Enabling Innovation in Spectrum Management

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The Potential Problem of Telecom company

- Mobile Carrier (Mobile Network Operators)
  - To offer high quality services
  - Need to deploy more base stations
  - Increase capital expenditure
- $275B on 4G reported by Morgan Stanley
- The capital spending of telecom companies
  - Very high and risky
  - May not gain significant returns on the investments*
  - Developing countries may not play this game

*https://www.morganstanley.com/ideas/5G-wireless-outlook
The CapEX breakdowns

- Infrastructure deployment
  - Radio access network and a core network
  - Operating costs
- Spectrum costs
  - Acquire more spectrum licenses for more spectrum capacity
  - US carries spent $95 billion on spectrum licenses for 5G*

*https://www.morganstanley.com/ideas/5G-wireless-outlook
Spectrum sharing

- Spectrum is a scarce resource for communication services
- Maximizing spectrum sharing matters
  - Dynamic Spectrum Sharing
    - 5G New Radio
  - Cloud-Radio Access Network (C-RAN)
    - Centralized/database-driven
Mobile Network Today

Licensed Spectrum → Spectrum Owner → Mobile Core Network → Mobile Access Network → Base Stations → Mobile Network Operator → User Equipment
Intelligent Mobile Network

- Enable a fundamental change in how to buy and sell the spectrum resources
- Three main ideas:
  - The new mobile network architecture
  - Spectrum recommendation
  - Real-time spectrum bidding market
The Assumptions in Intelligent Mobile Network

- Spectrum owner
- Spectrum holder
- Spectrum trader (SpectrExchange)
- Mobile network operator (Carrier)
- Intelligent UE
- Spectrum Access Right Epoch (SAR Epoch)
Spectrum Access Right Epoch (SAR Epoch)

- A basic trading unit
  - The right to access spectrum in the epoch
- Divide each channel into small divisions
  - Frequency, geography and time
- Tuple (cell, channel, time, pricing)
The New Mobile Network Ecosystem
Spectrum recommendation

● **Intelligent UE**
  ● Represent description of communication scenario into spectrum vector (spectrvec)

● Learn the association between
  ● Spectrum allocation
  ● Spectrum vector

● Turn the spectrum allocation problem to spectrum epoch recommendation
Real-Time Spectrum Bidding (RTSB)

- Leverage the concept of Real-Time Bidding
  - Popular using in Internet Ads industry
- Spectrum buyers bid on a SAR Epoch
  - Demand-side
    - MNOs
  - Supply-side
    - Spectrum stakeholders (owners & holders)
- Trader
  - SpectrExchange
An Example of RTSB: Initial SAR Epoch Offering Process

1. Supply inventory
2. Hex grid
3. Paging operation with spectvec
4. Bid request with bid price for $e_2$
5. Bid SAR epoch / ACK
6. Bid SAR epoch / ACK
7. Channel allocated

Time: 2021-06-25 19:10:00

t[e_1(\text{cell 81, f_1, 2021-06-25 19:10:00+60s, $0.1)}),
e_2(\text{cell 81, f_2, 2021-06-25 19:10:00+600s, $0.8})]
An Example of RTSB: trigger a bidding in MNO

1. Supply inventory
2. Hex grid
3. Paging operation with spectrvec
4. Bid request with bid price for e2
5. Bid SAR epoch / ACK
6. Bid SAR epoch / ACK
7. Channel allocated

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The details of the bidding operation, please refer to our paper
Future directions & Challenges

- The detail protocol-level design of the new architecture
- The design of real-time spectrum bidding market
- The spectrum recommendation models
- Incremental deployment
- Transparency
- Differentiated services
Conclusion

● A Novel Intelligent Mobile Network Architecture
  ● Fundamental change in how to buy and sell the spectrum resources
● Base on the assumptions and ideas
  ● A new architecture of cellular network
  ● Spectrum recommendation
  ● Real-time spectrum bidding market
● The sharing-economy thinking
Q&A

Thank you!
Thank you!

Looking research partners

Please drop us a line

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Mobile Network Today

- Wireless technologies achieved great improvements
- The high-level architecture of cellular networks
  - Spectrum Owner, ex., FCC
  - Mobile Network Operator (Carrier)
  - User Equipment (EU)
  - No changes over 30 years
An Example of Spectrum Recommendation

Intelligent UE

cell 81

cell 82

cell 83

$V_1$

$V_2$

$V_3$

channel_1

channel_2

channel_3

Recommend

High QoE

Low QoE