Experiences from weekly sports broadcasts over 5G - what's possible and what isn't yet.

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Who are Open Broadcast Systems?

- Company specialising in software-based encoders and decoders for Sport, News and Channel contribution (B2B)
- Based in Central London
- Build everything in house:
  - Hardware, firmware, software
- Not to be confused with:

Open Broadcaster Software

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Who are Nemeton?

- Ireland's largest independent production company, specialising in live sport OBs
  - HQ based in the South of Ireland
  - Office in Glasgow, Scotland
- Main Clients Irish Language Broadcaster TG4 & Scots Gaelic Broadcaster BBC Alba
- Fleet of 4 SNG Trucks (Ku Band)
- 5 Antenna Teleport

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Where are we today with 4G?

- Over last ten years massive growth of cellular bonding solutions
  - Especially in newsgathering (Talking heads)
  - Some use in sport (mainly web)
- Generally a single-vendor walled garden solution
  - Adaptive bitrate solutions (sometimes very aggressive)
- Not comparable to satellite/fibre for higher end productions
  - Adaptive bitrate ok for five mins of news reporting but for hours of sports is quite jarring
  - But do viewers actually notice?

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Why is 5G different?

- On paper, massive improvements in performance
  - 10-100x increase in bandwidth compared to 4G, comparable or better than fibre connections
  - 10x decrease in ping times, 4G ~30-50ms, 5G ~5-10ms. Again comparable to fibre
- Massive investment push from telco industry that broadcast can benefit from
  - Fierce competition in many countries
  - “build it and they will come” like 4G
  - Large numbers of cell towers

Fibre performance, anywhere

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Introduction to 5G

- 5th Generation of Mobile Cellular Communication Technology; 5G NR (New Radio)
- Why 5G? We cover many venues, most visited only once per year. Need satellite flexibility. Multi-annual fibre commitment not cost effective
- 5G comes in 3 Major Forms:
  - 5G NSA: Currently Live in Ireland on all networks
  - 5G SA: Under development in Ireland. Expected early 2023
  - DSS: Dynamically Shared Carrier between 4G/5G, typically on lower frequency bands like 1800MHz, upload performance very similar to 4G. Enables faster speeds without need for new antennae

5G NSA vs SA

- 5G NSA (Non-Standalone):
  - New 5G radios allow higher throughput, wider RF Bandwidths
  - New frequency bands, Band 78 (3.5GHz – 3.8GHz)
  - Core network still 4G Evolved Packet Core
  - Basically 4G but faster, reduced latency
  - mmWave, 6GHz+
- 5G SA (Standalone): Ground up Rebuild
  - Same radios & bands as NSA
  - New 5G Core, most offerings virtualised/cloud native
  - Enabling even higher throughput & lower latency
  - Network Slicing*

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5G Network Slicing

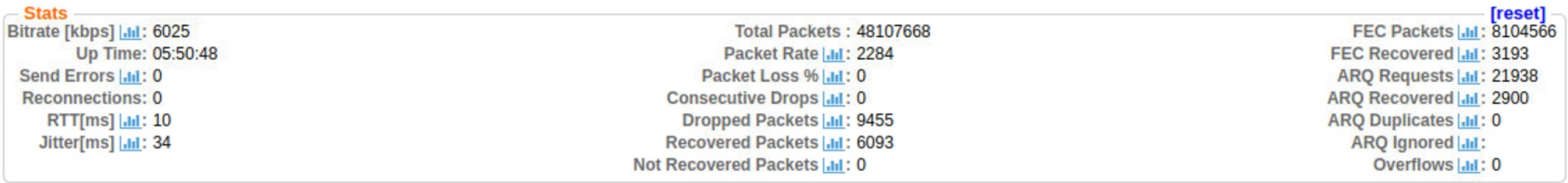
- Partition the 5G RF Carrier and create an IP pipe to your endpoint.
- Endpoint can be in the cloud or your facility; IPsec VPN
- QoS applied to the pipe giving guaranteed bandwidth, latency, packet loss. Not competing with the general public. No crazy fluctuations
- Many applications, including broadcast
- Unknowns: Pricing & Timeline. 5G Core needed

First Tests with 5G

- Bonded 3x 4G & 1x 5G connections
- 20 Mbps TS
- Worse packet loss than our single modem 5G broadcasts

Over 48 million video packets transmitted over @eir #5G from Croke Park for the All Ireland Hurling Final today using @OpenBroadcastSy, @ZixiNews and @elementaltech. @nemetontv

9:08 PM · Dec 13, 2020 · Twitter Web App



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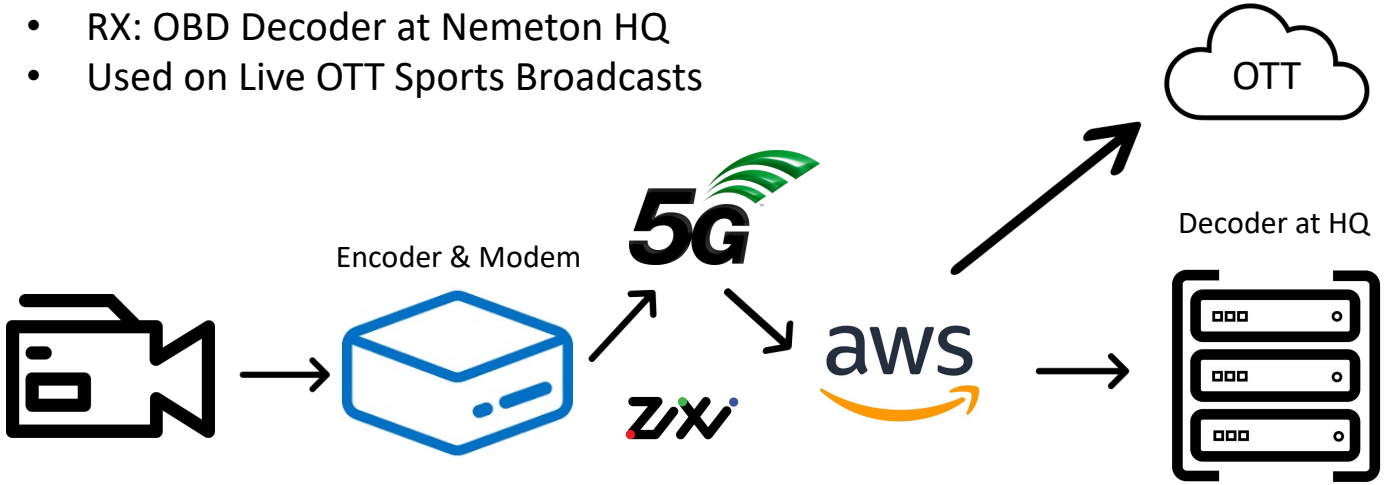
Current 5G TX Setup

- Ordinary 5G SIM, no QoS or Slicing
- OBE Encoder - 15 Mbps TS – Zixi Protocol
- Single Quectel RM500Q Modem, 4x Omnidirectional Antennas, 4x4 MIMO
- AWS Elemental Mediaconnect, EU-West-1 Datacentre
- RX: OBD Decoder at Nemeton HQ
- Used on Live OTT Sports Broadcasts



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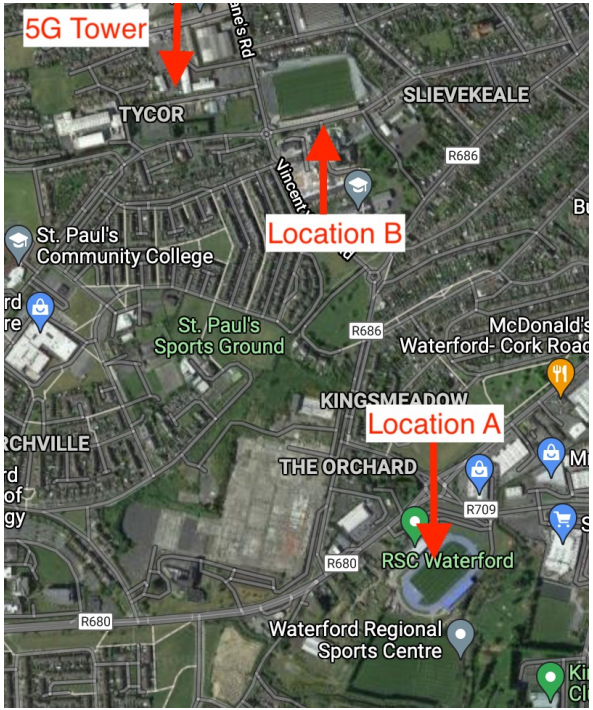
5G Locations

- Locations, distance to 5G Tower:
  - Location A 1km, non-Line of Sight
  - Location B 300m, Line of Sight
  - Location C 450m, non-line of sight (Croke Park, Dublin)



Venue	Network	Ping (ms)	Uplink (Mbps)	Downlink (Mbps)	Date
RSC (Location A)	Network A (4G)	23	30	66	16/06/2021
Waterford City	Network A (5G)	14	98	357	16/06/2021
	Network B (4G)	20	47	71	16/06/2021
	Network C (4G)	20	34	28	16/06/2021
	vDSL	13	19	94	16/06/2021

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5G Tower Serving Cell

Huawei integrated 5G Radio/Antenna
3.6GHz, 32 x 32 Massive MIMO

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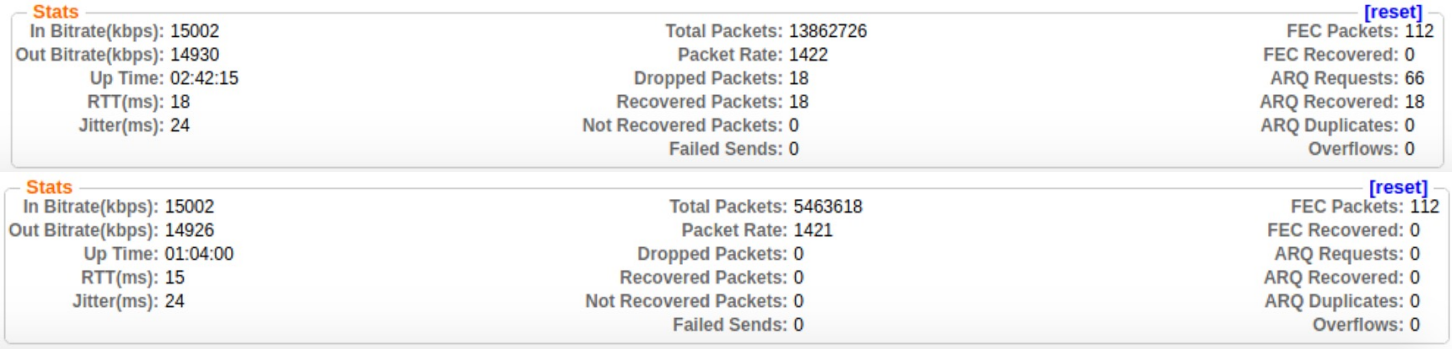
Results

- In most cases Zero Packet drops over 2+ hours!
- Average RTT ~15ms, lowest observed 9ms
- Jitter varies, normally ~20ms. Occasional 250ms+ bursts (at a guess due to TDD on Band 78)



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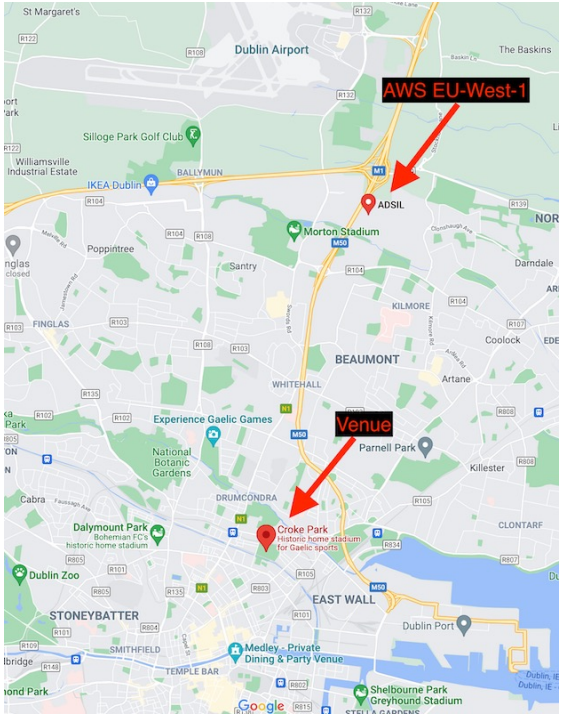
Results & Next Steps

- 9ms Ping seen at venue very close to the data centre (5km/3miles)

- Push up Bitrate & Reduce buffer
- Goal is 30 Mbps & <250ms Buffer comparable to Satellite
- Remote Production: 100 Mbps+ using bonding, multiple camera angles



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Future: 5G Remote Production

- 5G delivering ~5-10ms RTT in many cases
- Encoding achievable at ~100ms end-to-end (H.264)
- Doable today, apart from large network ping spikes

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Future: Replacing in-car RF links with 5G

- In car cameras often use high-end RF equipment
- Racing semi-professionally at famous tracks such as Le Mans, Spa and Magny Cours
- In-car video used as part of team's race
- Latency more important than picture stability
  - Ok to glitch under a bridge or in a tunnel and come back
- Challenging content for encoder, track + multiview
  - Can't adapt bitrate down and then wait 30s to come back
- Currently bonded 4G with ~3-5s latency
  - For non-interactive, strategic decisions
- 5G could cut this to ~100-200ms
  - Can make interactive, instant decisions

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