

Can New Physical Layer Approaches Enable Massive Resource Sharing?

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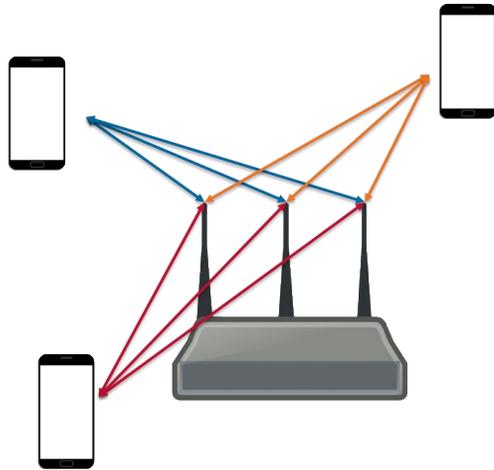
The need for Extreme Resource Sharing

According to **Global Mobile Data Traffic Forecasts**:

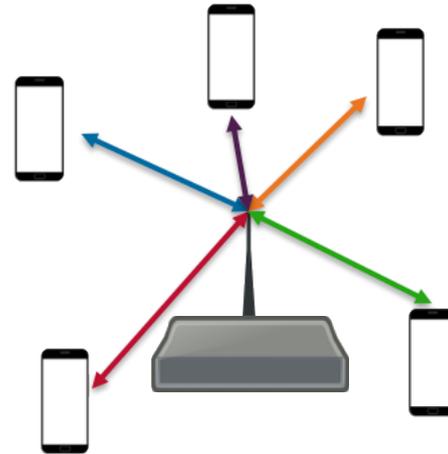
- ❑ Almost **half a billion** (429 million) mobile devices and connections **were added in 2016**
- ❑ Globally, there were 325 million wearable devices (a sub-segment of the machine-to-machine [M2M] category) in 2016
- ❑ There will be **11.6 billion mobile**-connected devices **by 2021**, including M2M modules—exceeding the world’s projected population at that time (7.8 billion)

We need to support these devices despite the actual limited “resources”

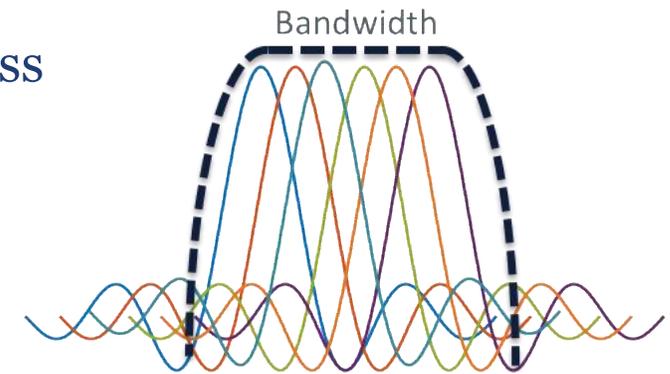
Form “Orthogonal” to “Non-Orthogonal” Transmission



Aggressive Spatial Multiplexing



Non-Orthogonal Multiple Access



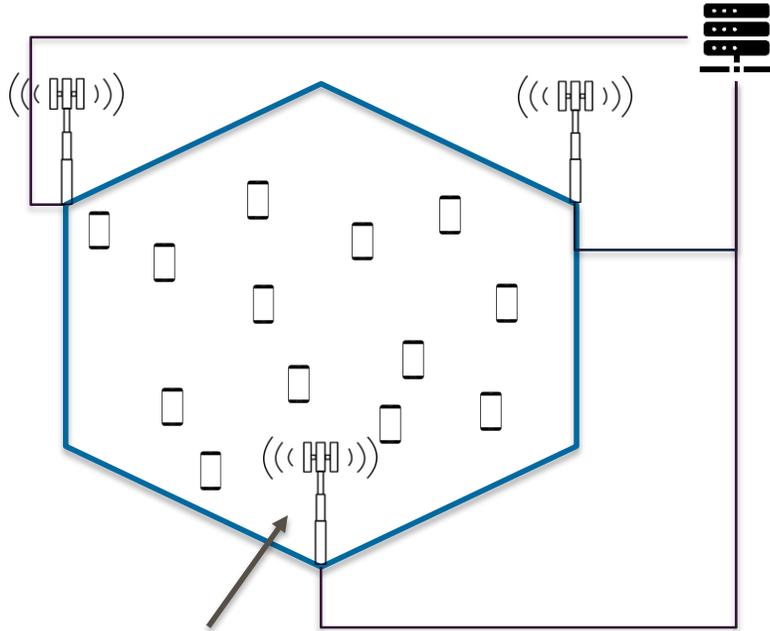
SE-FDM

There is a need to **revisit** the **Maximum-Likelihood** detection problem

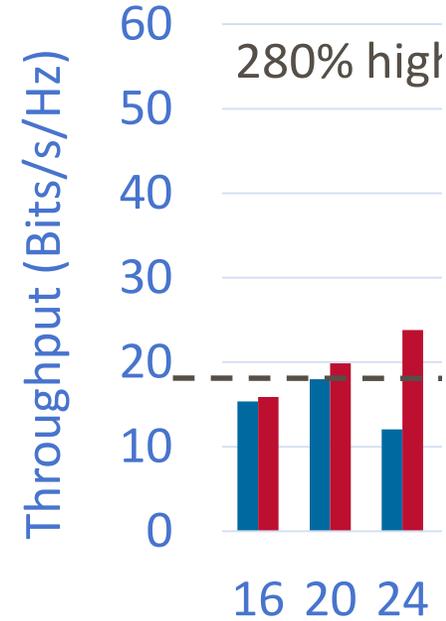
The Need for Parallelization

Base-Band-Pool

Uplink: 3 x 8-antenna RRH; 4-QAM, 1/2 rate FEC



8-antenna Remote Radio Head (RRH)



Concurrent Information Streams

■ Zero Forcing

280% high



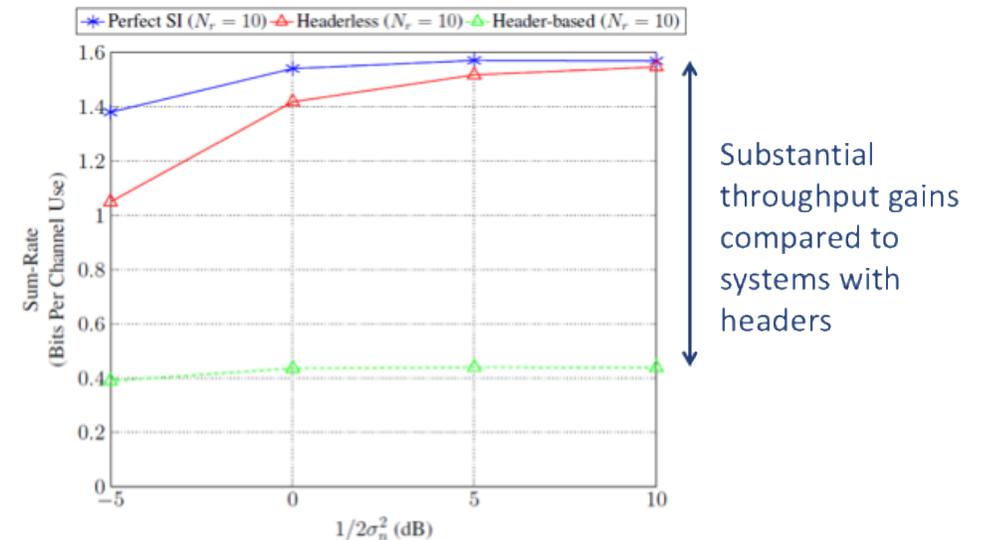
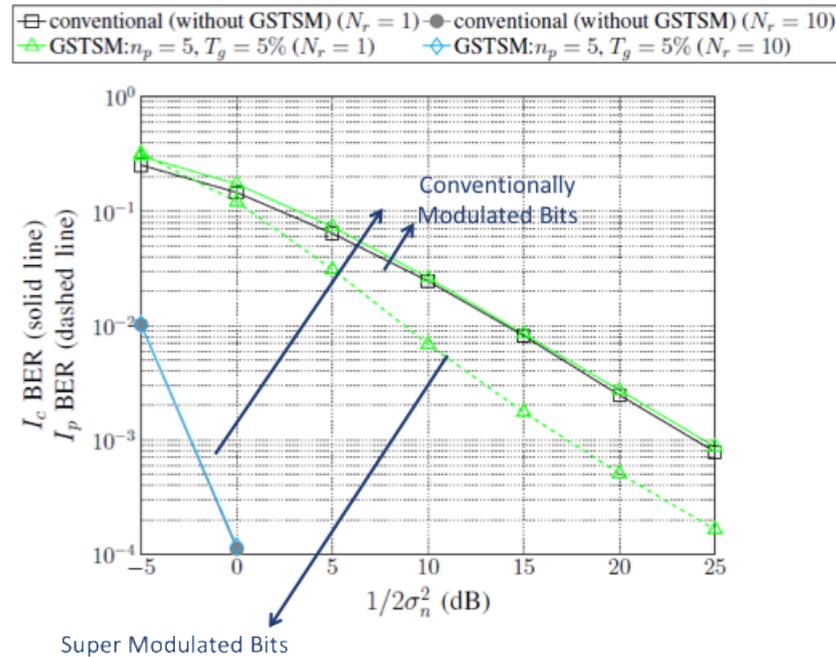
“Overloading-factor” of 2.2 without any specific non-orthogonal multiple access scheme

Simulations utilize the 5G close-in (CI) free space reference distance model with a path loss exponent $\alpha=2.8$ and a shadowing standard deviation of $\sigma=8.3$ (urban microcell, NLOS). The UEs transmit with a TX-power of 0dBm.

Based on: C. Jayawardena and K. Nikitopoulos “Massively Parallel Detection for Non-Orthogonal Signal Transmissions” in IEEE Globecom ET5GB workshop 2018

Low-Latency and Highly Reliable Transmission

- Generalized **Space-Time Super-Modulation (GSTM)** enables highly-reliable, one-shot transmission without any needing for headers.
- By exploiting the spatial and temporal domains it can transmit an **additional low-rate and highly reliable information stream** by super modulating (SM) information on top of traditionally encoded sequences.



Achievable sum-rate in “Multi-User Environment with Two-Colliding Users” (GSTSM, with rateless coding and $K=200$, and 9 ID bits)
 GSTSM with $N_r=10$ can provide nearly optimal rates

* With $N_r=10$, no error has been observed for super-modulated bits when transmitting 10^5 information packets
 * $2 \times N_r$ Rayleigh channel, conventional information is BPSK modulated

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 Raptor's inner LT code: Raptor RFC 5053

- **New Physical Layer approaches** have the potential to enable **extreme resource sharing**
- **Parallelization** and **algorithmic-architecture co-design** is likely to play a significant role in future networks (i.e., use communication theory in conjugation to hardware design)
- **Elastic Approximate Computing** methods **that massively parallelize the fundamental maximum likelihood detection problem**, are promising candidates in order to break the the walls imposed by hardware limitations, and to give rise to **new, more efficient, non-orthogonal**, transmission approaches