Cost Efficiency Maximization in Cloud-RAN

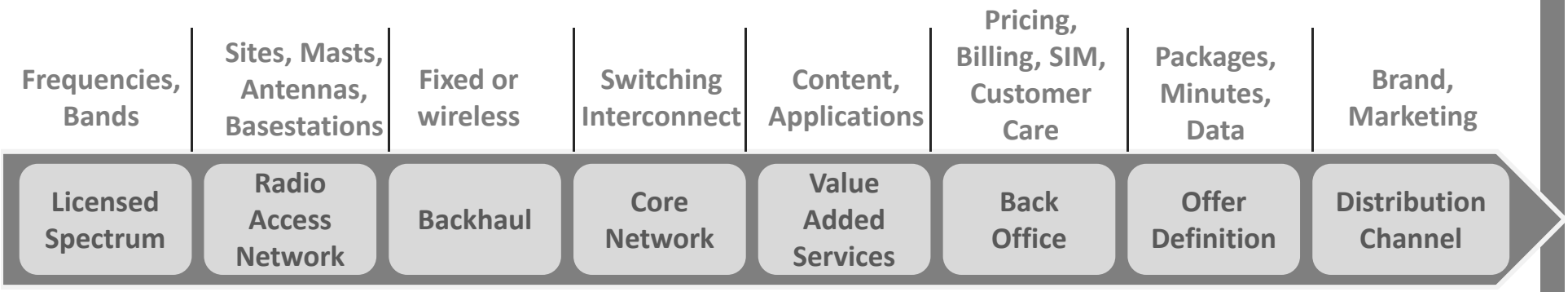
Ismael Gomez

11th March 2014, WInnComm, Schaumburg, IL

CTVR / the telecommunications research centre

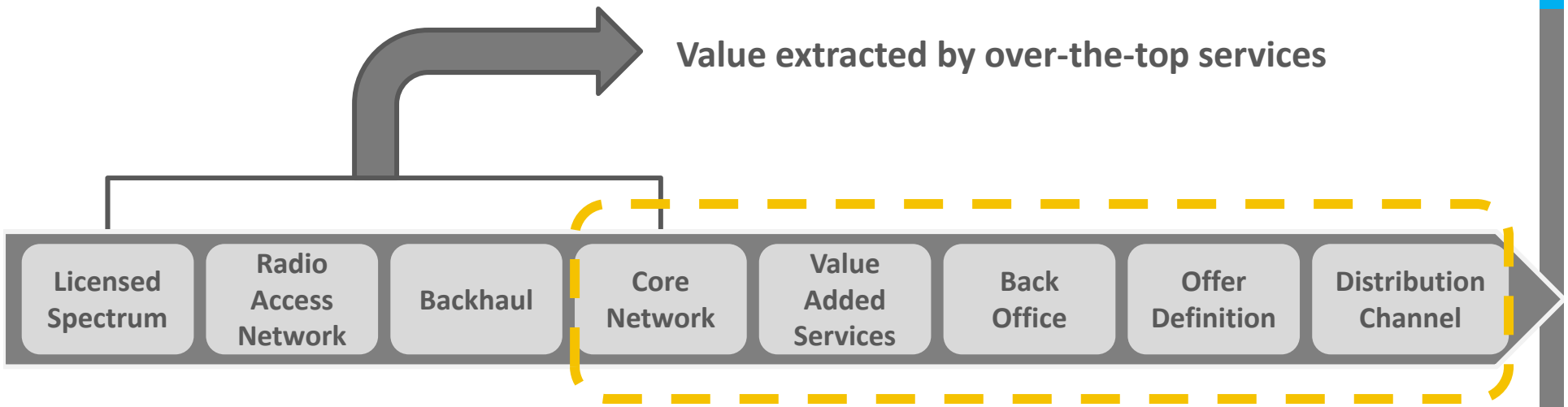
TRINITY COLLEGE DUBLIN
COLÁISTE NA TRÍONÓIDE, BAILE ÁTHA CLIATH
THE UNIVERSITY OF DUBLIN

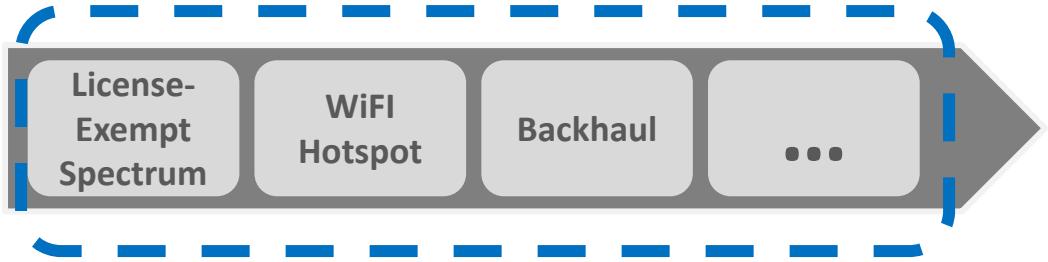
The Traditional MNO Value Chain



L. Doyle et al. "Spectrum Without Bounds, Networks Without Borders," ***Proceedings of the IEEE,*** **March 2014**

Emerging Issues in the Value Chain



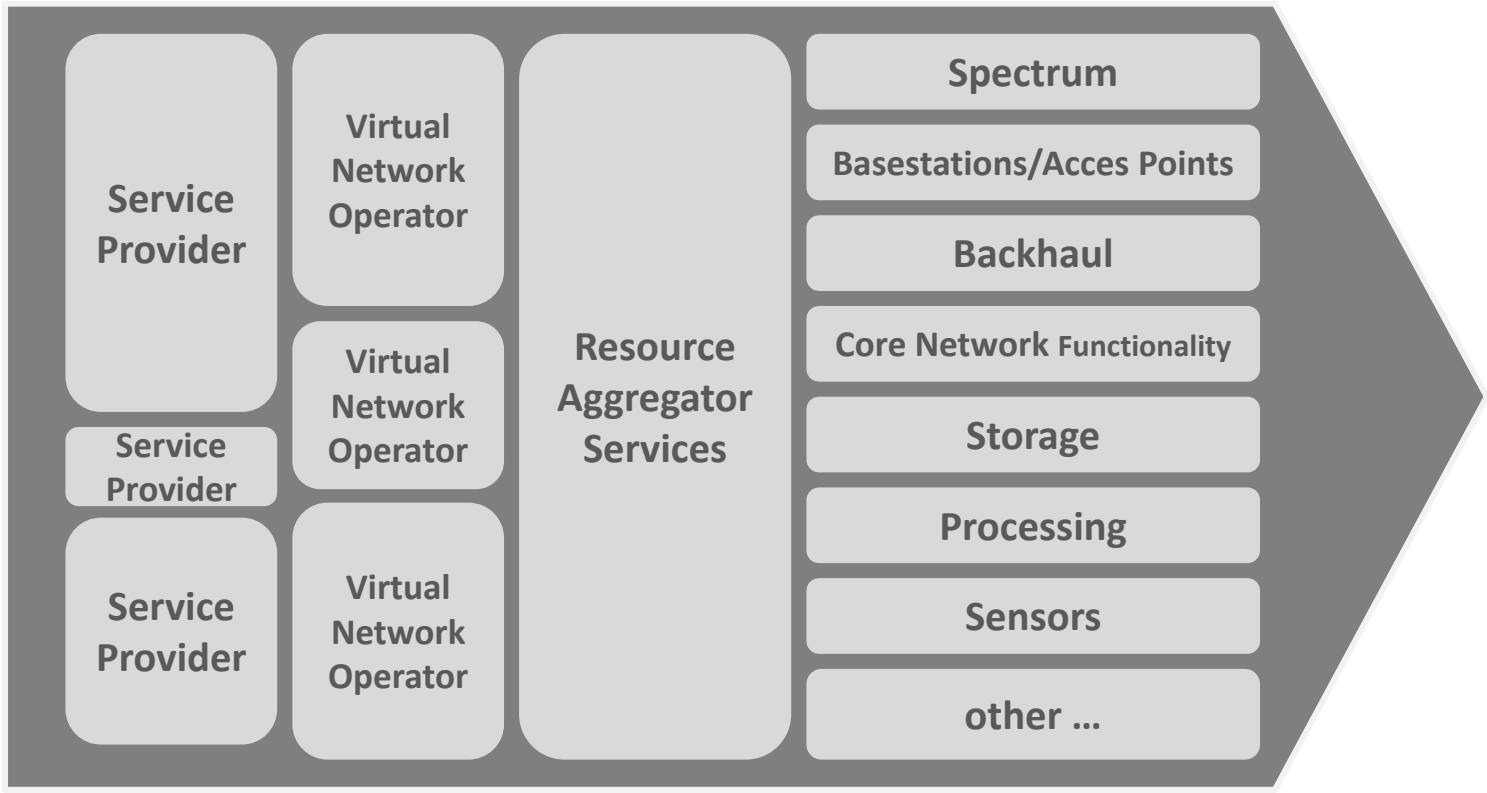


Challenges in the provisioning of networking infrastructure

- Increasing complexity and expense of new technologies
- Speed at which these new technologies emerge
- Coverage in remote areas
- Revenue extracted via over-the-top services (e.g. Whatsapp, Skype)

To respond to these large costs we see a growth in the sharing of the ownership and control *within* the infrastructure

The Resource Sharing Concept

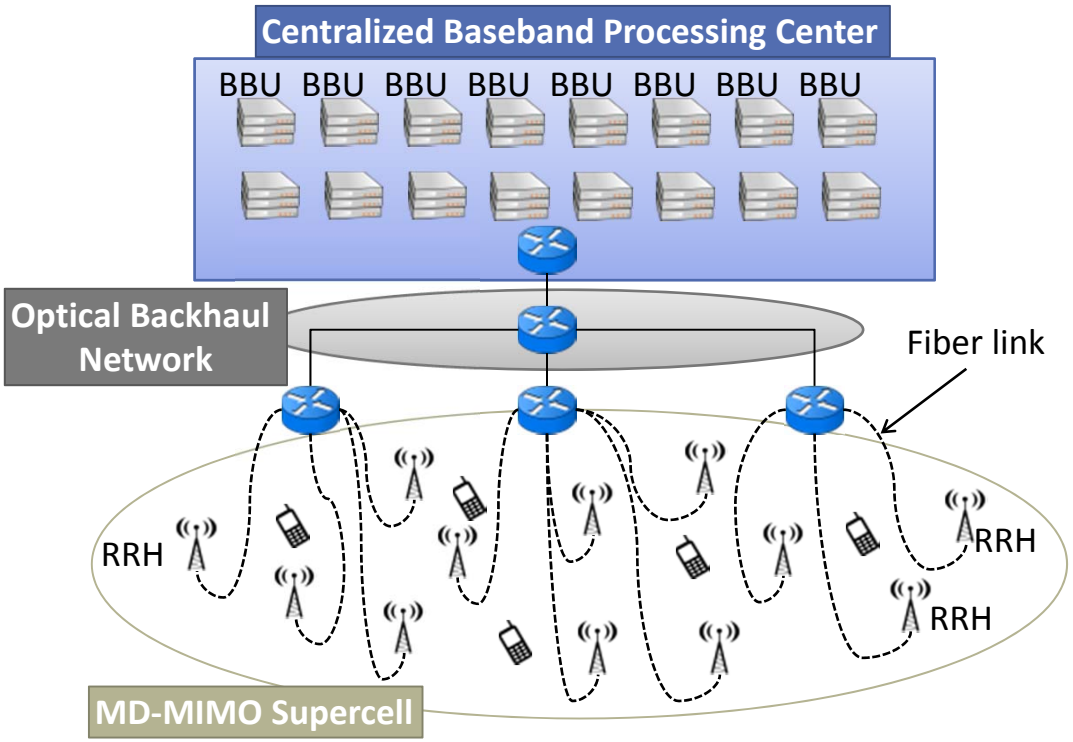


Characteristics of a Shared Infrastructure

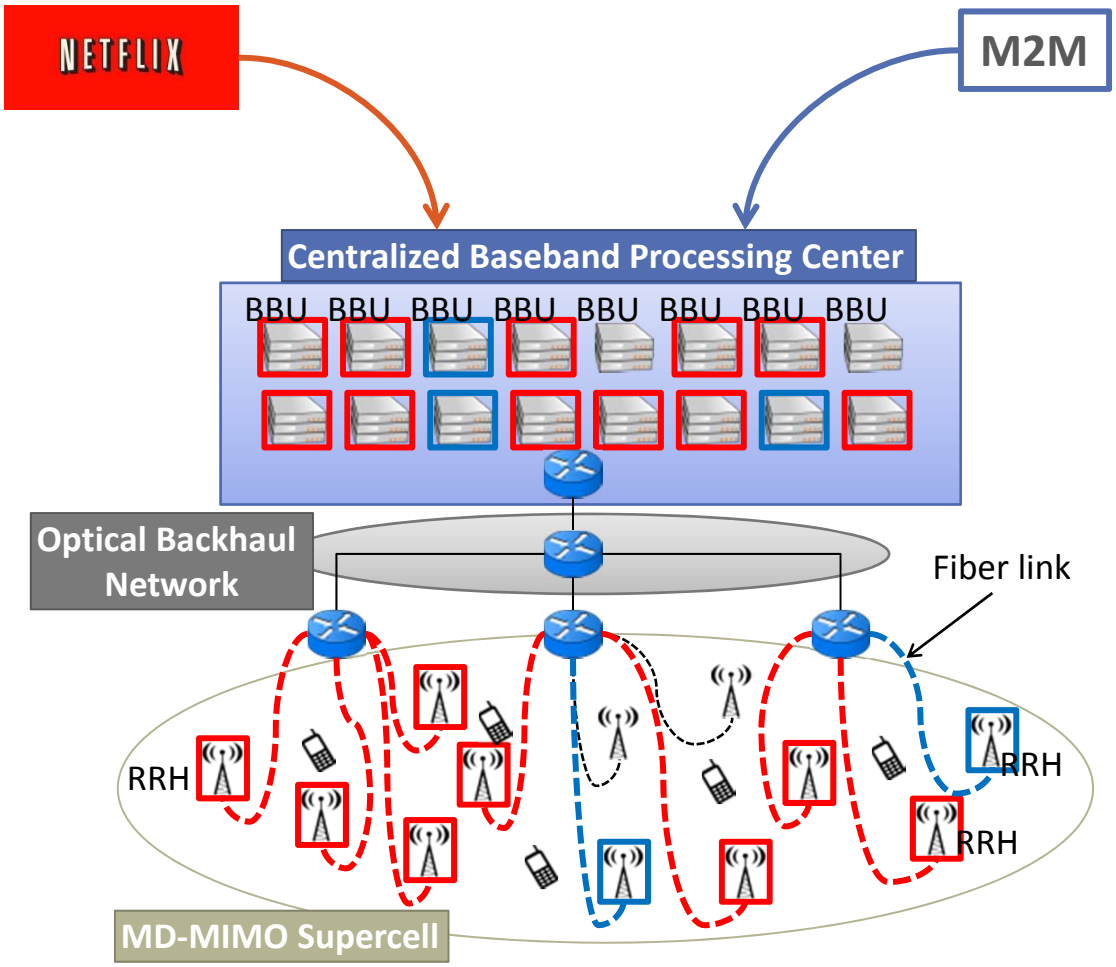
- Pool of resources to choose from
- Service-driven networks
- The Virtual Network Operator obtains the necessary amount of resources from the pool
- Unused resources are left for other networks or uses

Cloud-RAN

The Ideal Infrastructure for Resource Sharing

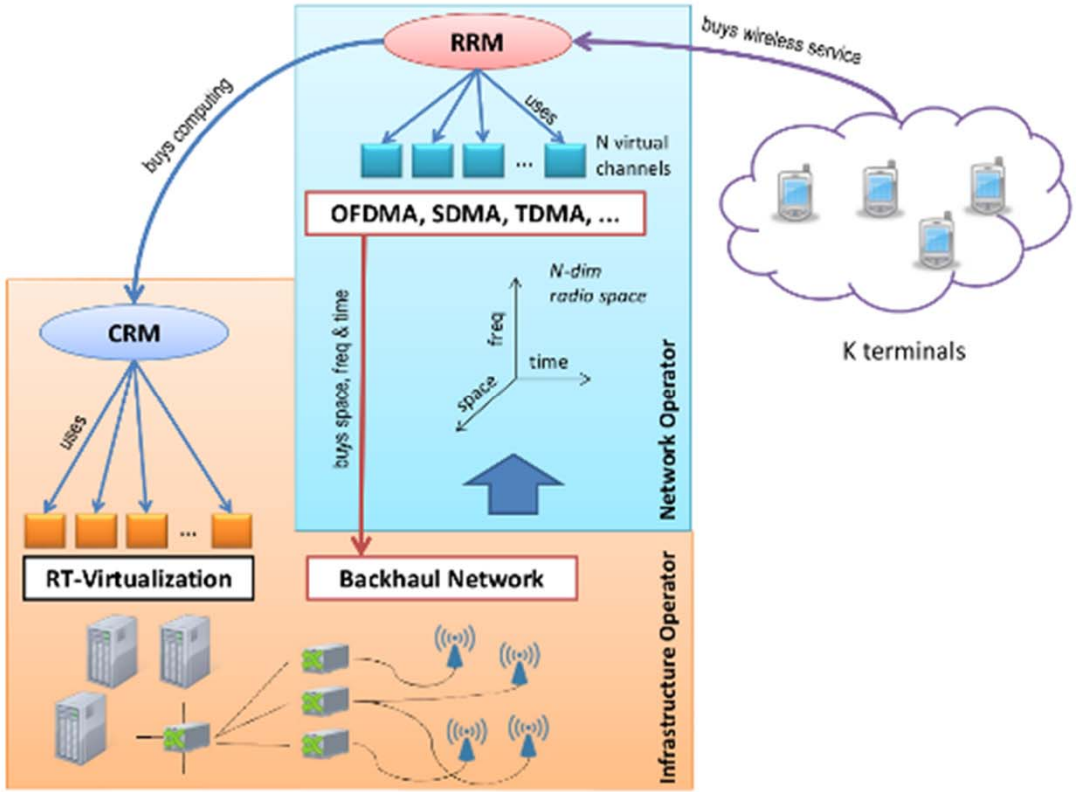


Cloud-RAN as an Ideal Candidate for Virtualization and Resource Sharing

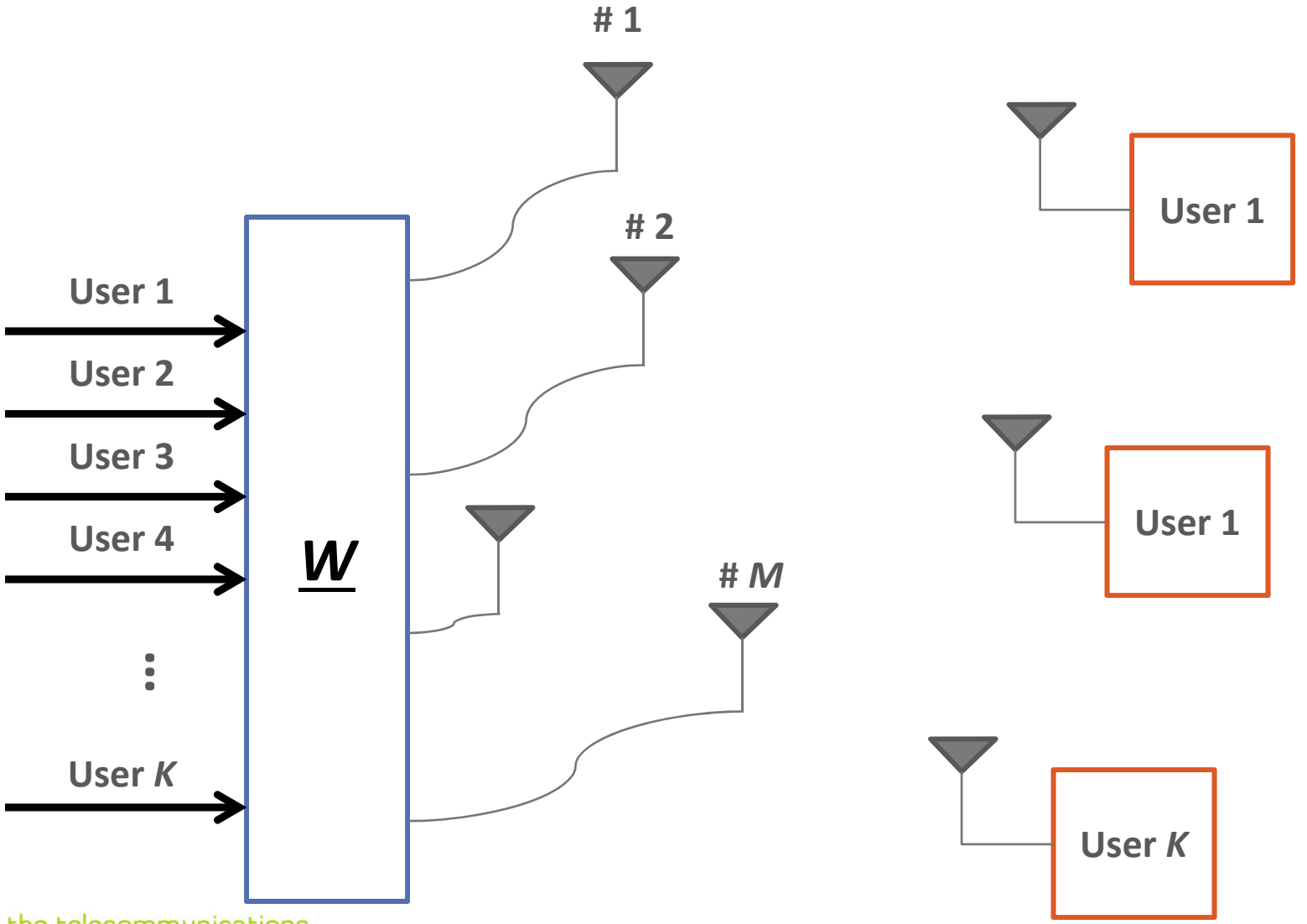


Resource Management

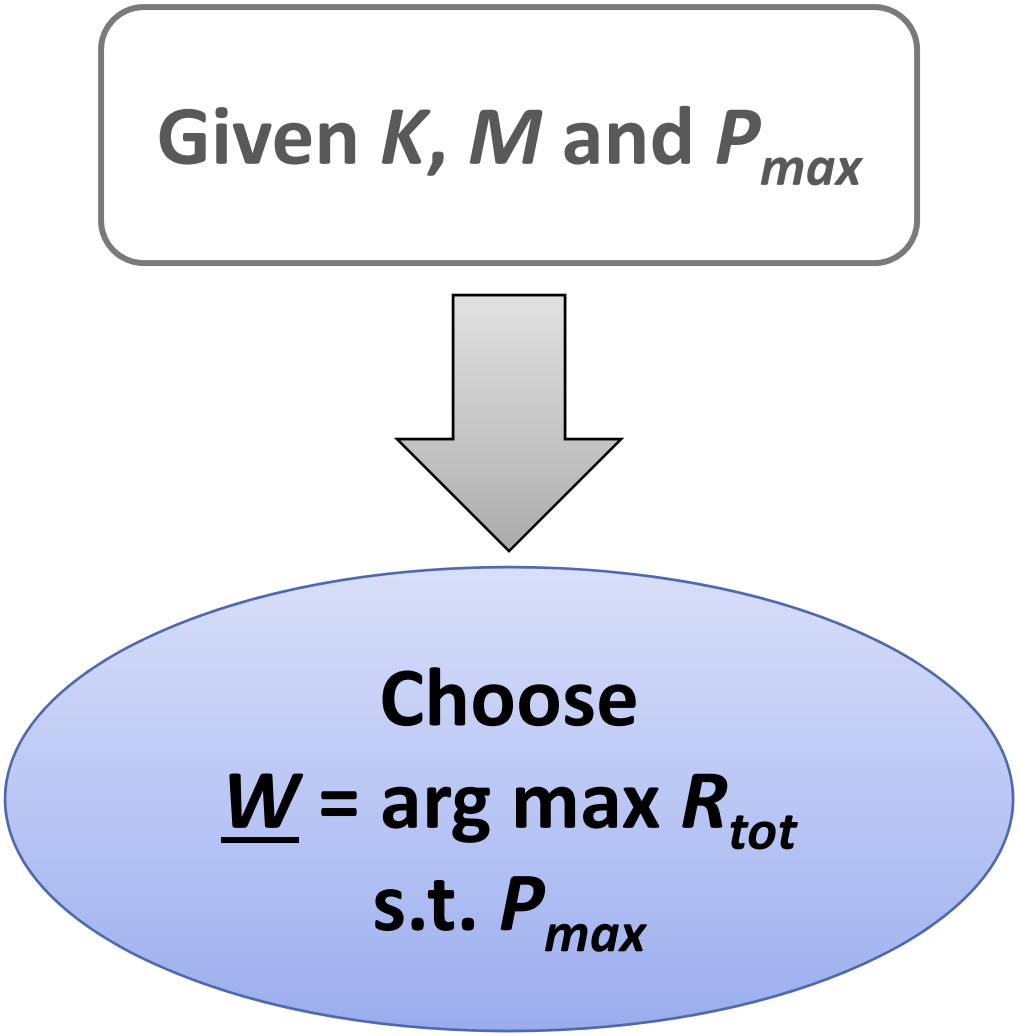
- **How is Resource Management affected by these new shared resource or ownership models?**



- Distributed MISO Broadcast channel
- K < M
- CSI at the TX



Traditional Approach



But…

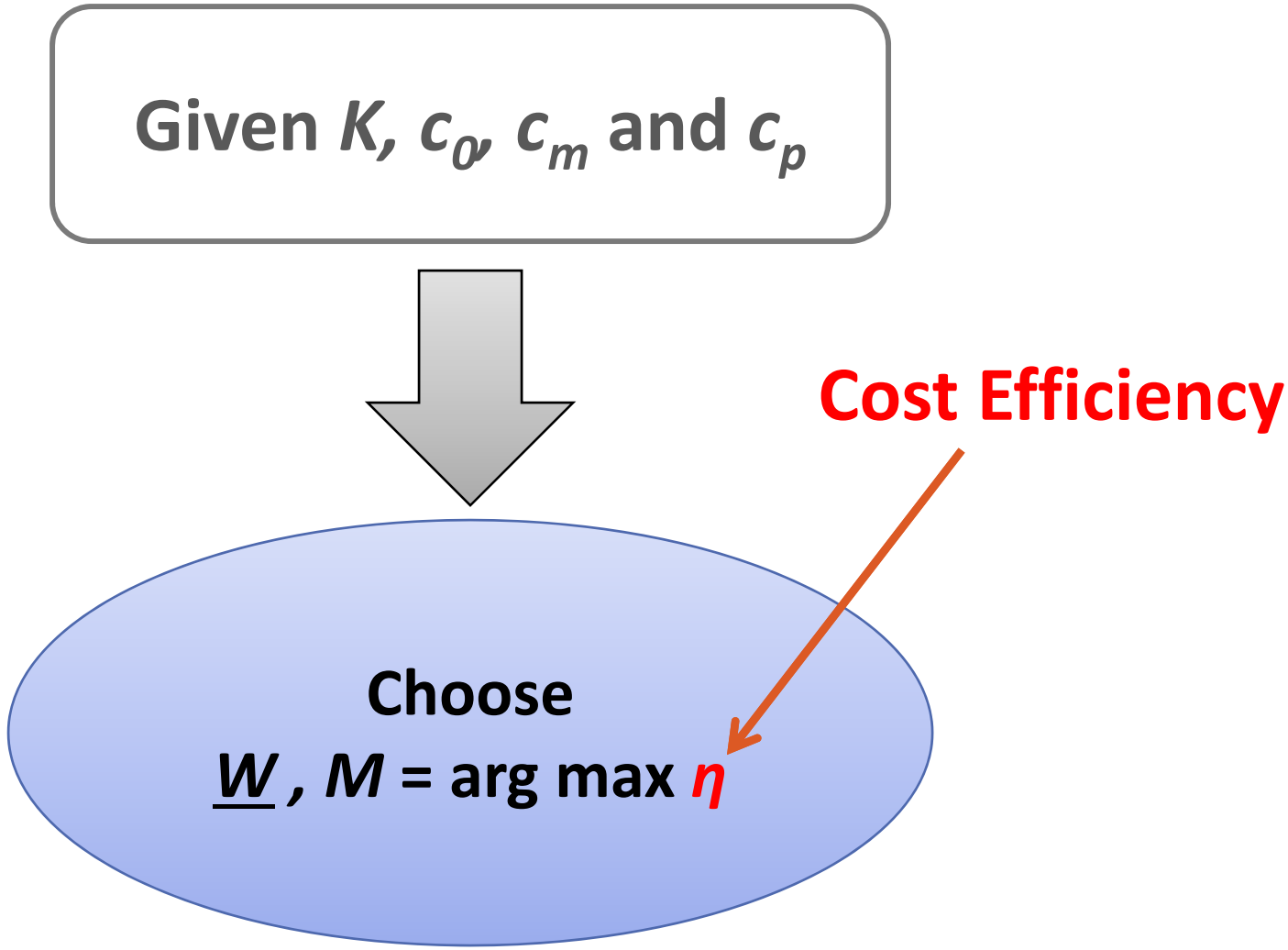
What happens if we can choose any *M* or P_{max} from the pool?

Ideally, *M* and P_{max} are unlimited in the Cloud-RAN but using them has a cost

Pay-per-use Cost Model

C_0: Cost of using the infrastructure [currency units/sec]
C_m: Cost per antenna [cu/antenna/sec]
C_p: Power cost [cu/Joule]

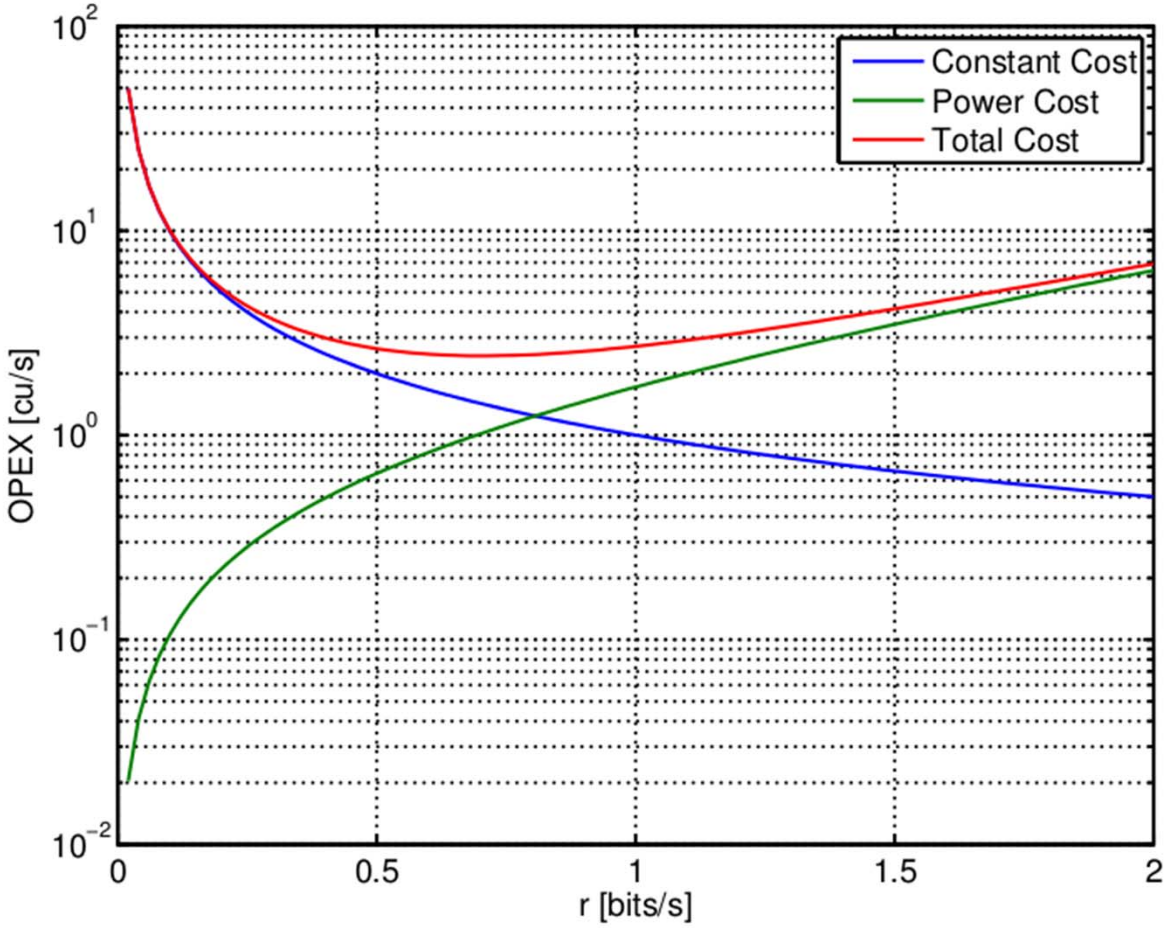
Cost-Driven Resource Management



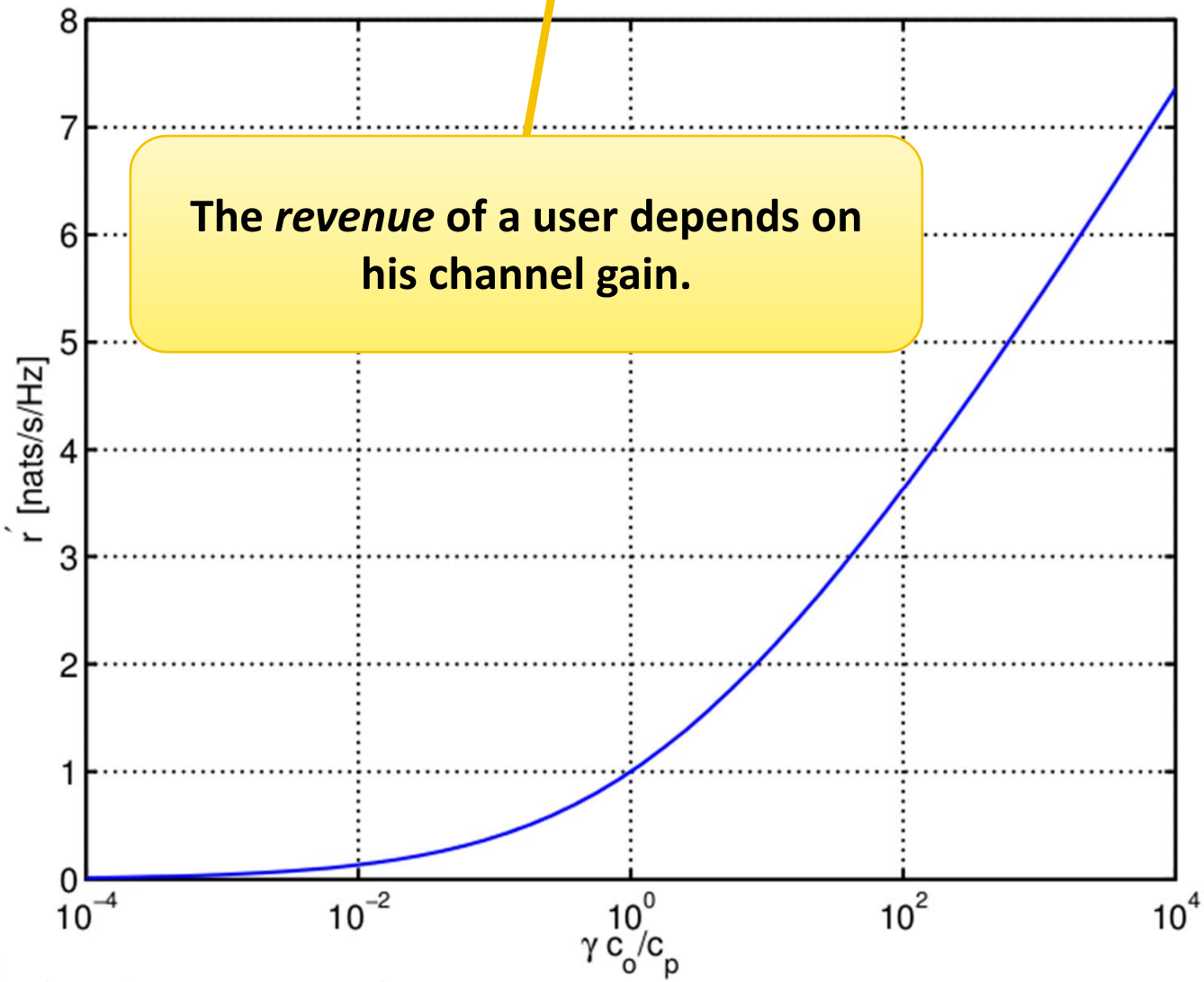
Cost Efficiency

$$\eta = \frac{R_{tot}}{c_0 + c_m M + c_p P_{tot}} \text{ [Mbits/cu]}$$

Example: 1 antenna 1 user



$$r_{opt} = 1 + W\left(\left(\gamma \frac{c_0}{c_p} - 1\right) e^{-1}\right)$$



RE-Thinking Resource Management

- **Cloud-RAN + resource sharing model motivates re-thinking how me manage resources**
- **Pool of resources, each with a cost and an outcome**
- **Resource Management now includes**
  - Choosing number of resources: antennas, computers, power, spectrum, etc.
  - Allocating them to users, accounting for fairness, costs and outcomes of each user (e.g. depending on the channel gain, for instance)
  - **Trading:**
    - Utilization time vs power
    - Antennas vs power
    - Antennas vs spectrum
    - Power vs spectrum
    - etc

Number of Antennas vs Power

- Increasing the transmission power increases the spectral efficiency
- But so does increasing the number of antennas
- Both have a cost: cost per antennas and cost per Watt
- … then, what do we want/need?

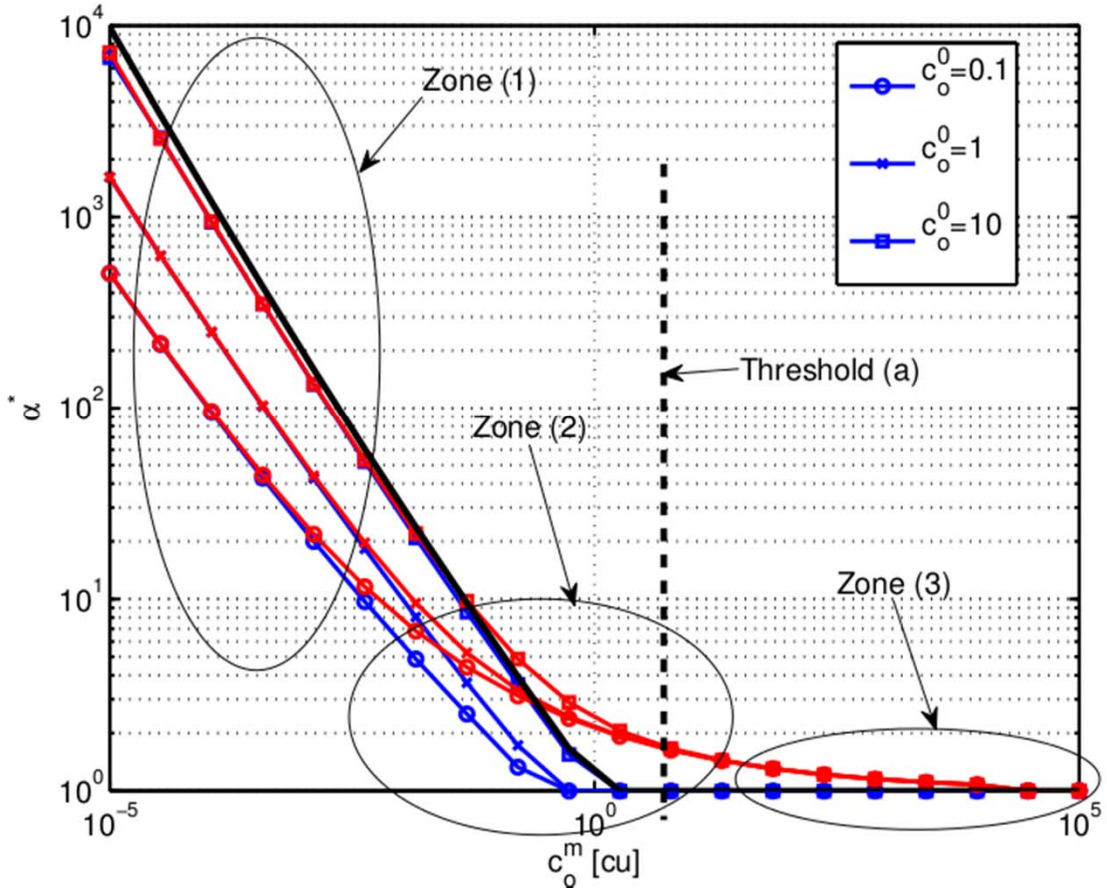
Number of Antennas vs Power

$\alpha = M/K$ (antennas/user)

1. $C_m << c_p \cdot K \cdot A$
2. $C_m \approx c_p \cdot K \cdot A$
3. $C_m >> c_p \cdot K \cdot A$

(A is a constant inverse to th
average channel gain among
all user-antenna pairs and
channel model)

- MISO BC Capacity (DPC)
- Zero Forcing



Conclusions

- **Current MNO ownership and business model is becoming economically unsustainable**
- **Sharing of the ownership is seen as a solution to increase revenue**
- **Pay-per-use model is a proven success in Cloud Computing**

- **Cloud-RAN is an ideal candidate for resource sharing.**
- **It is a flexible platform allowing:**
  - Antennas vs Power
  - Antennas vs Spectrum
  - etc

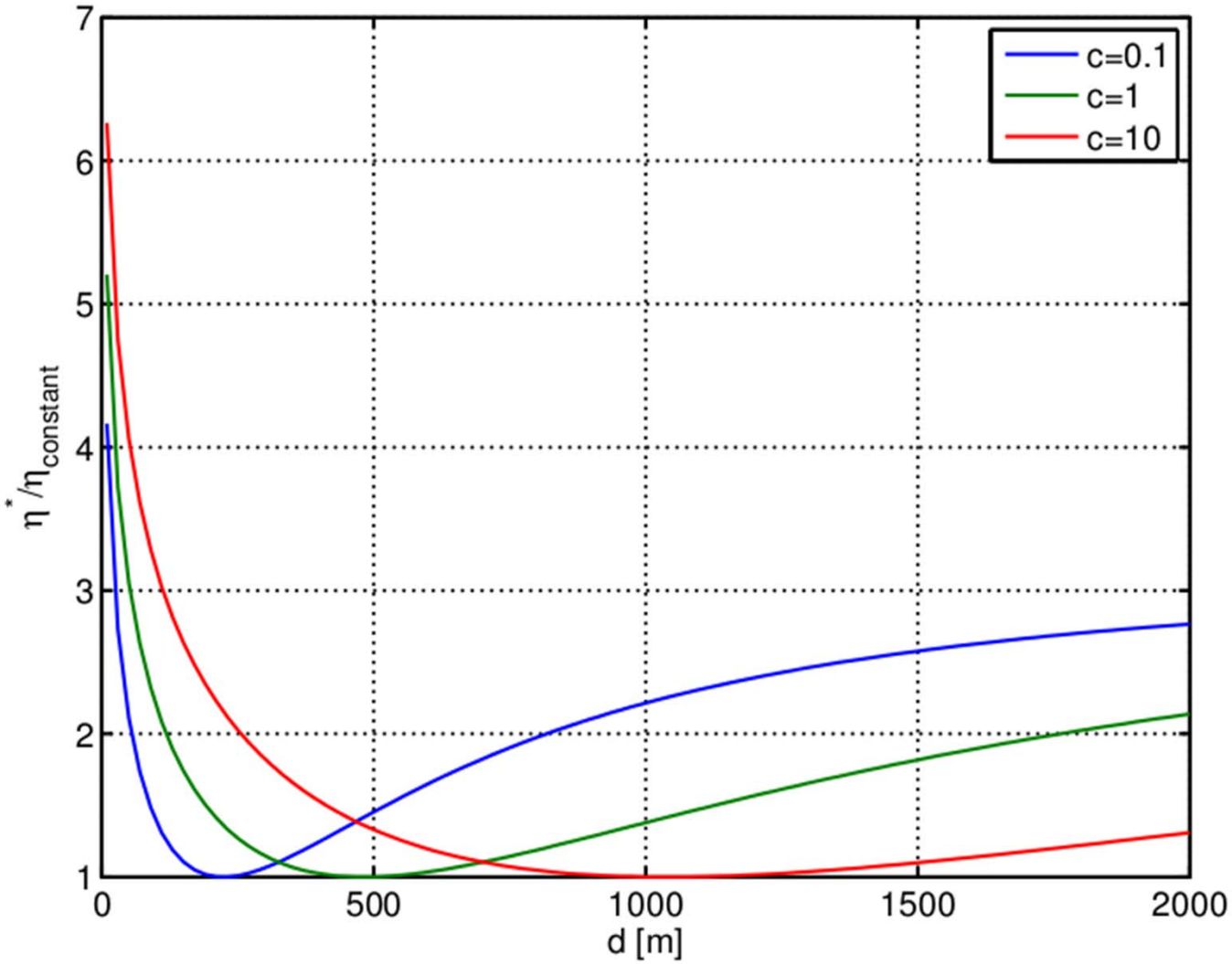
- **Many research challenges and open problems!**

The End!

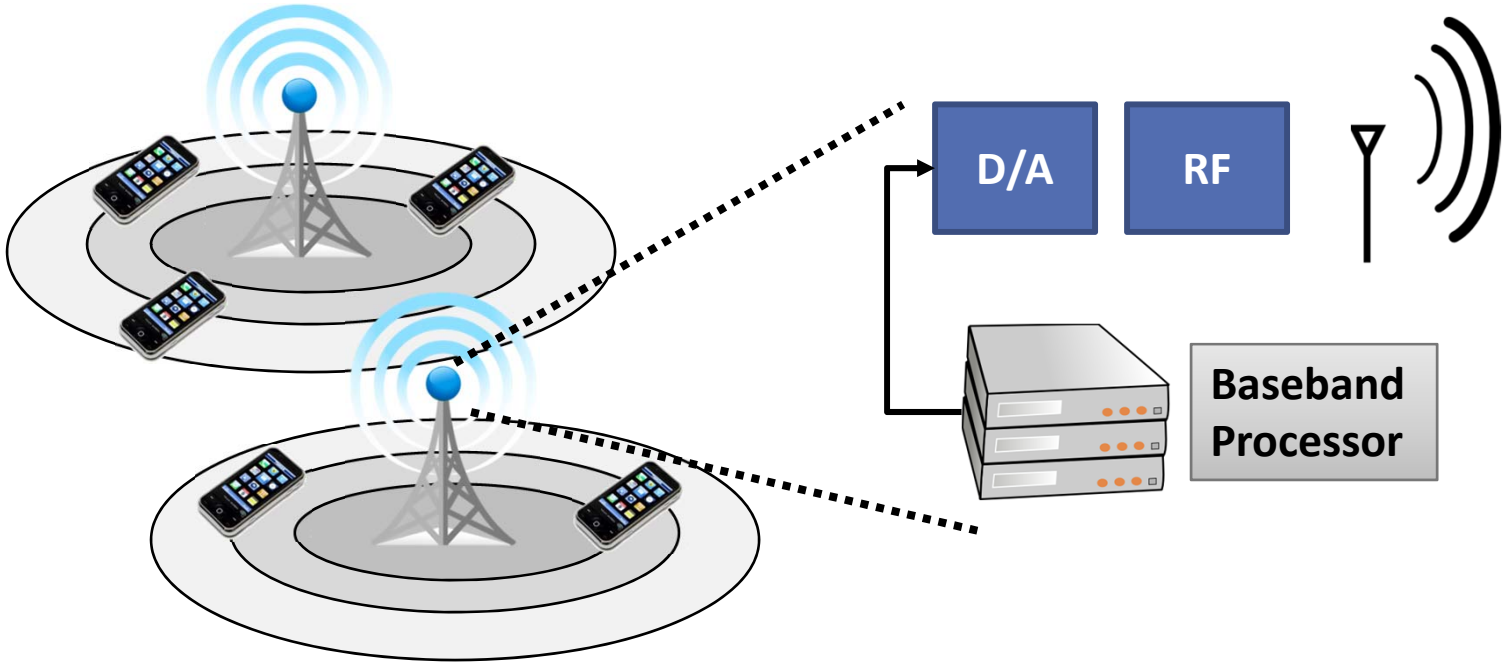
Thank you for your attention

Science Foundation Ireland
CTVR / the telecommunications research centre
TRINITY COLLEGE DUBLIN
COLÁISTE NA TRÍONÓIDE, BAILE ÁTHA CLIATH
THE UNIVERSITY OF DUBLIN

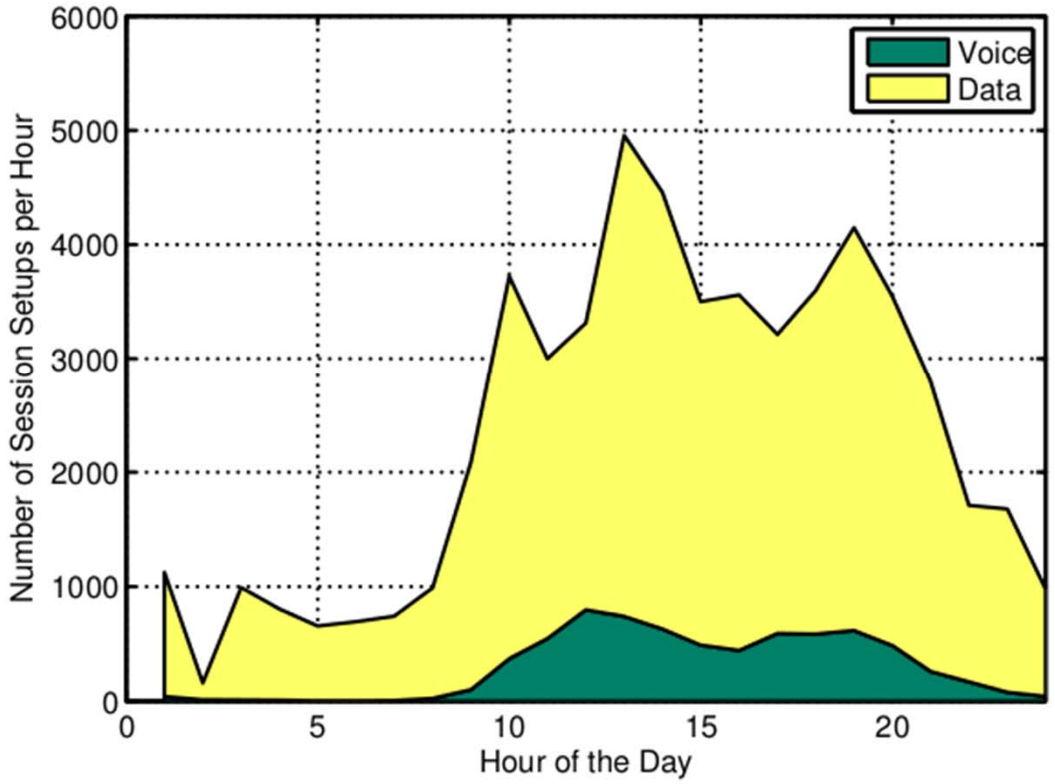
Potential Savings



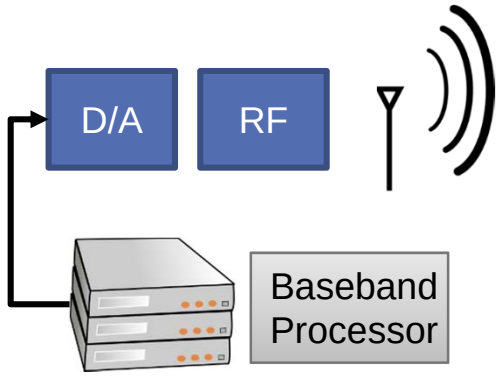
Today's Cellular Infrastructure



Problems



- ✗ Non scalable
- ✗ Expensive
- ✗ Capacity Limited by Interference



BBU + FIBER + RRH