HELLENIC REPUBLIC
National and Kapodistrian
University of Athens

DEPARTMENT OF
INFORMATICS &
TELECOMMUNICATIONS

OTE ACADEMY

Spectrum Trading
in Virtualized 5G Networks

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5G AURA

MARIE CURIE ACTIONS

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- ❑ **Mobile technology offers ubiquitous communication**

- ❑ **Increasing mobile connections and data traffic**

- ❑ **Need for spectrum, but it is scarce!**
  - ➤ **Inefficient spectrum management**
  - ➤ **Static frequency allocation scheme**

- ❑ **Required network features**
  - ➤ **Intelligence, efficiency, scalability**
  - ➤ **Service quality and reliability guarantee**

State-of-the-Art
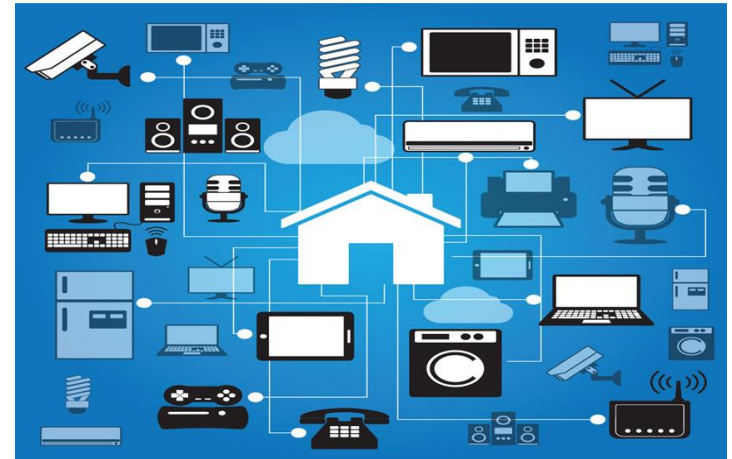
❑ **5G Attribute:** *Spectrum Efficiency*

❑ **5G Functionality:** *Wireless network virtualization*

> ➤ **Physical resources (infrastructure, spectrum) are abstracted into virtual resources**

❑**Business model of virtualized 5G network**

> ➤ **Mobile Virtual Network Operators (MVNOs) dynamically lease and efficiently share the available resources owned by Mobile Network Operators (MNOs)**

❑ **Advantages**

> ➤ **MNOs gain more revenues, reduced CAPEX / OPEX**

> ➤ **MVNOs better serve on-demand their clients' different needs**

> ➤ **Higher network performance with less spectrum underutilization**

Research Challenge

□ **Spectrum trading market**

- ➢ Assuming there is unutilized spectrum

- ➢ MNOs offer it for sale

- ➢ MVNOs are interested in buying

- ➢ Cooperation between MNOs and MVNOs

□ ~~The problem is that both have conflicting interests~~

- ➢ <u>MNOs</u>: more revenues for certain bandwidth

- ➢ <u>MVNOs</u>: more bandwidth for certain cost

□ **The research challenge is to create mutually beneficial relations between MNOs and MVNOs**

Contribution
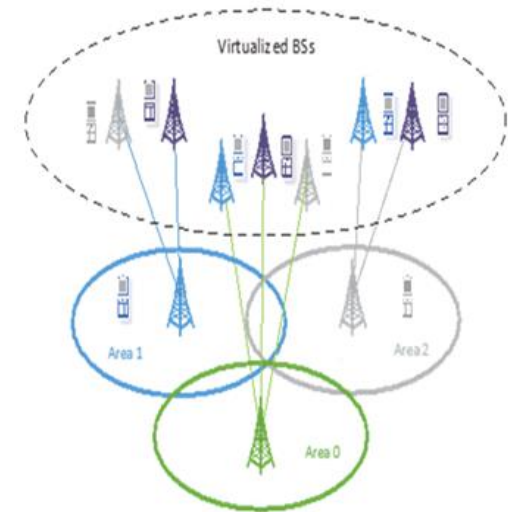
❑ **We propose to model this spectrum trading problem as a Many-to-Many Matching (M2MM) game**
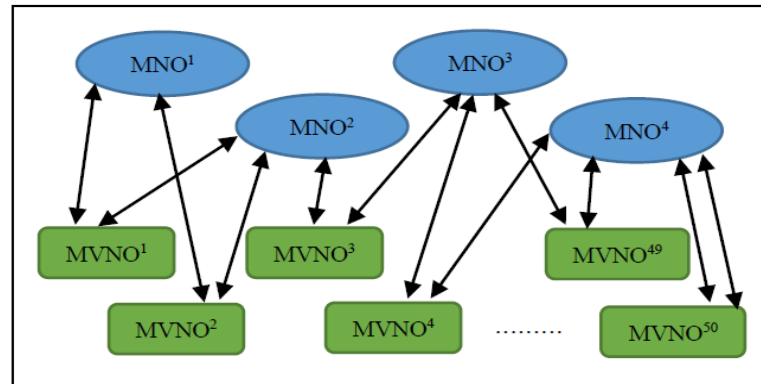
➢ **One MNO can form a partnership with multiple MVNOs and one MVNO can form a partnership with multiple MNOs, as well**

❑ **We propose the construction of specific utility functions for MNOs and MVNOs**

➢ **The value of each utility function sets the ordered preference list of one entity to the other**

Contribution – Matching Model

❑ **Network model**

  ➢ **4 MNOs**

  ➢ **50 MVNOs**

❑ **How M2MM scheme with utility-based preferences works**

  ➢ **MNOs advertise bandwidth to sell and relevant price (supply)**

  ➢ **MVNOs advertise required bandwidth and price willing to pay (demand)**

  ➢ **Both sides construct their preference list based on their utility function**

  ➢ **After applying an extension of the deferred acceptance algorithm, a stable matching between each MNO and MVNO is achieved**

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- ❑ **Each utility function includes parameters that enable each entity to characterize the matching entity**
  - ➢ Bandwidth, price, reputation, QoS

- ❑ **Each parameter has different weight or importance for each entity**
  - ➢ Thus, each entity builds its own strategy plan for the matching entity

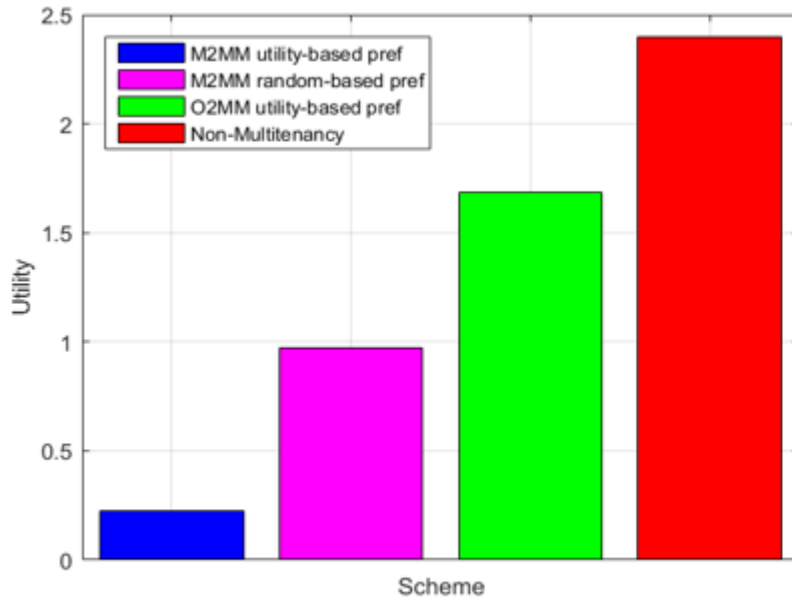$$W_{MNO} = [W_{MVNO,BW}, W_{MVNO,PR}, W_{MVNO,REP}]$$

$$W_{MVNO,BW} + W_{MVNO,PR} + W_{MVNO,REP} = 1$$

$$W_{MVNO} = [W_{MNO,BW}, W_{MNO,PR}, W_{MNO,REP}, W_{MNO,QOS}]$$

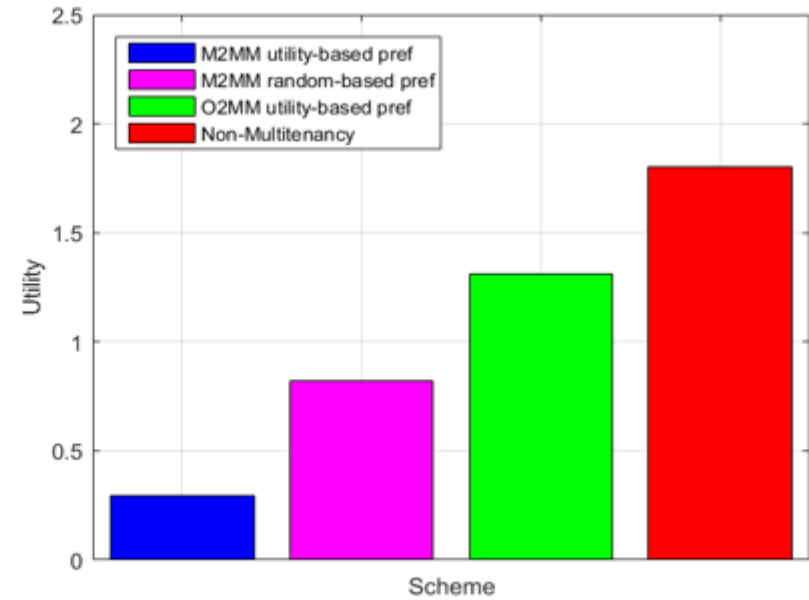$$W_{MNO,BW} + W_{MNO,PR} + W_{MNO,REP} + W_{MNO,QOS} = 1$$

$$\begin{aligned} U_{MNO}(i,j) = \big| W_{MVNO,BW}\,(5 + BW_{MVNO}(j) - BW_{MNO}(i)) \\ + W_{MVNO,PR}\,(5 + PR_{MVNO}(j) \\ - PR_{MNO}(i)) + W_{MVNO,REP}\,REP_{MVNO}(i,j) \\ - U_{MNO}max \big| \end{aligned}$$

$$\begin{aligned} U_{MVNO}(j,i) = \big| W_{MNO,BW}\,(5 + BW_{MNO}(i) - BW_{MVNO}(j)) \\ + W_{MNO,PR}\,(5 + PR_{MNO}(i) - PR_{MVNO}(j)) \\ + W_{MNO,REP}\,REP_{MNO}(j,i) \\ + W_{MNO,QOS}\,QOS_{MNO}(j,i) - U_{MVNO}max \big| \end{aligned}$$

(a)

Average utility of a MNO request in 4 different schemes

(b)

Average utility of a MVNO request in 4 different schemes

Results – Satisfaction

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MNOs / MVNOs satisfaction over various conditions

	MNO > MVNO	MNO = MVNO	MNO < MVNO
Bandwidth	✓	✓	✗
Price	✗	✓	✓
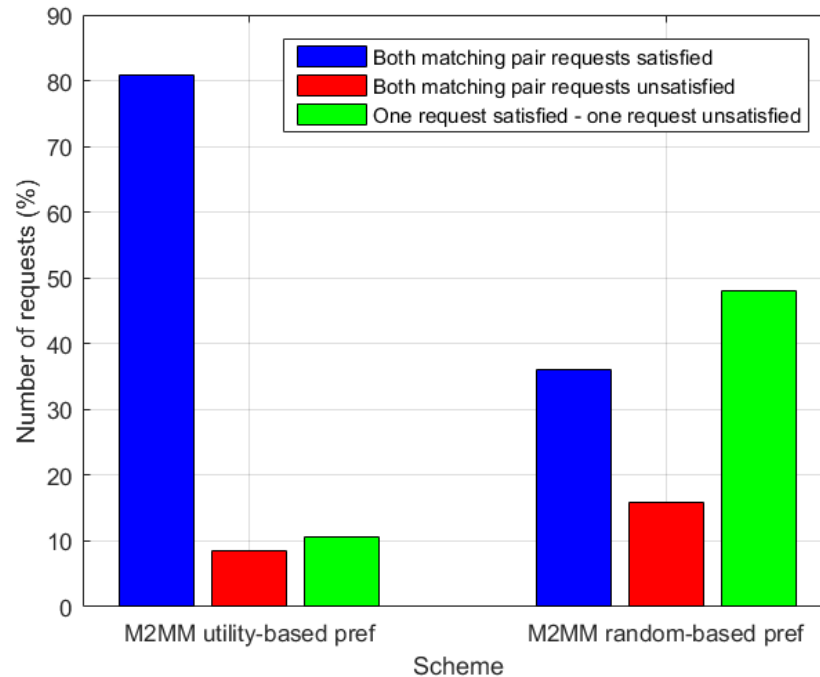
Average number of satisfied or unsatisfied matching pair requests

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Thank You!

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