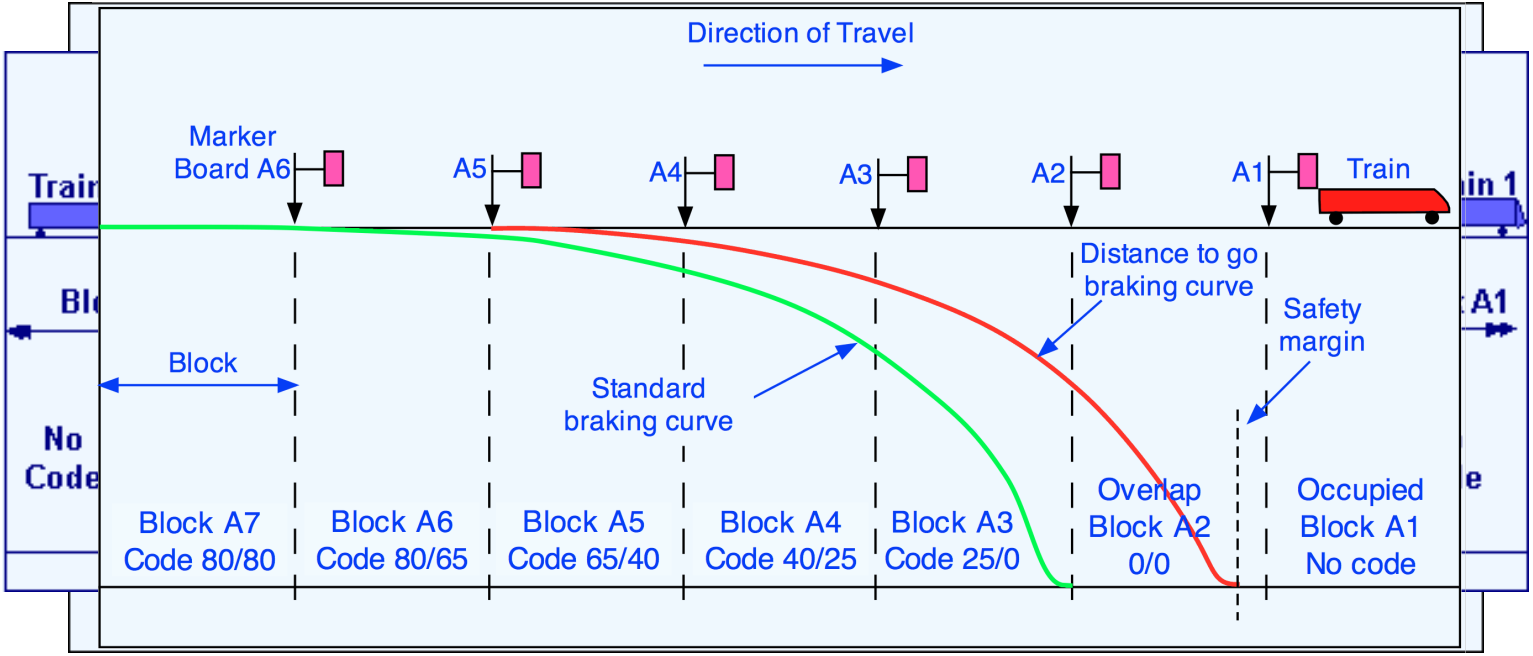
CBTC over Wi-Fi

Gathering Clouds

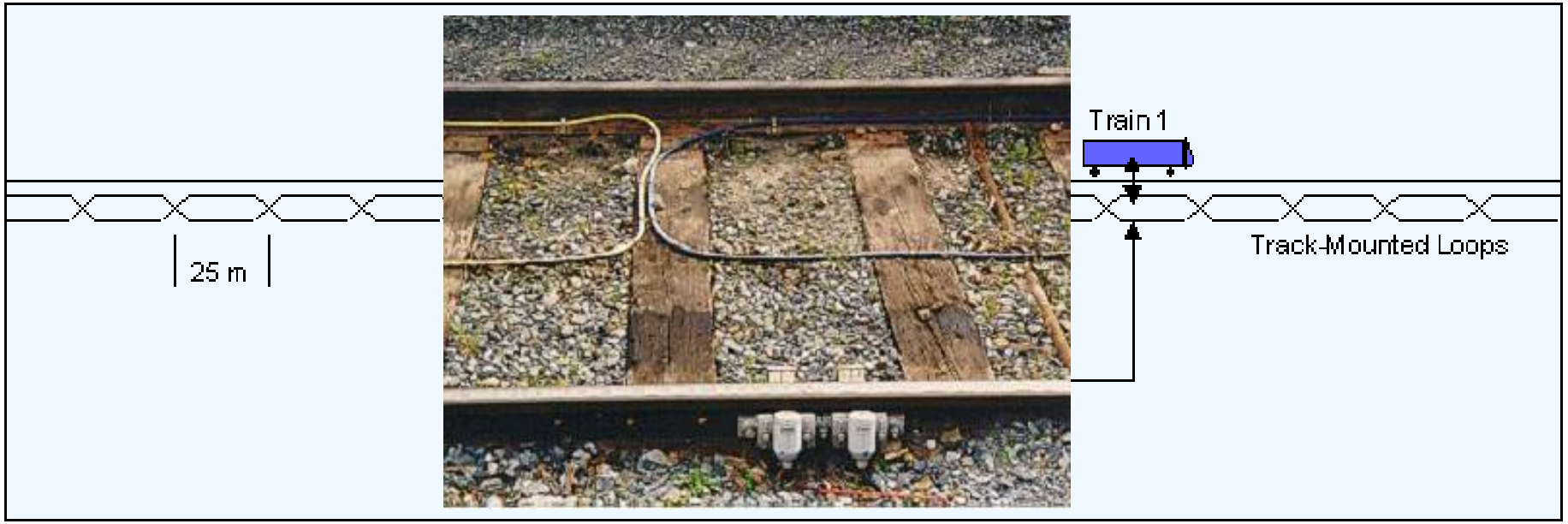
by Rodrigo Álvarez
Senior ICT Consultant

AusRAIL: Perth, 11-12 November 2014

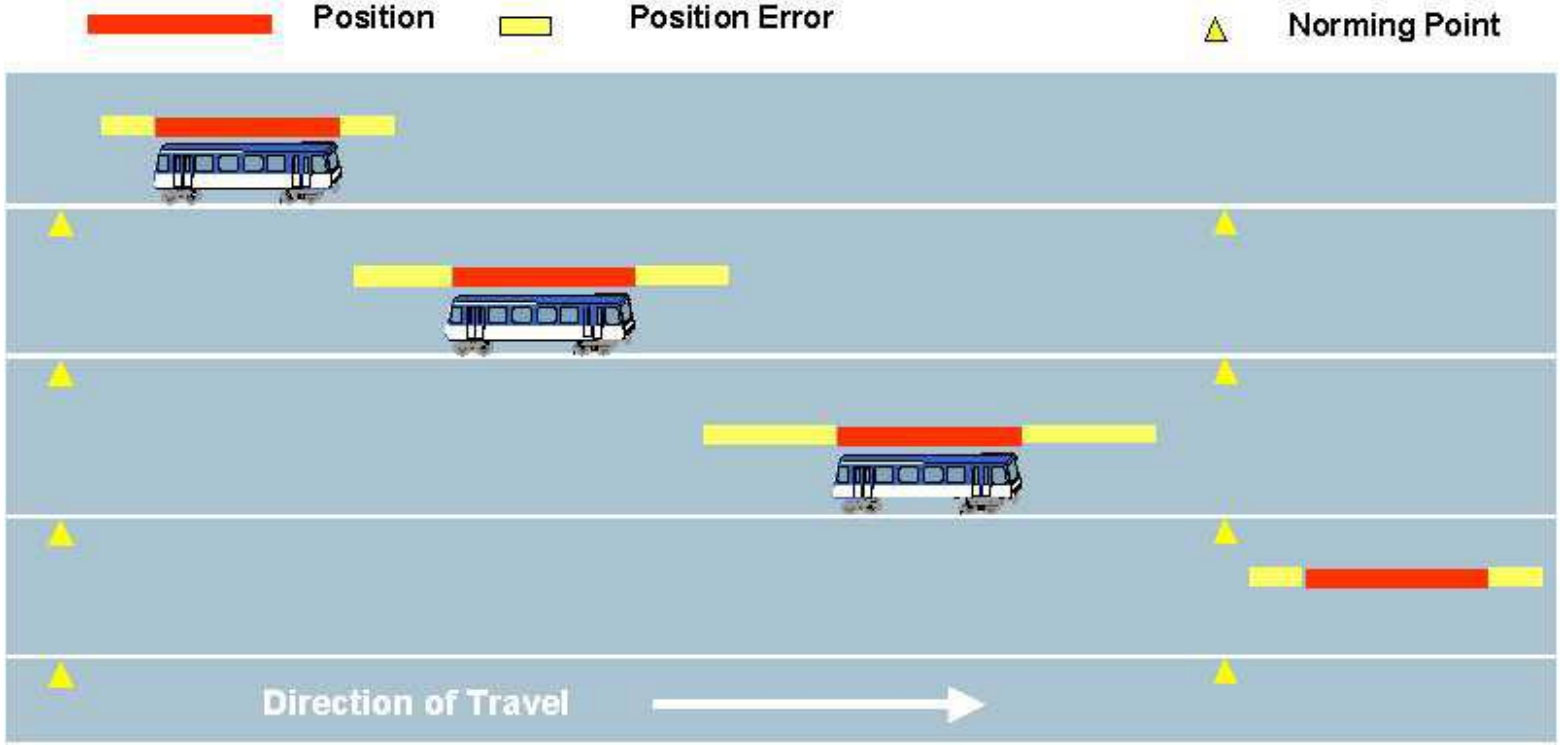
Speed Code Automatic Train Protection



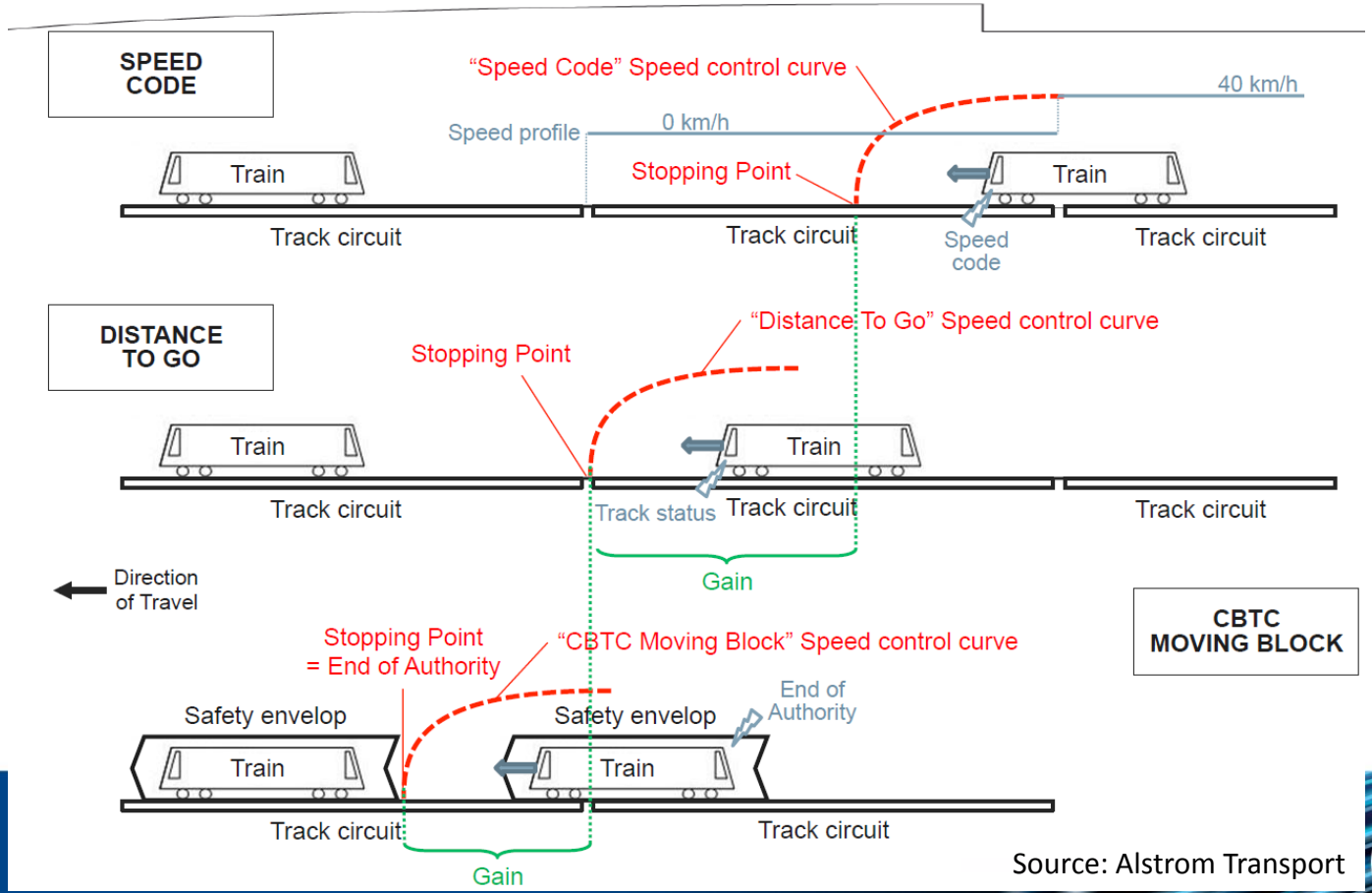
Transmission-Based Train Control (TBTC) or IL-CBTC



Communications-Based Train Control (CBTC) or RF-CBTC



Comparison between Metro ATP Systems



Source: Alstrom Transport

CBTC Proprietary Radios

Siemens
Proprietary CBTC
Radio @ NYCT
Canarsie Line

The Origins of Wi-Fi (i)

1985

FCC (US) makes unlicensed ISM band available for wireless LANs

Many different WLAN spread spectrum proprietary solutions appeared

1988

IEEE committee 802.11 starts to define a new WLAN standard.

The Origins of Wi-Fi (ii)

IEEE
Networking the World™

1997

Wi Fi
ALLIANCE

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The Growth of Wi-Fi (i)

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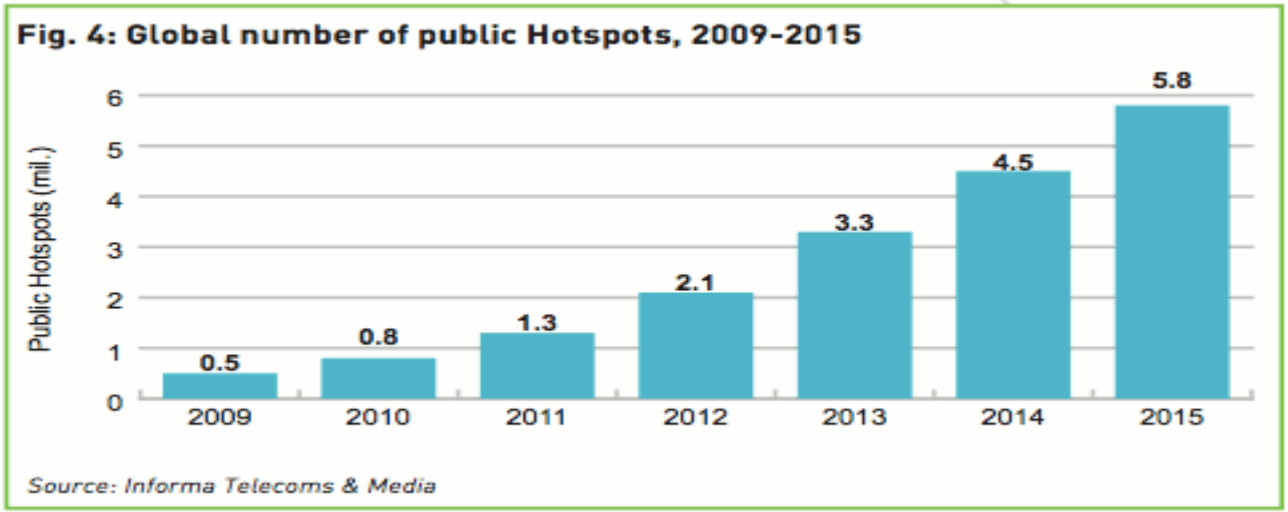
The Growth of Wi-Fi (ii)



The Growth of Wi-Fi in Railways

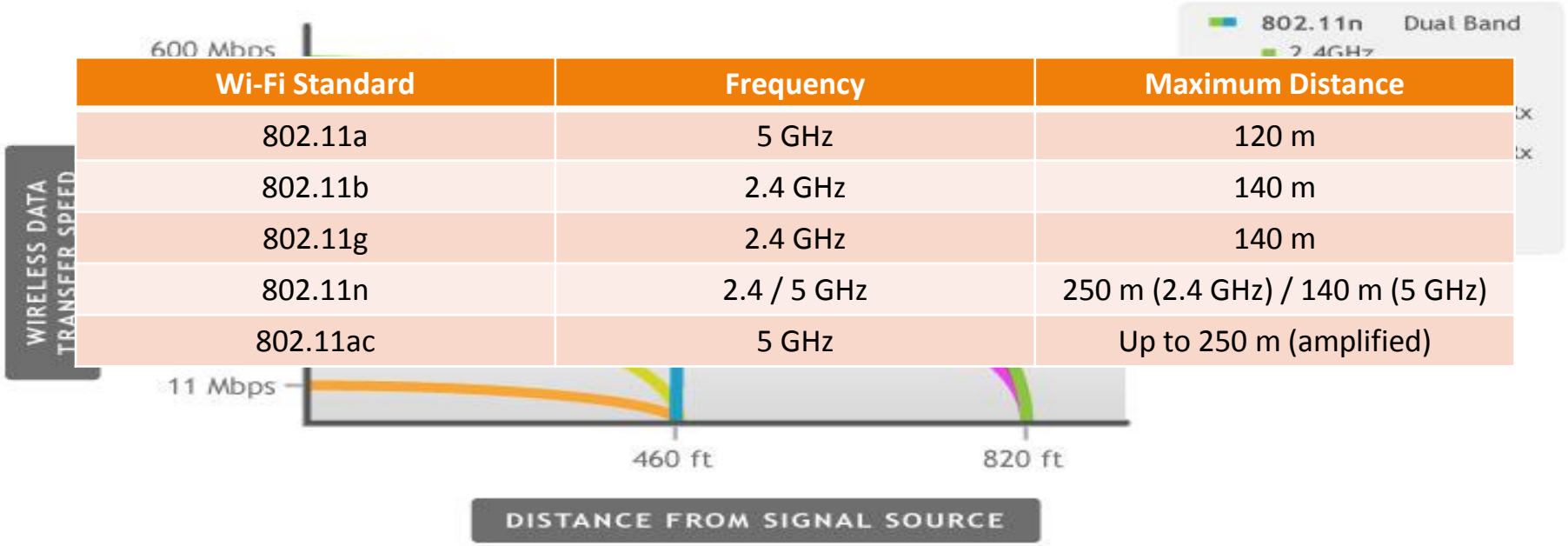
Public passenger broadband services
Station Information and Surveillance
Railway depots and yards
Centralised train telemetry
On board equipment diagnostics
DOO / DAVS
Real time on board CCTV streaming
Train control (CBTC)

Wi-Fi Variants: IEEE 802.11 PHY Standards

Release Date	Standard	Band (GHz)	Bandwidth (MHz)	Codificat'n	Antenna	Maximum Data Rate
1997	802.11	2.4	20	DSSS, FHSS	N/A	2 Mb/s
1999	802.11a	5	20	OFDM	N/A	54 Mb/s
1999	802.11b	2.4	20	DSSS	N/A	11 Mb/s
2003	802.11g	2.4	20	DSSS, OFDM	N/A	54 Mb/s
2009	802.11n	2.4 / 5	20 / 40	OFDM	4 x MIMO	600 Mb/s
2014	802.11ac	5	40 / 80 / 160	OFDM	8 x MIMO	6.93 Gb/s

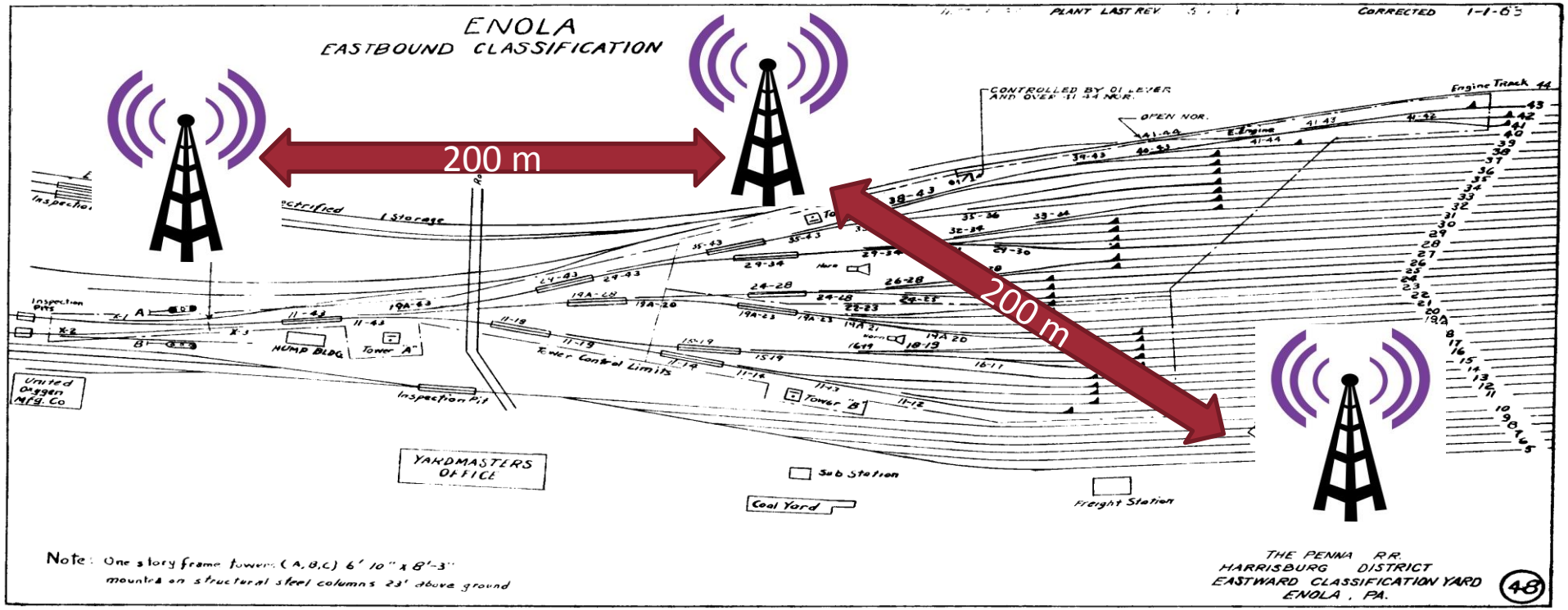
Wi-Fi Variants: Range

Wi-Fi Standard	Frequency	Maximum Distance
802.11a	5 GHz	120 m
802.11b	2.4 GHz	140 m
802.11g	2.4 GHz	140 m
802.11n	2.4 / 5 GHz	250 m (2.4 GHz) / 140 m (5 GHz)
802.11ac	5 GHz	Up to 250 m (amplified)

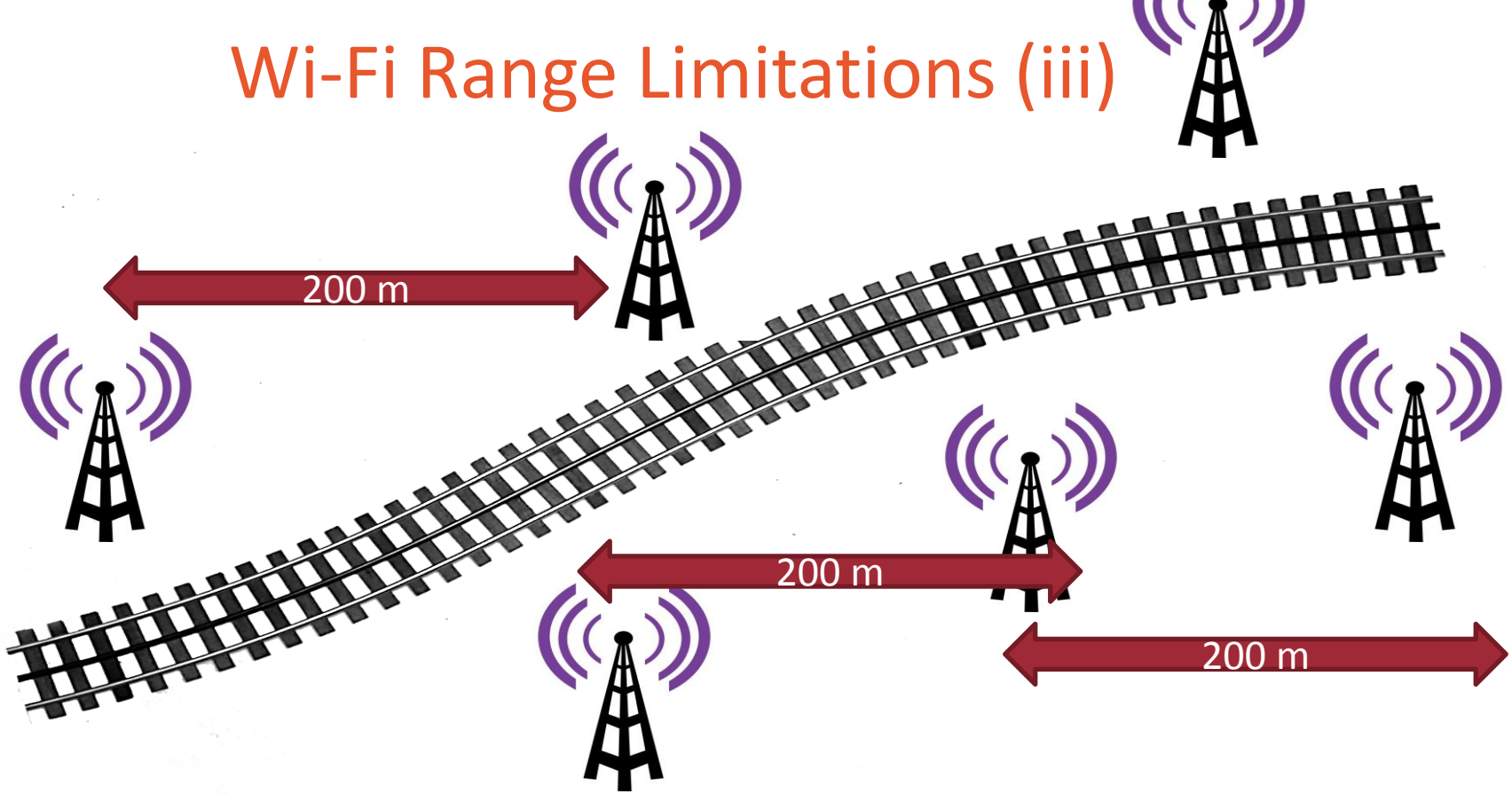


Wi-Fi Range Limitations (i)

Wi-Fi Range Limitations (ii)



Wi-Fi Range Limitations (iii)



Wi-Fi Range Limitations (iv)

$$100\ km\ line \rightarrow N_{AP} = 100\ km \times 2\frac{AP}{site} \times \frac{1000}{200} site/km = 1{,}000\ \text{AP}$$

1,000 Access Points!!

1,000 AP → 1,000 EthSw → 1,000 FO links → 1,000 masts → 1,000 bases → 1,000 UPS

+ Maintenance Cost!!

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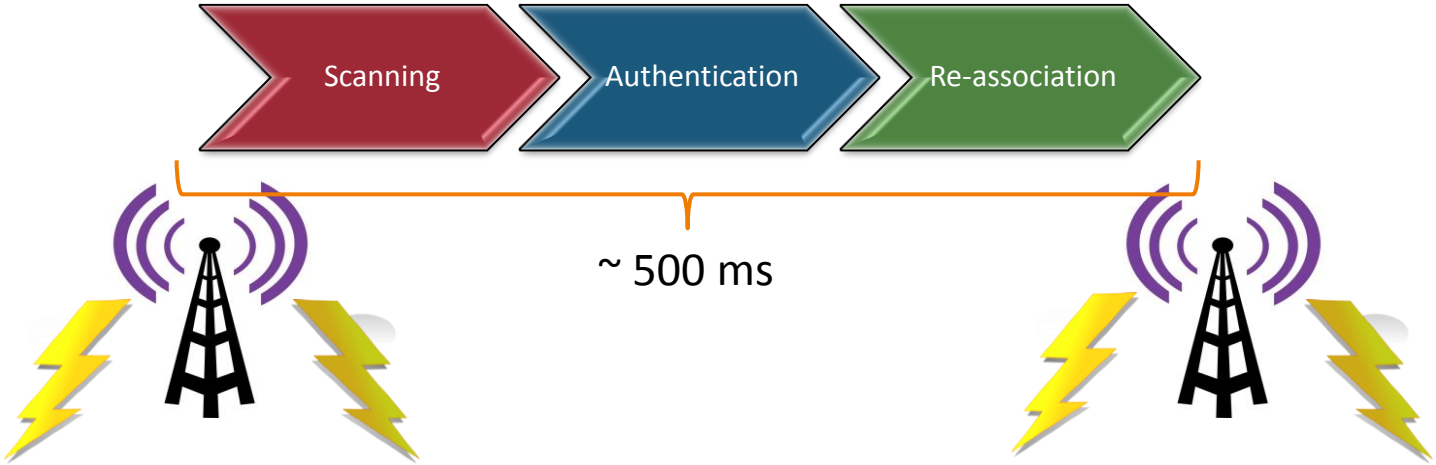
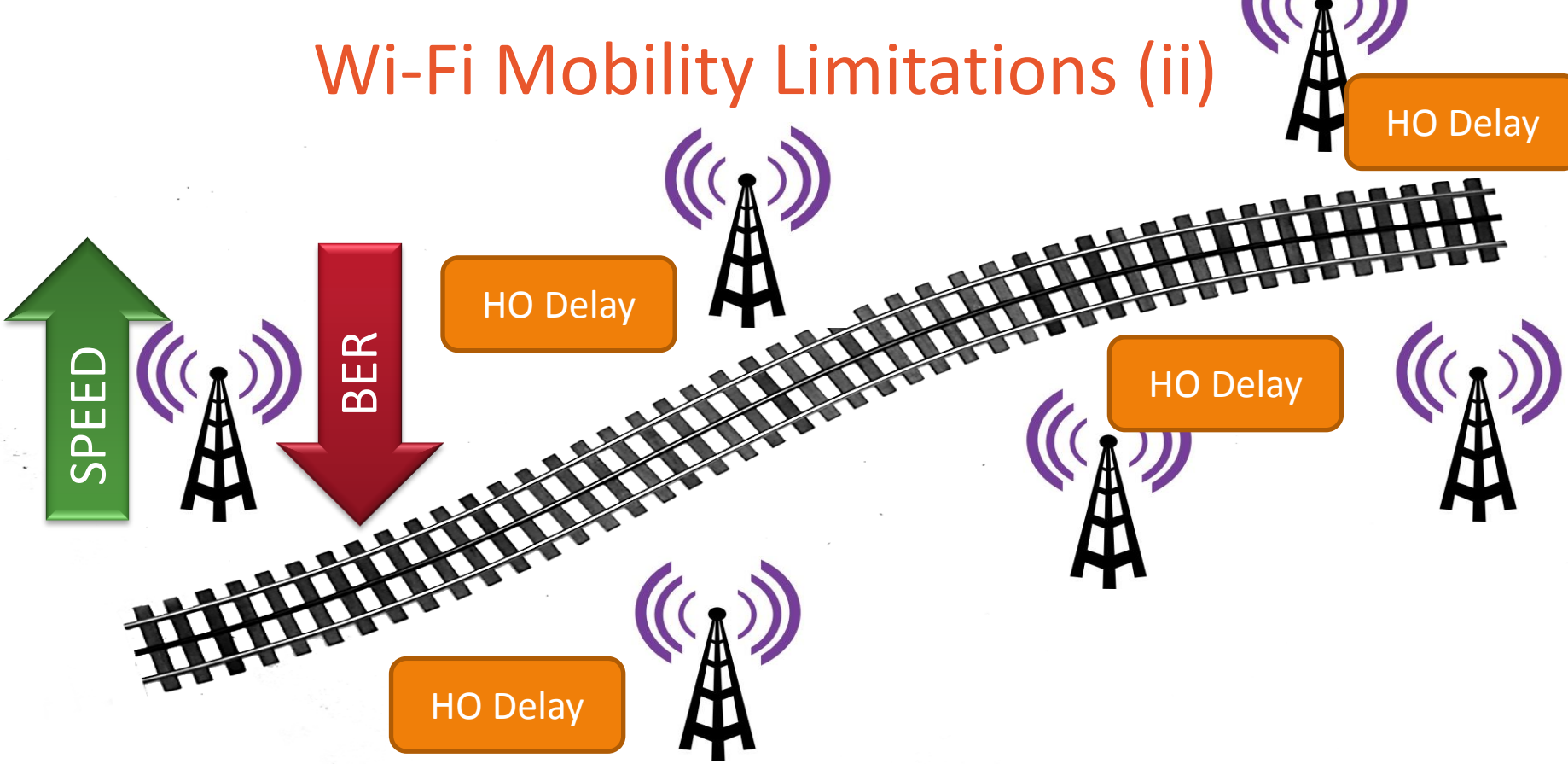
Wi-Fi Mobility Limitations (i)



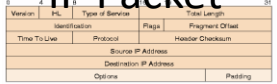
Wi-Fi Mobility Limitations (ii)



Wi-Fi Radio Resource Access – CSMA/CA

- CSMA/CA = Carrier Sense Multiple Access with Collision Avoidance
- MAC Layer in all 802.11 protocols

IP Packet

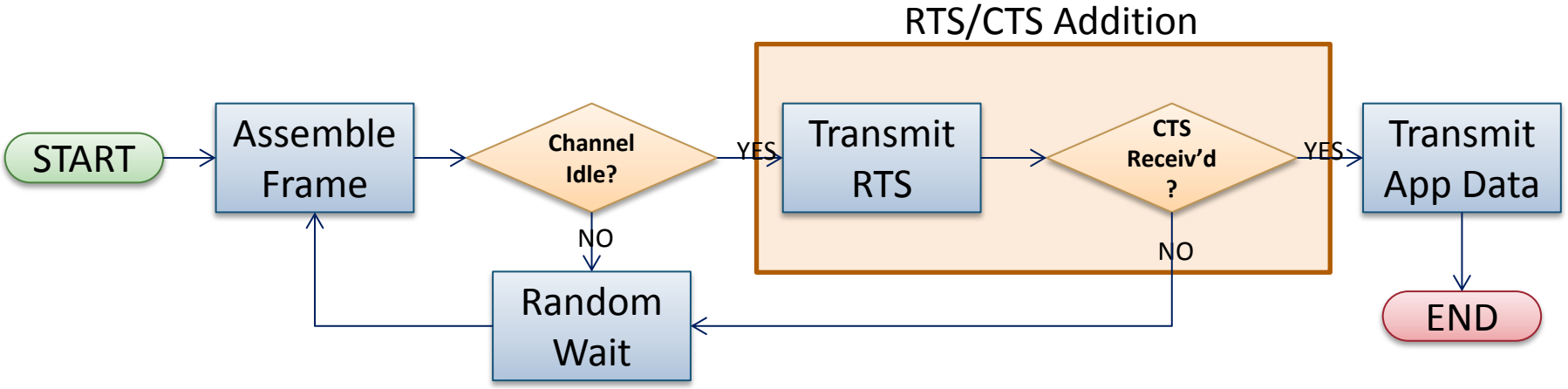


Wi-Fi User

IP Packet

Wi-Fi Radio Resource Access – RTS/CTS

- RTS/CTS = Request to Send / Clear to Send
- Enhances CSMA/CA



Wi-Fi QoS

- No QoS discrimination in original IEEE 802.11 MAC Layer

Wi-Fi User

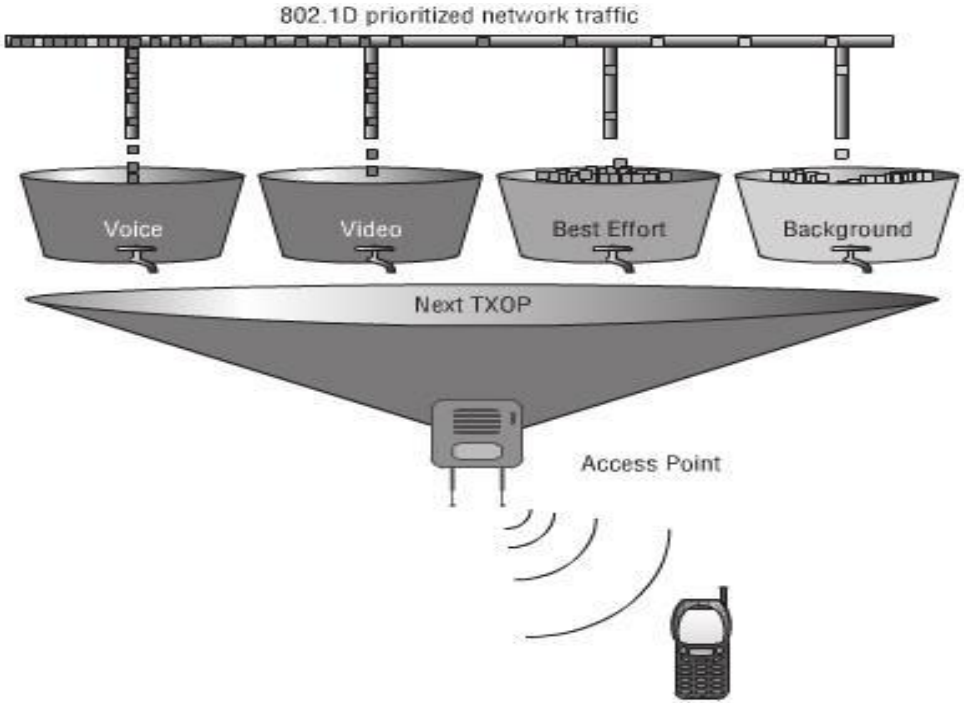
Wi-Fi QoS: 802.11e EDCA (i)

- EDCA = Enhanced Distributed Channel Access
- High priority traffic waits a little less before sending packets by using reserved periods of time.
- No guarantees – probabilistic mechanism

Traffic Type	Access Category	CWmin	CWmax	AIFSN	Max TXOP
Background	AC_BK	15	1023	7	0
Best Effort	AC_BE	15	1023	3	0
Video	AC_VI	7	15	2	3.008 ms
Voice	AC_VO	3	7	2	1.504 ms
Legacy CSMA/CA		15	1023	2	0

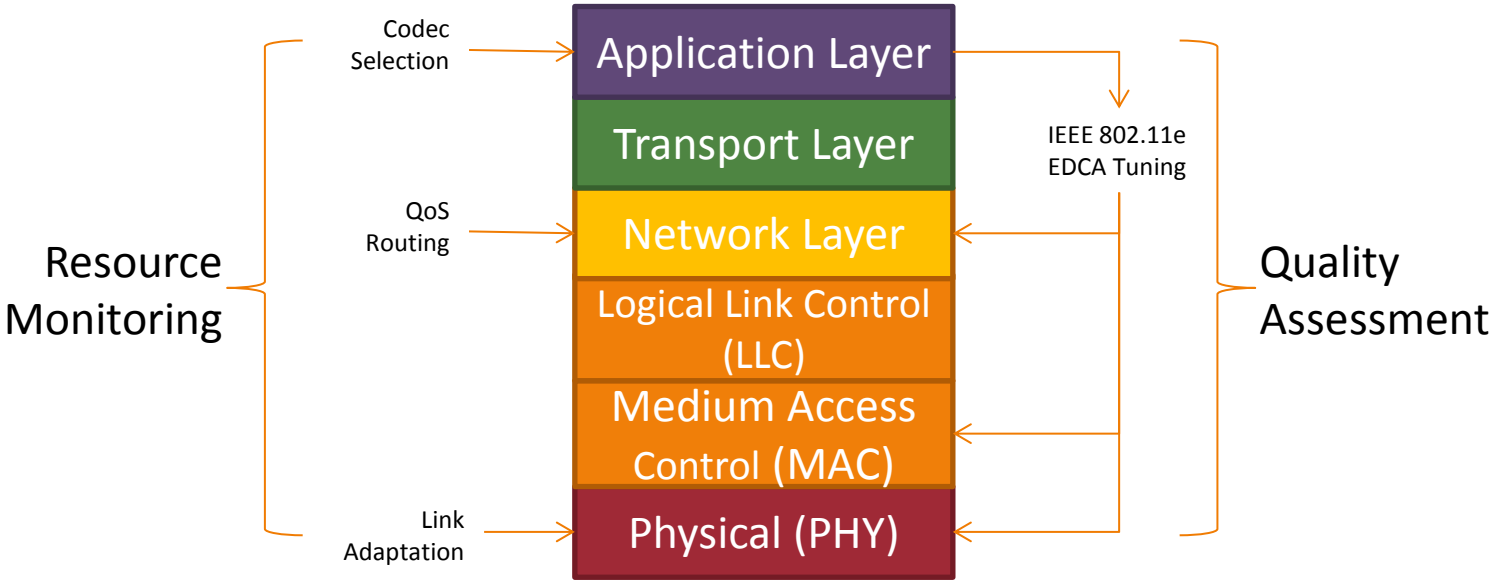
CW = Contention Window ~ Limits to select random back-off timers – slot time = 9µs
AIFSN = Arbitration Inter-Frame Space Number ~ Back-off period value – wait before re-transmitting
TXOP = Transmit Opportunity ~ Length of time to transmit once access has been obtained

Wi-Fi QoS: 802.11e EDCA (ii)

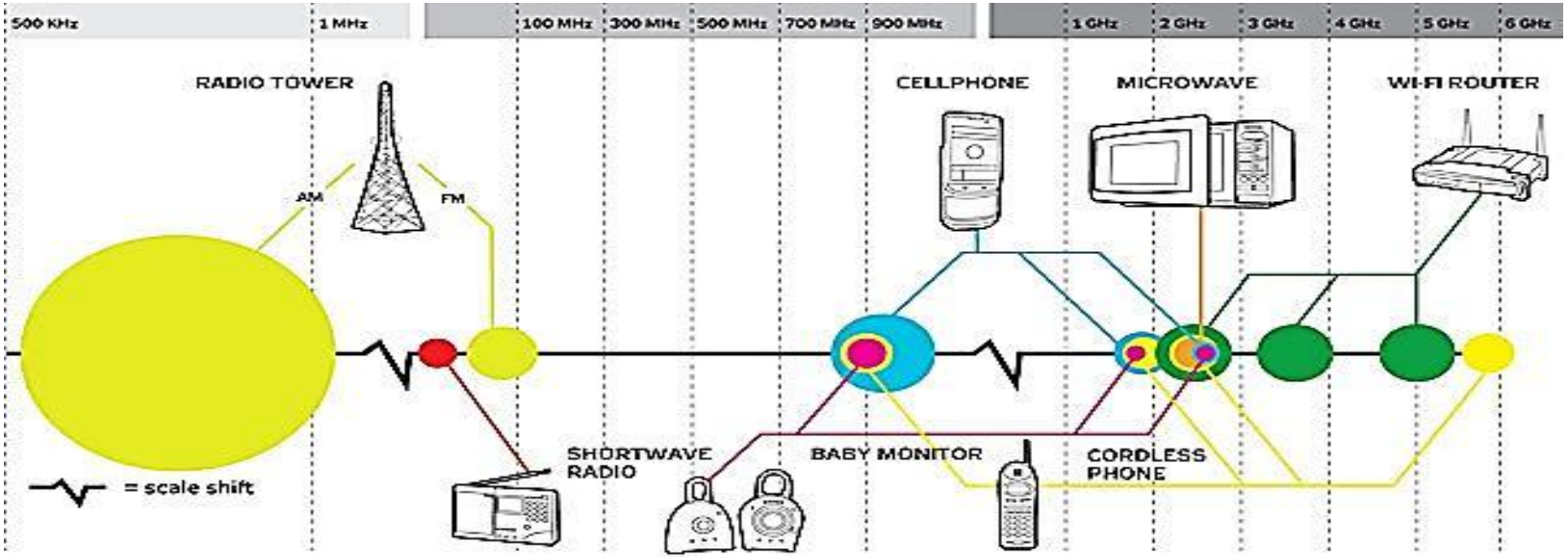


Wi-Fi QoS: 802.11e EDCA (iii)

- Where is QoS controlled in 802.11e?

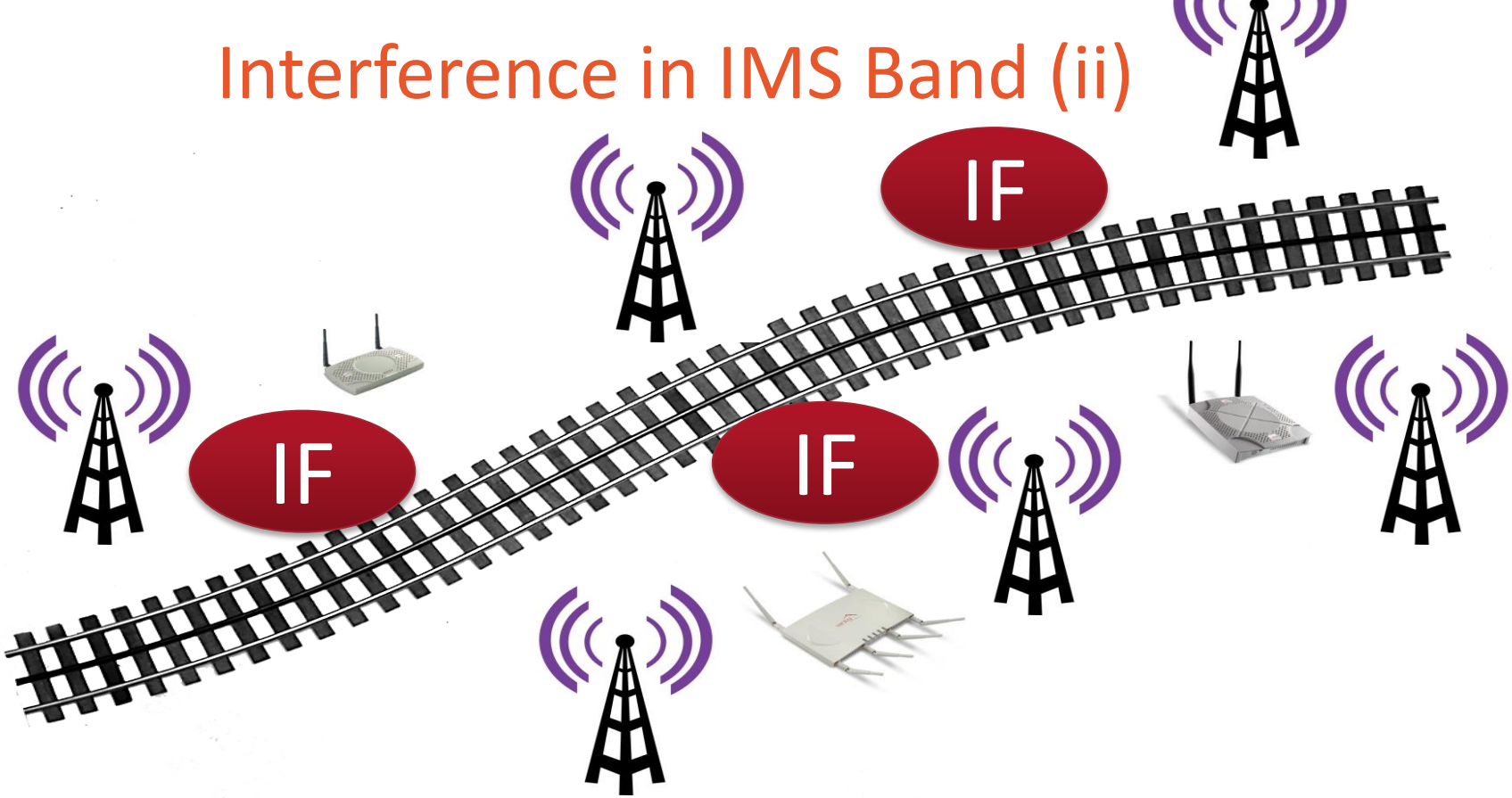


Interference in IMS Band (i)



Source: Popular Mechanics

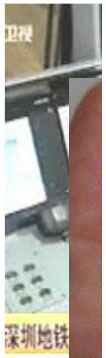
Interference in IMS Band (ii)



Problem 1 in CBTC Radi

Interference

Case 1: The train is stopped or degraded due passengers



Occurring condition	Passengers in carriage 1 or 6 (the first or last c the Internet .
Probability	• 10 times per line per day in first-tier cities • 1 time per line per day in second-tier cities
Cause	The 2.4 G frequency band MiFi used by passenger WiFi used by CBTC
Typical cases	• Shenzhen Metro Line 2 is stopped due to the us • In an internal test carried out by Shenzhen Subv train is stopped when three MiFi hotspot is enab

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NEWS • CHINA • TRANSPORT

Passenger Wi-fi freezes third Shenzhen Metro train in a week

Shenzhen Metro under fire about security of its wireless control system amid breakdowns

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UPDATED : Friday, 09 November, 2012, 4:10am

Passenger Wi-fi freezes third Shenzhen Metro train in a week

The Shenzhen Metro is facing mounting calls to resolve questions about its wireless control system, after a train came to a halt in between stations for the third time in a week.

In the latest incident, a train on the Huanzhong Line stalled twice in a tunnel between the Changlong and Buji stations during the morning rush hour on Wednesday, the *Southern Metropolis Daily* reported.

The train stopped at 8.40am for about two minutes before starting and stopping again.

The breakdown came after the Shenzhen Metro blamed interference by signals of passengers' Wi-fi enabled mobile phones with similar incidents on the Shekou Line on Monday and the previous Thursday. Mainland media has blamed the problem on the transport company's cost-saving move to operate its trains using the publicly- available 2.4-gigahertz wireless band - which is also used by consumer electronics.

It was unclear if the same issue contributed to the problem on the Huanzhong Line.

Neither the Shenzhen Metro nor the city's telecommunications authorities were available for comment yesterday.

Several passengers took to Sina Weibo to complain about being trapped on

RELATED TOPICS
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RELATED ARTICLES

China Digest, December 10, 2012
10 Dec 2012 - 12:00am

Shenzhen Metro shuts off 3G service for a day after trains inexplicably stop
17 Nov 2012 - 12:00am

SUCCESS story
27 Apr 2012 - 12:00am

HK should leave the

aused by Open-Band

degraded on the overhead railway or

verhead railway or ground segment

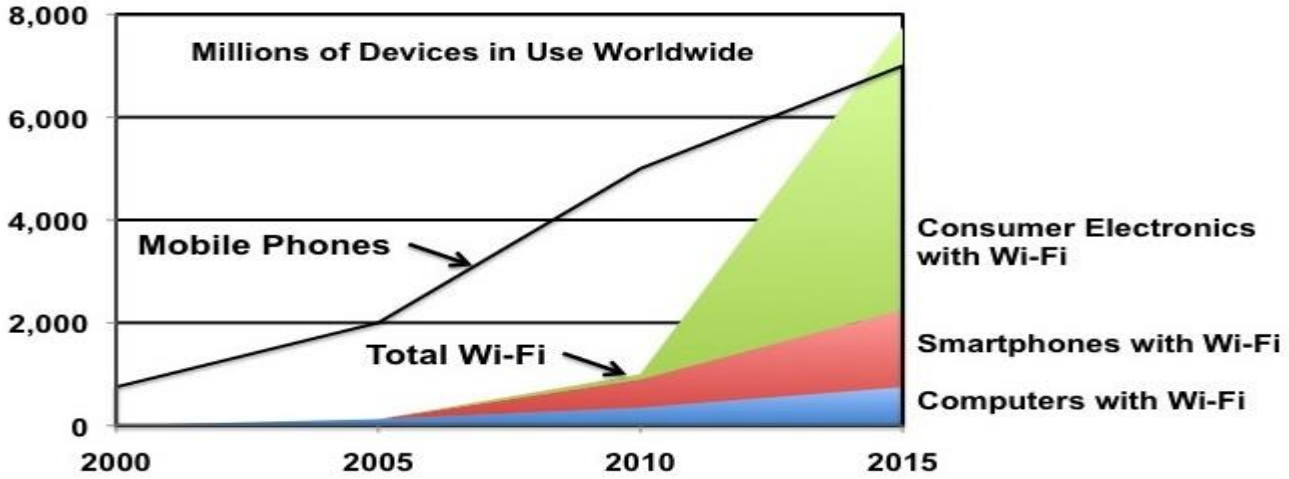
e following conditions:
video services are performed in the near AP hotspot.
lical instrument is turned on.

er medical instrument occupies the WiFi channel.

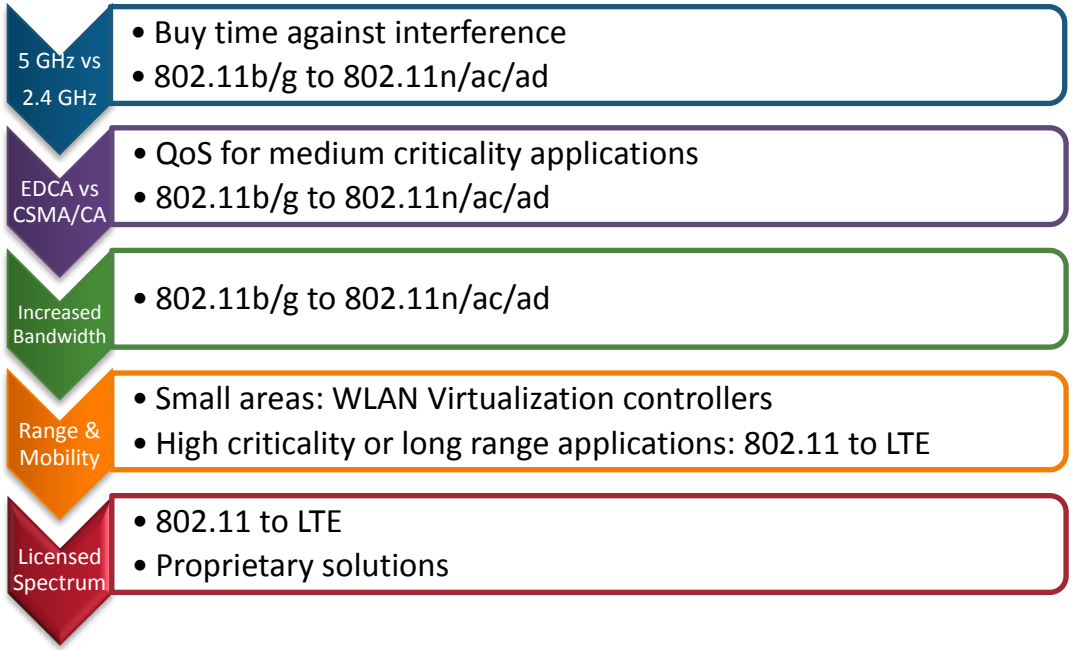
stopped when passing through a overhead railway due to
wer microwave medical instrument.
ro Line 2 constructed by Insigma is stopped in a ground segment

众合 UNITED

Interference in IMS Band (iii)



Prospective Solutions



Latest Developments

Zhengzhou Metro L1

- CBTC over LTE trial (ASTS/Huawei)
- If successful, operational in Q4 2014.

郑州地铁 ZHENGZHOU SUBWAY

Alstom Valenciennes

- CBTC over LTE pilot
- Joint Alstom – Huawei exercise

ALSTOM

MTR Hong Kong

- GE CBTC over LTE trial
- Operational network
- Ericsson eNodeB
- Huawei OBU

MTR港鐵

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Thank you

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Titan Snapshot

- Independent Consultancy
- Australian owned
- Established in 2003
- 60 employees in Perth and Brisbane offices

Services

- Train Control Systems
- Telecommunications
- IT consulting
- Project and construction management

Main Rail Projects

- PTA Radio Replacement
- Perth city Link
- Pilbara Rail (Rio Tinto)
- Brookfield Rail
- Southern Suburbs Rail

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