University of BRISTOL

AI and Massive MIMO

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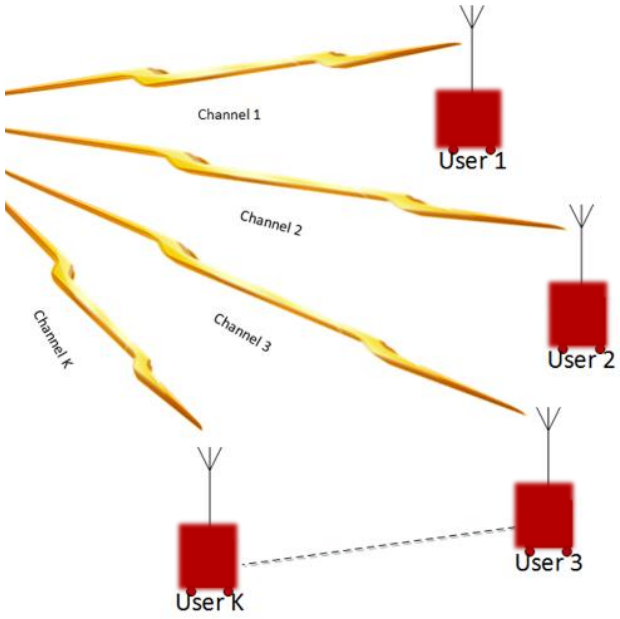
UK Spectrum Policy Forum
6G: Technology Enablers for Spectrum & Energy Efficient Wireless Access
Wednesday 26th May 2021

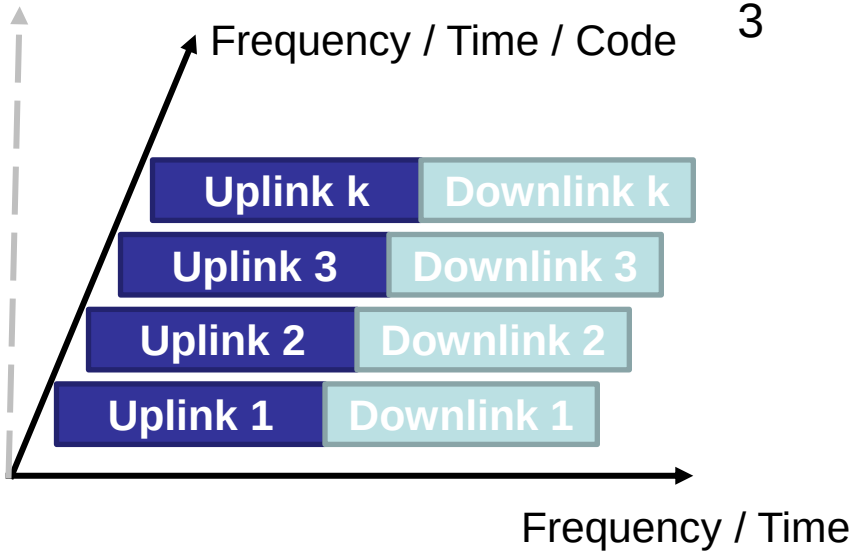
bristol.ac.uk/smart **bristol.ac.uk/engineering/research/csn/**

Summary

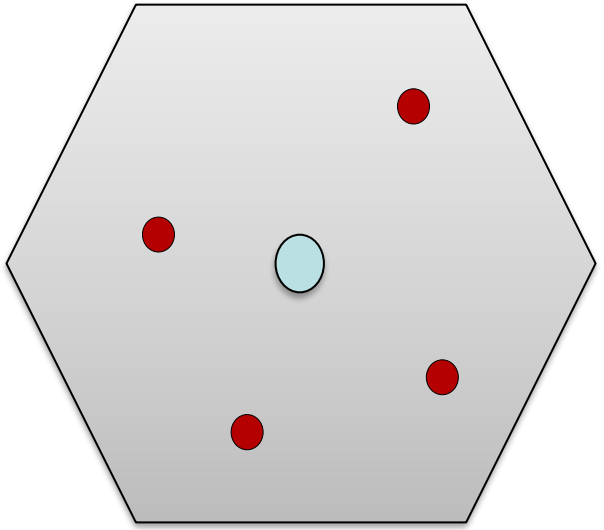
- Massive MIMO
- UoB Massive MIMO Testbed
- Channel Hardening & User Grouping
- AI Massive MIMO
- AI Massive MIMO Testbed

Conventional Cellular Radio



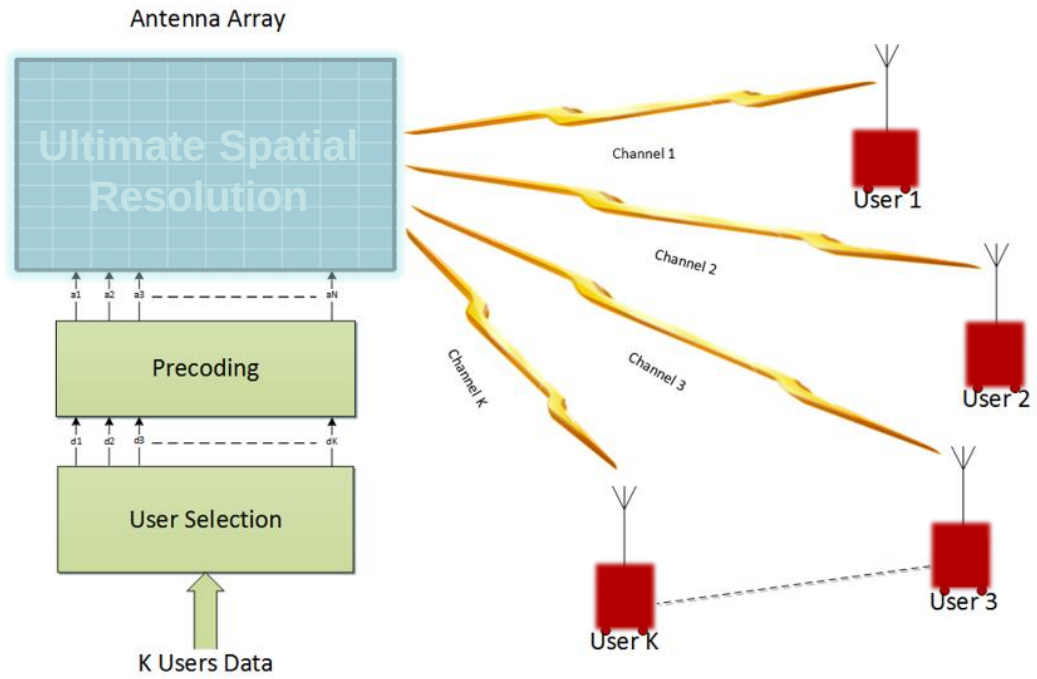


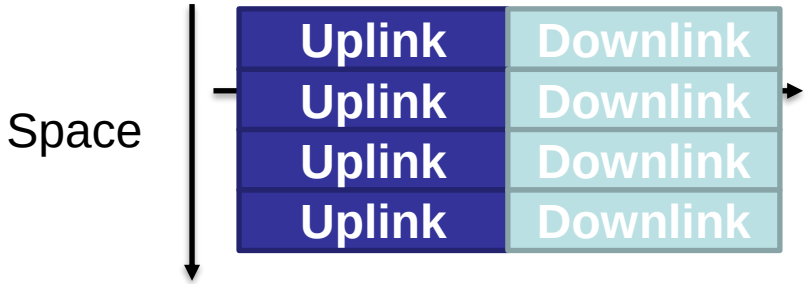
Cellular View

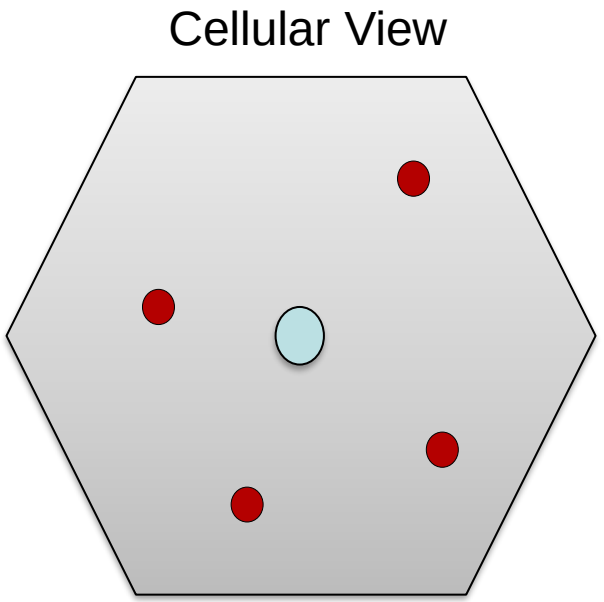


- Multiple users share same time, frequency or code resources

Exploiting the Spatial Domain





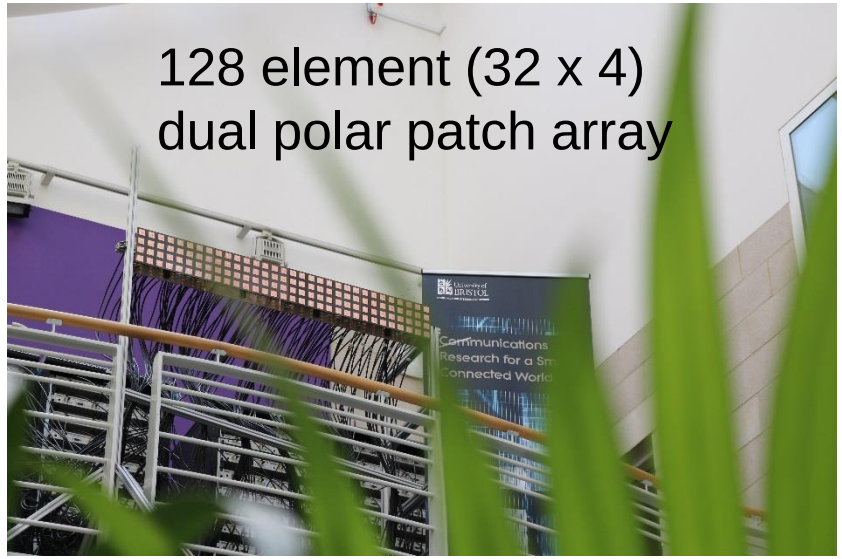


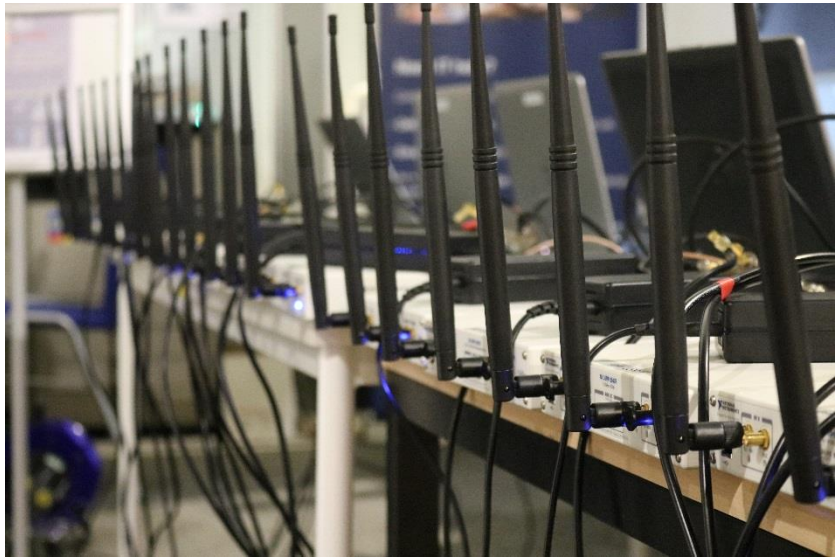
- Accurate spatial multiplexing for multiple access
  - Same Radio Channel, Same time (slot)
  - Space Division Multiple Access (SDMA)
- Increased spectral efficiency and network capacity

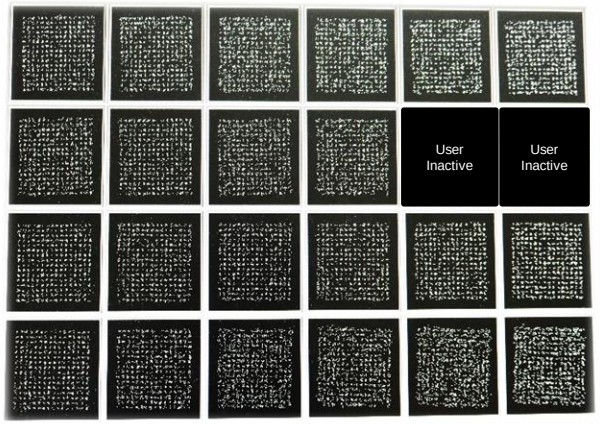
UoB Massive MIMO test-bed

- 128 Programmable Radio Heads
- 20MHz Bandwidth
- ‘LTE’ like interface
- 1.2 – 6.0GHz Carrier
  - 3.51GHz used
- 4 Racks of 32 Radios
  - Data consolidation
- Channel processing
  - 24 Clients
- Massive MIMO signal processing supporting
  - 12 clients

Real-time Evaluation (Wed 11th May 2016)





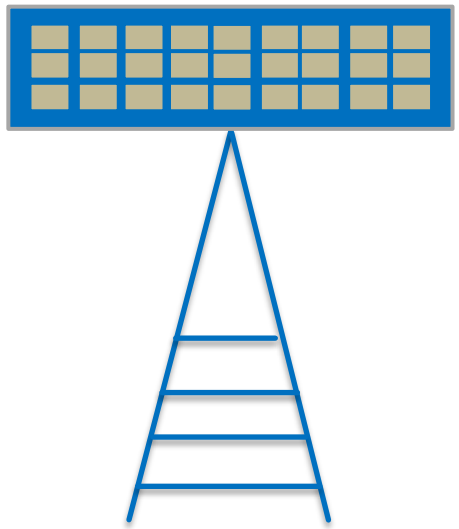


22 users running 256 QAM in 20MHz Channel
Using same frame structure as before:

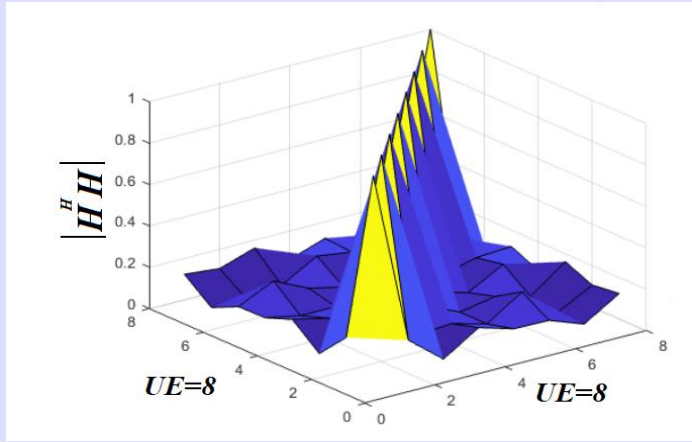
- 145.6 bits/s/Hz
- Sum rate of 2.915 Gbps

http://spectrum.ieee.org/tech-talk/telecom/wireless/5g-researchers-achieve-new-spectrum-efficiency-record
http://www.bris.ac.uk/news/2016/may/5g-wireless-spectrum-efficiency.html

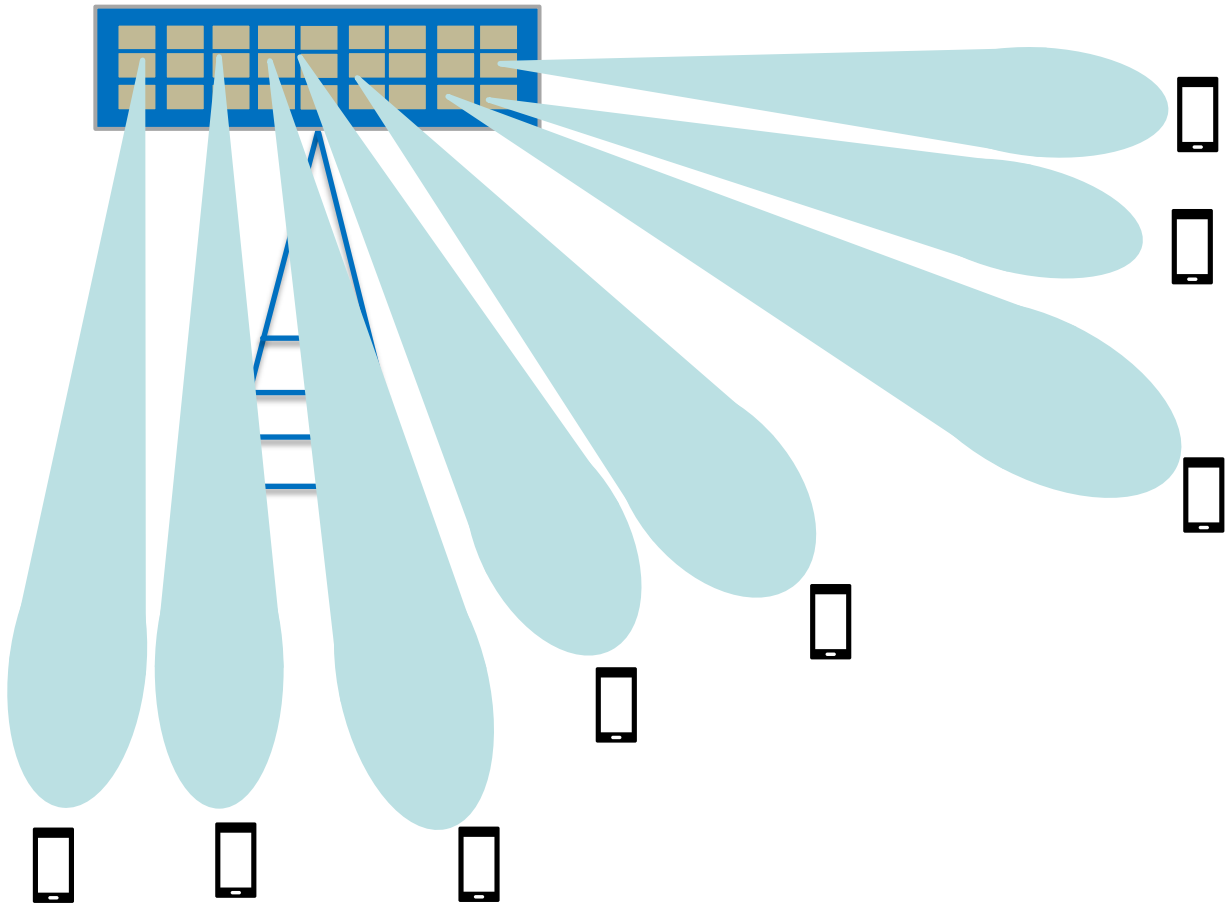
Channel Hardening Effects & Pairwise Orthogonality



Accurate CSI +



Channel Hardening Effects & Pairwise Orthogonality



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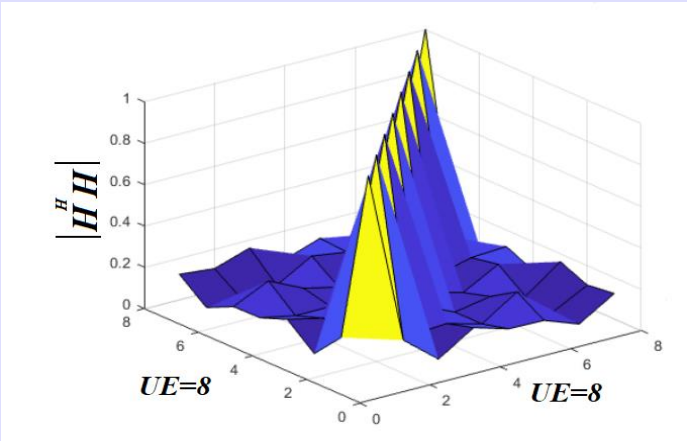

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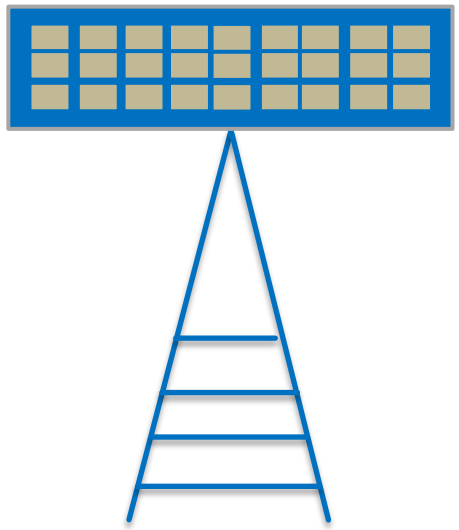

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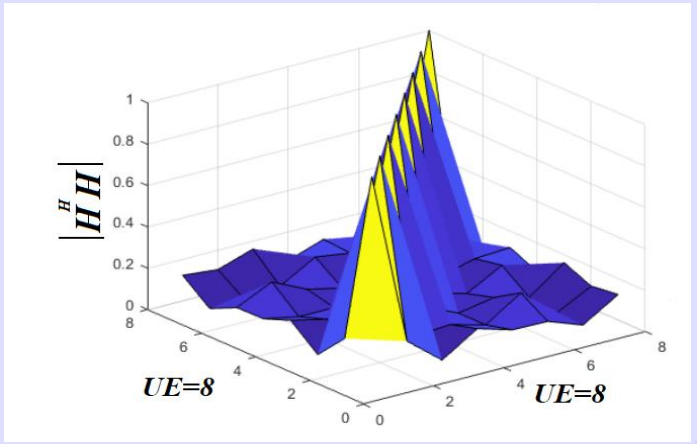
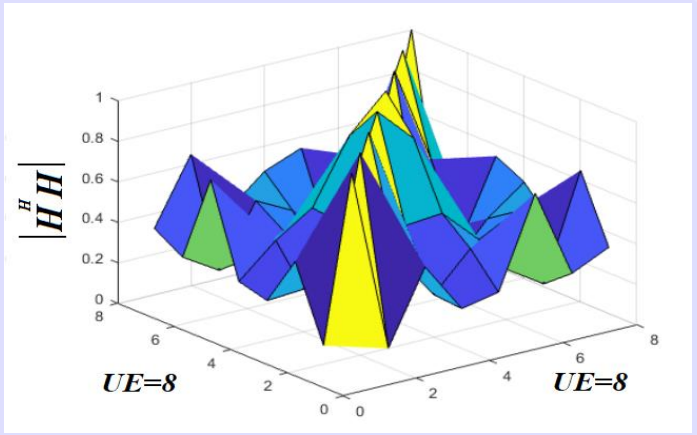


OR

Accurate CSI +



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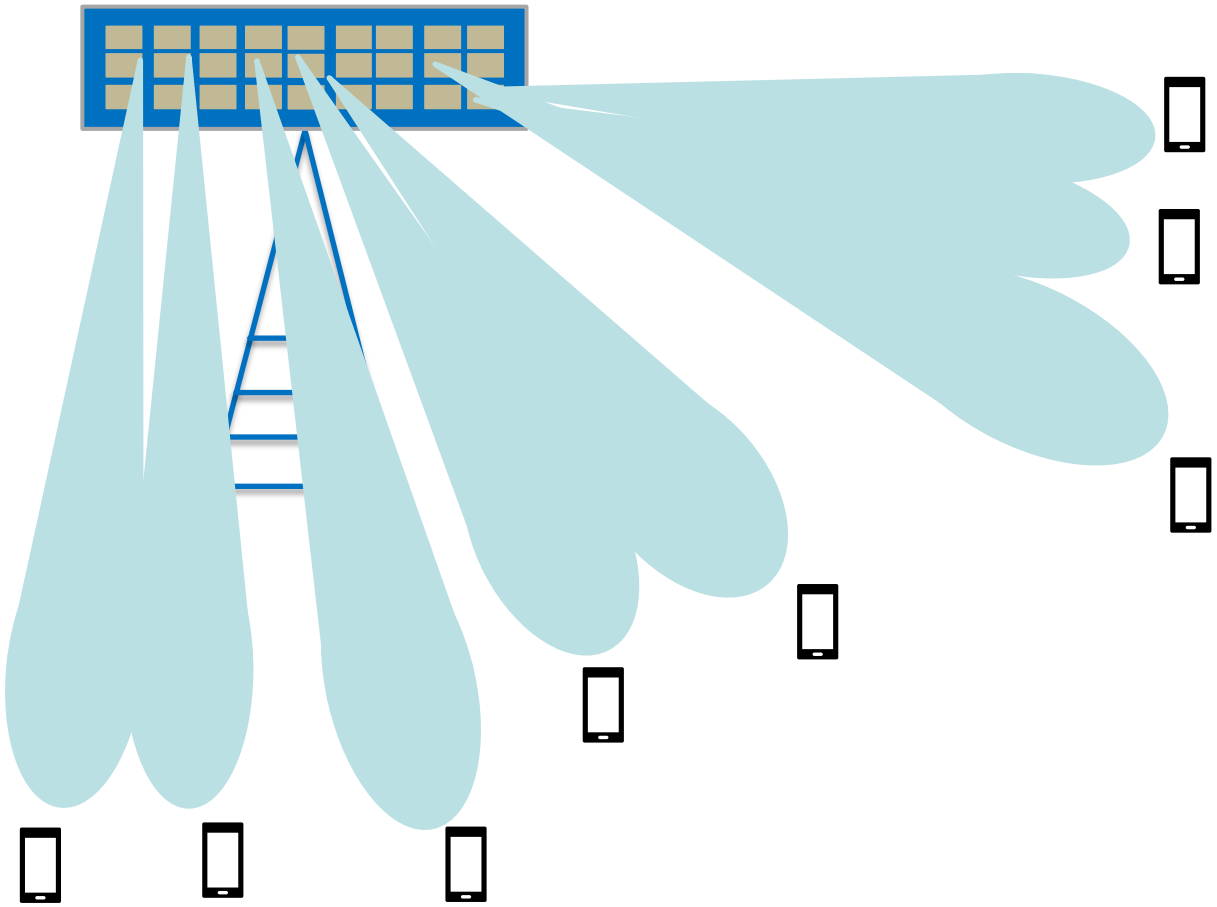

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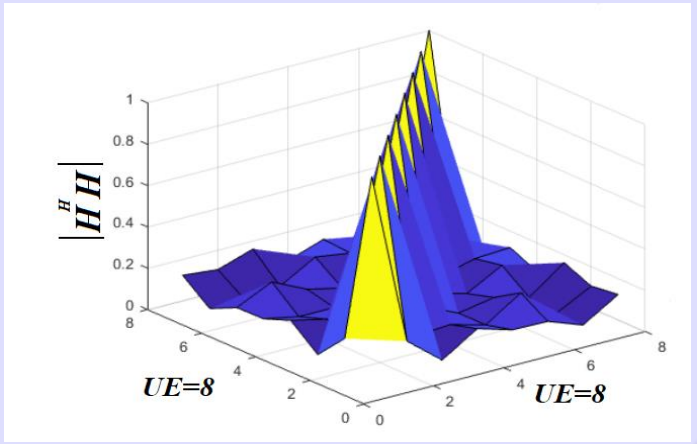

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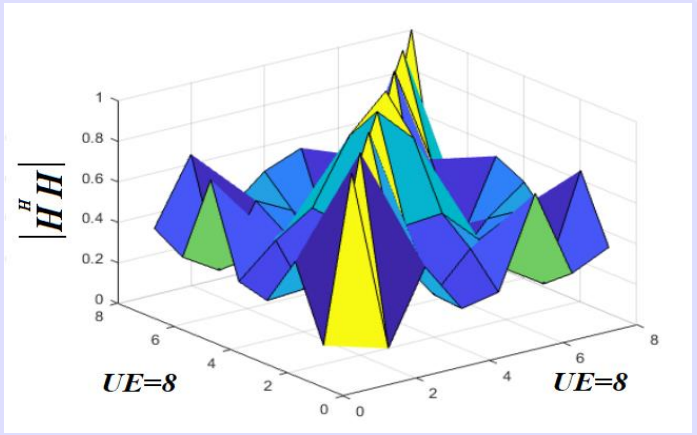

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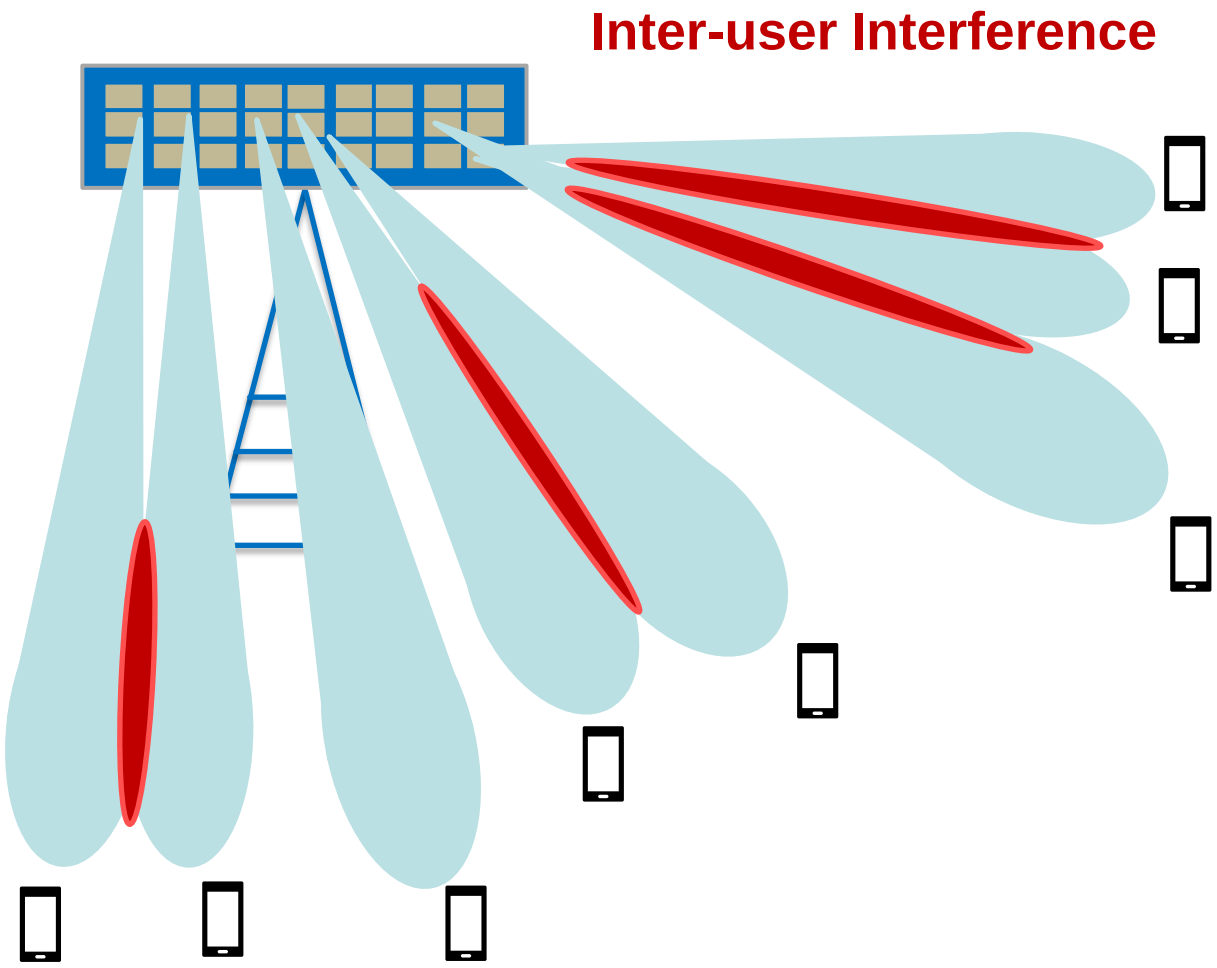

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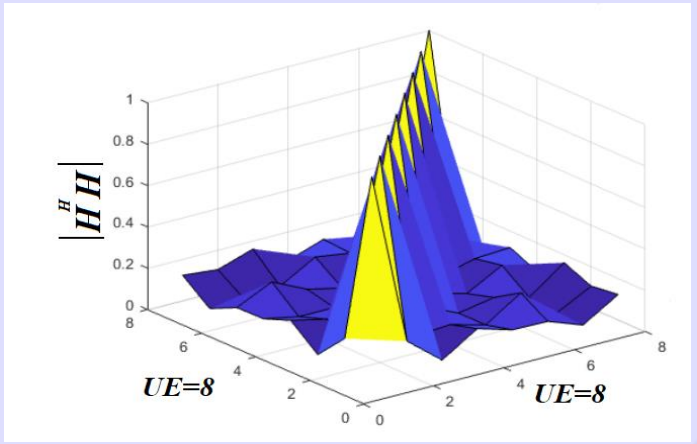

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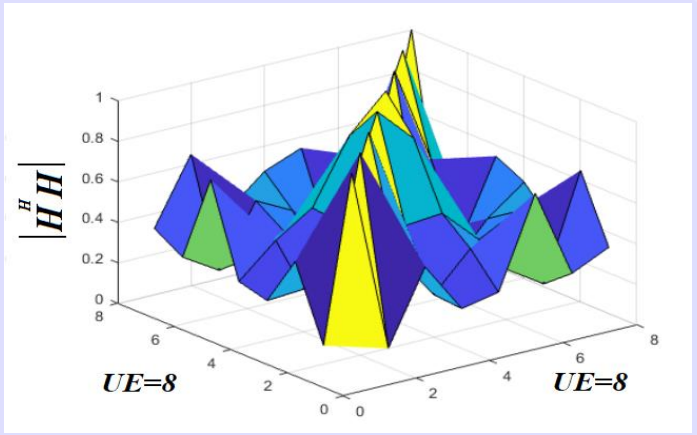


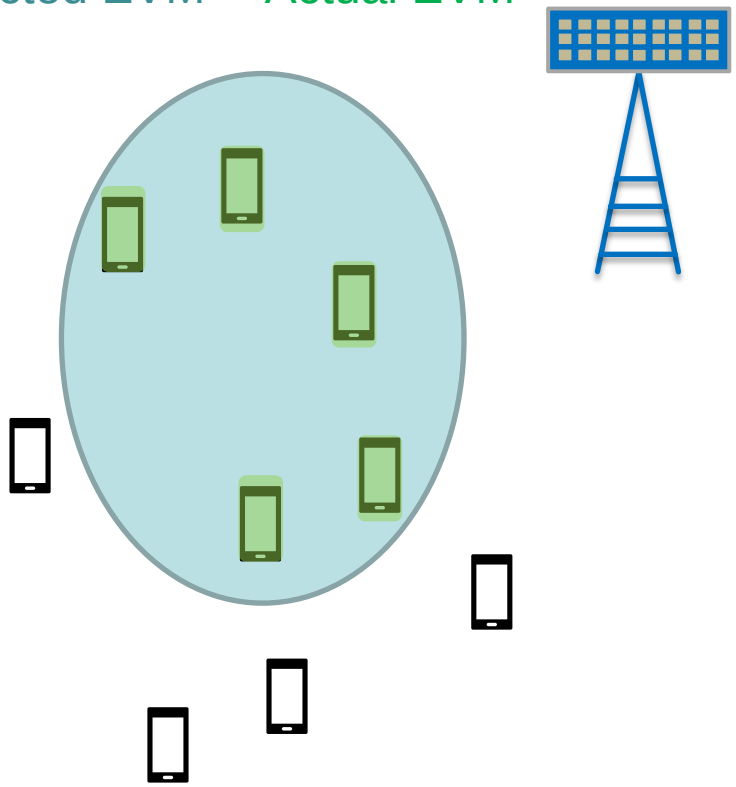
EVM Prediction Method for a Single Cell Ma-MIMO

Predicted EVM ≈ Actual EVM

- Predicting the EVM value for different number of users without the need of retransmitting data each time the number of users is changed.

$$SINR \approx \frac{1}{EVM_{RMS}^2}$$

- This method allows the EVM to be used for the Ma-MIMO algorithms to cover the impact of inaccurate CSI and Spatial Correlation.
- This EVM prediction method can be used for user grouping and power control algorithms.



DCMS 5G Testbeds & Trials Programme 5G

Layered Realities Weekend (17th & 18th April 2018)

http://www.bristol.ac.uk/news/2018/march/5gexperience.html

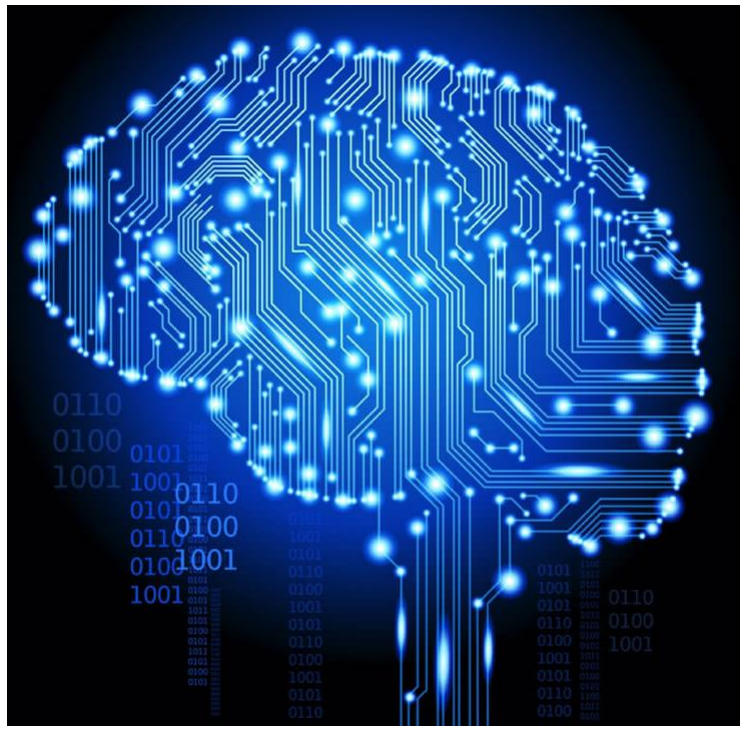
Real-time Results for User Grouping

	Max EVM		Number of Groups		MCS	
	UL	DL	UL	DL	UL	DL
Maximizing SE	6	8	4	6	64-QAM	16-QAM
Link quality	12	12	2	4	QPSK	QPSK
Maximizing number of simultaneous users	16	16	1	3	QPSK	QPSK
Deactivate user grouping	16	35	1	1	QPSK	QPSK

	Uncoded UL throughput (Mbps)	Uncoded DL throughput (Mbps)	Spectral efficiency (bits/s/Hz)
Maximizing SE	182	64	12.3
Link quality	135.3	53.2	9.4
Maximizing number of simultaneous UEs	84	58.6	7.1
Deactivate user grouping	84	0	4.2

Applying AI to Massive MIMO

- Investigate the potential benefits for using AI in Massive MIMO.
  - ✓ Increasing the spectral efficiency.
  - ✓ Reducing overheads & latency.
  - ✓ Covering the impact of inaccurate CSI.



AI Massive MIMO Project

Title: AIMM (AI-enabled Massive MIMO)

Clusters: UK, Germany, France, Canada

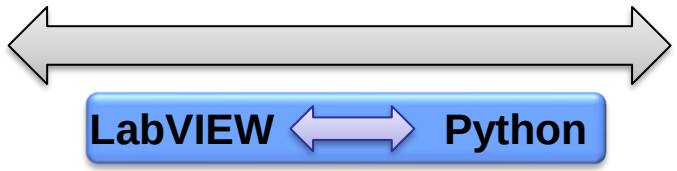
Duration: 2 years

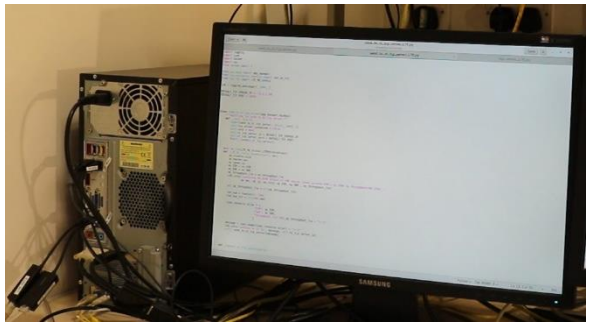
Work-Packages: 6

Website: https://www.celticnext.eu/project-aimm/

Centralised AI Massive MIMO testbed

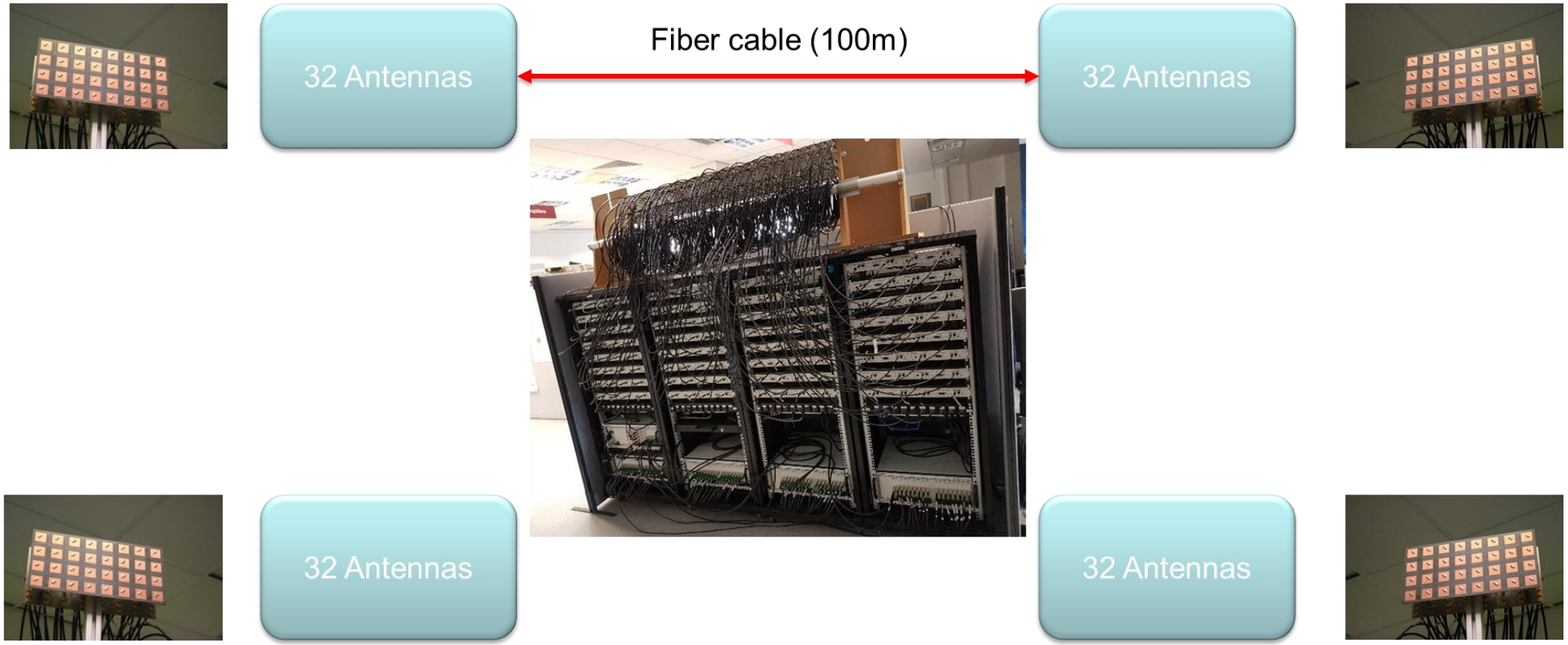
- Establishing data transfer connection between massive MIMO testbed and external AI machine.
- Creating an interface between the massive MIMO testbed and the external AI machine (LabVIEW & Python).
- Controlling the massive MIMO testbed through the external AI machine.





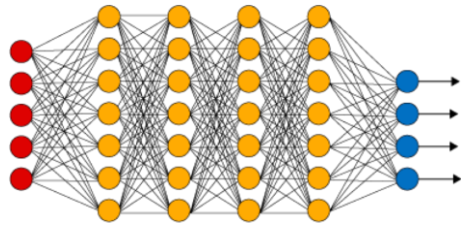
Distributed AI Massive MIMO testbed

- Splitting the massive MIMO testbed into four racks, where the distance between any rack and the main rack is 100 meters.



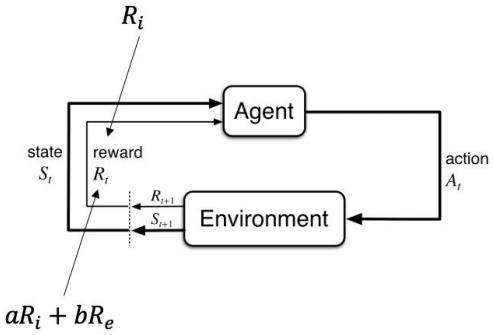
Reinforcement Learning Training Using Massive MIMO testbed

- Mapping I/O (state, reward and action) between WP6 (Testbed and Demonstration Development) and WP4&WP5 (AI for radio resource optimisation & AI for network operation and management).



- Online technique: training the agent at external AI machine in real-time.

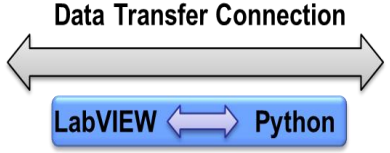
- Hybrid technique:
  - Agent is at the massive MIMO testbed.
  - Training the agent at external AI machine (offline).

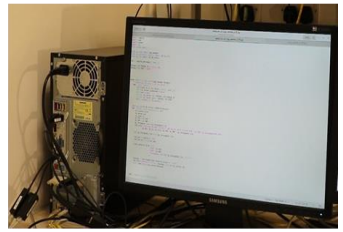


- Power Control and User Grouping & Scheduling.

  Consider the Impact of inaccurate CSI.

  Dynamically optimise Quality of Service for multiple users.





Any Questions?