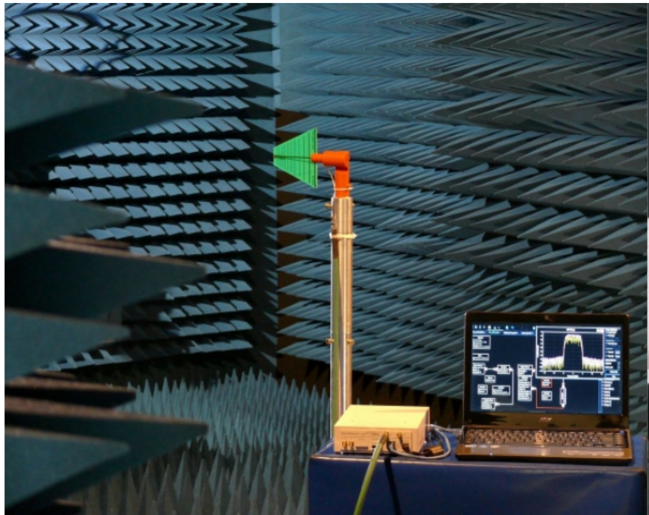
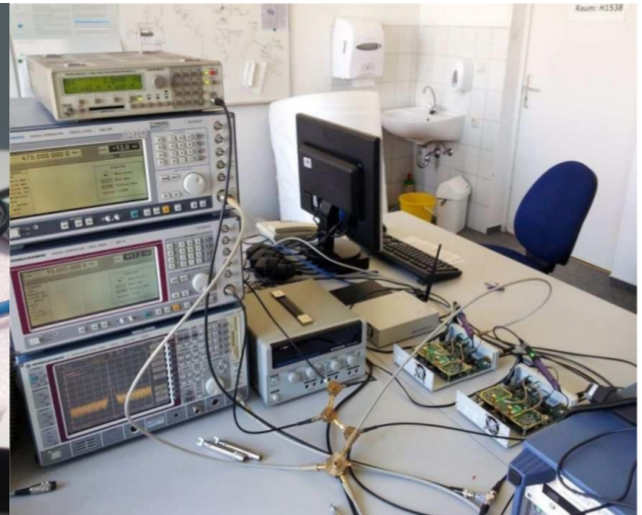
# Evolving Hypernetworks based Channel Prediction for Secondary Access in CRAHN

**Shah Nawaz Khan,** Andreas Mitschele-Thiel



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# Outline

- Introduction
- Radio resource map
- Radio spectrum abstraction
- Hypernetworks based prediction
- Results & conclusion

# Introduction

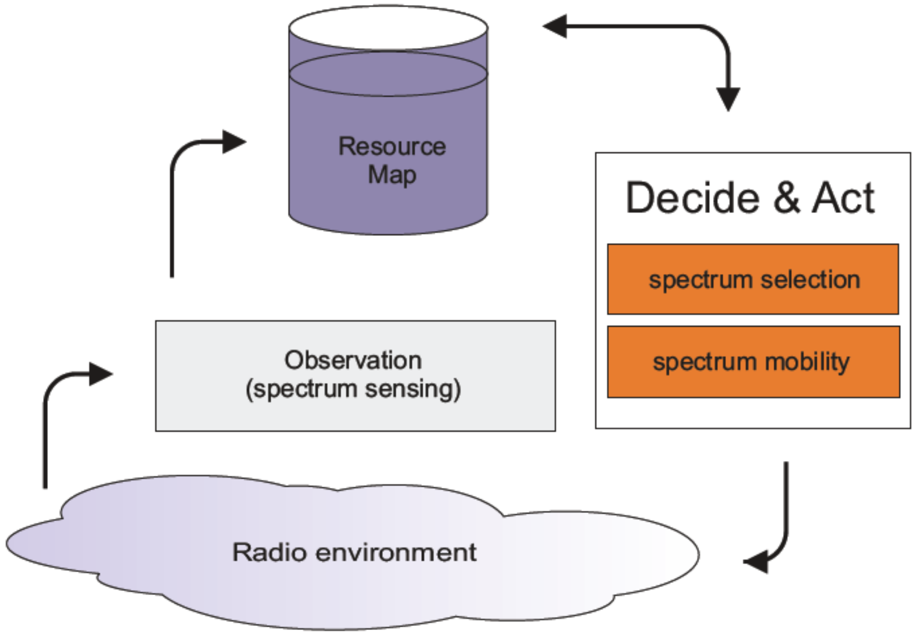
- Cognitive radio can operate
  - **Independently (PU, SU concept)**
  - Cooperatively (Spectrum Lease/sharing)
  - **Mixed modes**

- Fundamental aspect (Cognition)
  - Sensing capability (The eyes to observe)
  - Learning & optimization (The brain to orient, act, learn)

- **Cognitive "Radio"**
  - Lower layer adaptations related to channel access are most important

# Radio resource map

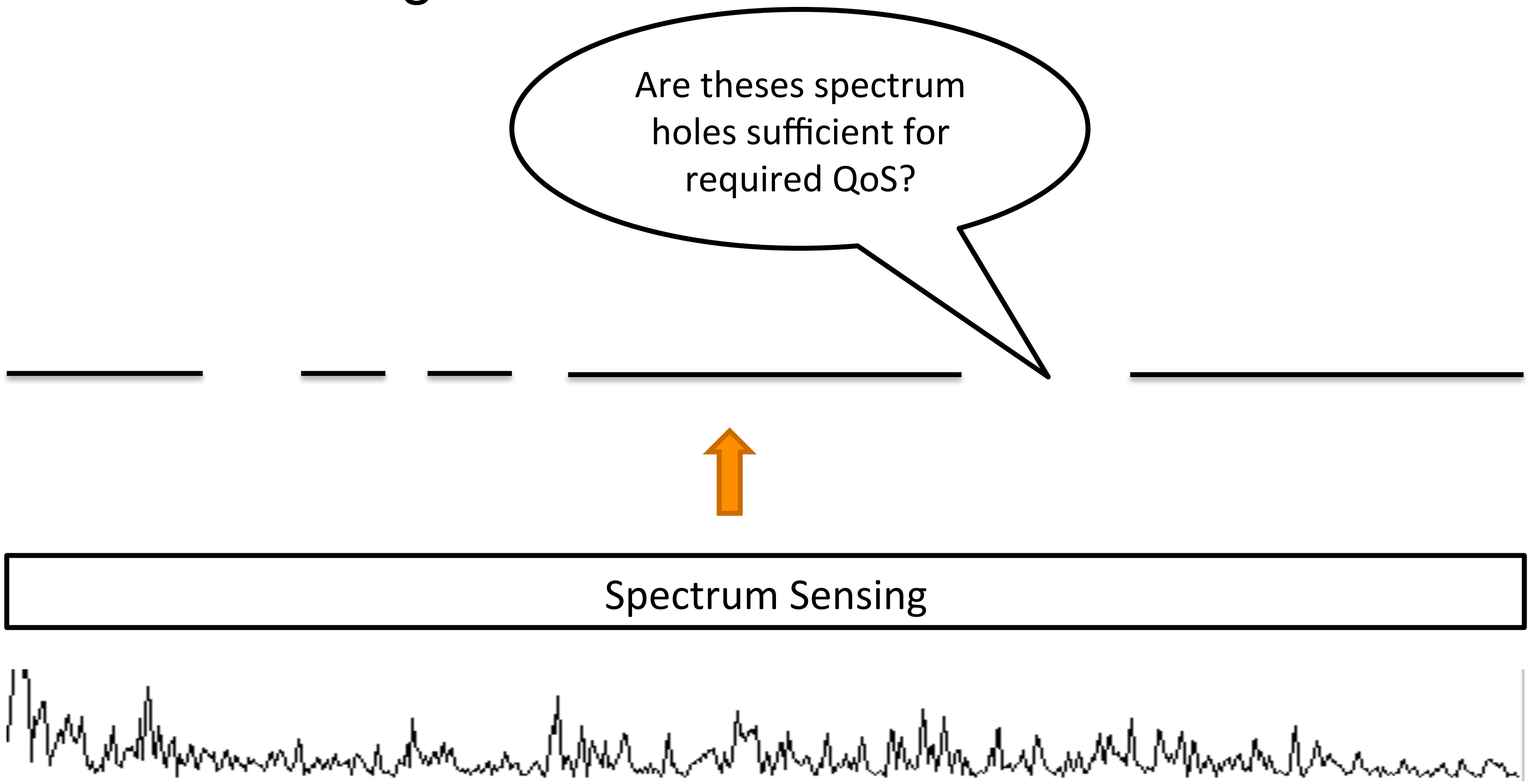
- Learning channel's behavior over time is very important




- **Objective:**
  – CR applications must provide certain QoS guarantees

# Radio Spectrum Abstraction

- Identifying & utilizing useful information from primitive channel sensing



# Hypernetworks

- A merger of graph theory & evolutionary learning

- Evolving Hypernetworks based spectrum prediction
  - An evolutionary learning technique
  - Can predict short & long term states
  - Develops patterns in the given dataset
  - Learns through a reward/penalty function

B. Zhang, "Hypernetworks: A Molecular Evolutionary Architecture for Cognitive Learning and Memory"

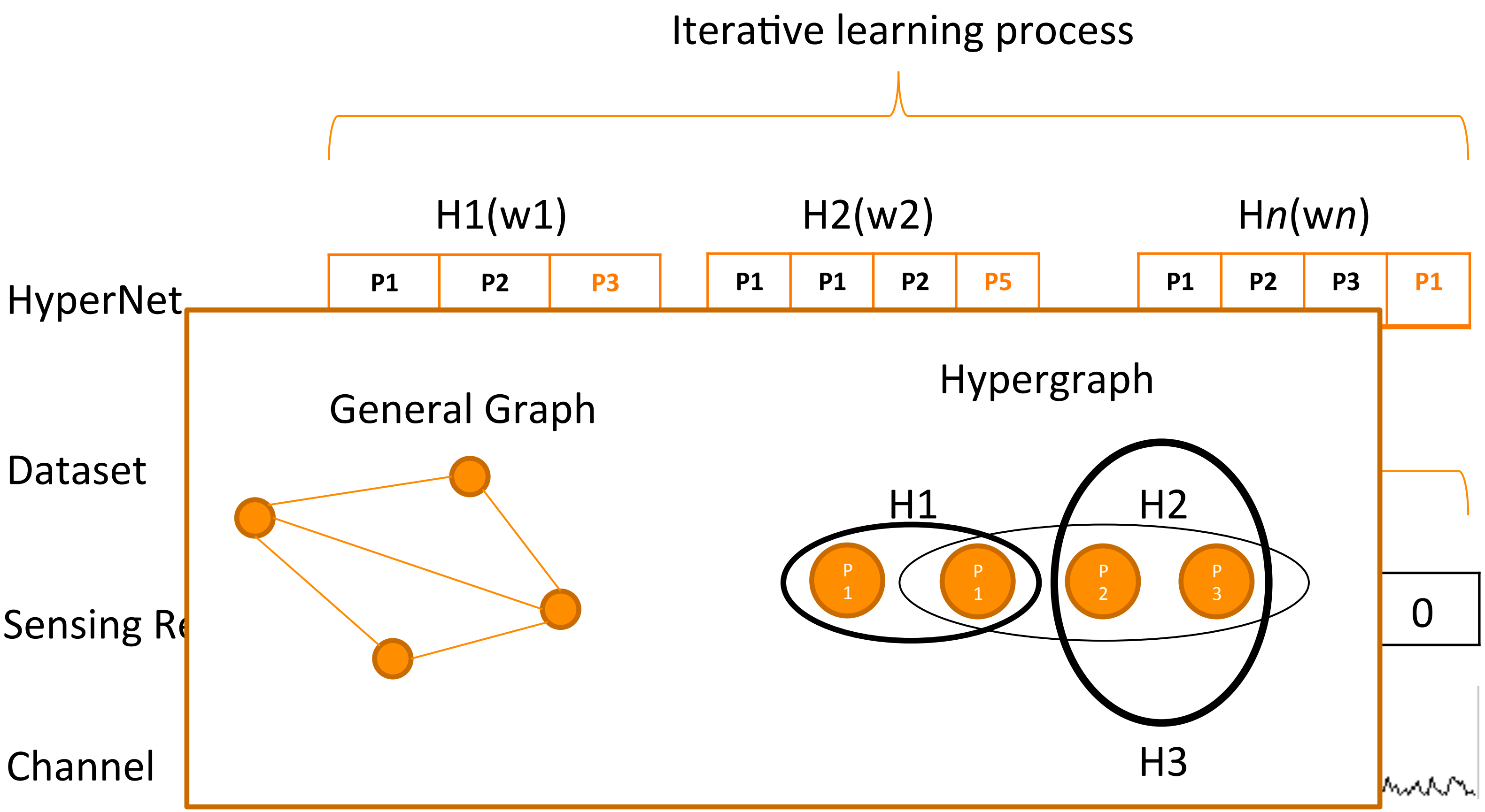
# Hypernetworks based abstraction

- Hypernetwork Creation
  - Create patterns from the provided dataset
  - Specify the order of the hypernetwork (complexity)

- Hypernetwork Training/Learning
  - An iterative learning process
  - Randomly create new hyperedge and evaluate
  - Use the reward function to update weights

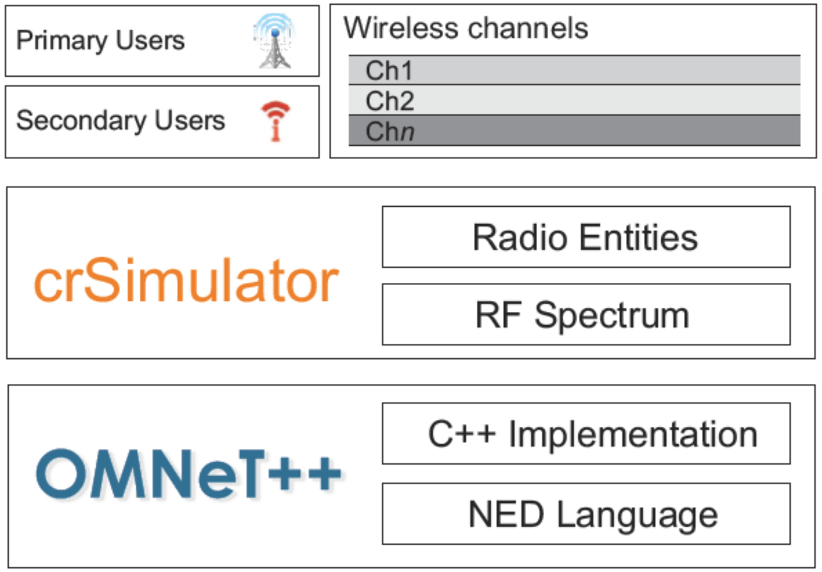
- Hypernetwork prediction
  - Given a sequence, it can predict the next state/s

# Hypernetwoks based abstraction



# Results

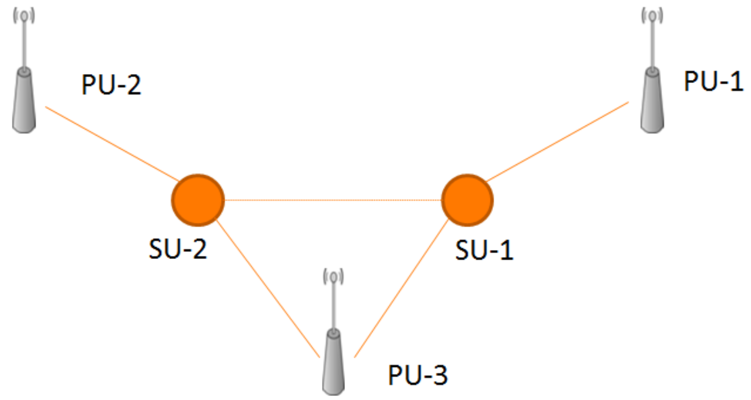
- **crSimulator**
  - A discrete event simulation model developed in OMNeT++
    - Implements a practical node architecture for CRAHN




Shah Nawaz Khan, Mohamed Abdrabou Kalil, Andreas Mitschele-Thiel: Crsimulator: a discrete simulation model for cognitive radio ad hoc networks in omnet++ , IFIP/IEEE (WMNC2013) , Dubai, UAE, April 2013

A. Puschmann, Shah Nawaz Khan, Ali Haider Mahdi, Mohamed Abdrabou Kalil, Andreas Mitschele-Thiel: An Architecture for Cognitive Radio Ad-Hoc Network Nodes , ISCIT , Queensland, Australia, October 2012

# Preliminary Results




- Scenario:
  - One CR link under 3 PU influence
  - Simple Hypernetwork
    - Hyperedges based on duration of spectrum opportunity
      - Order (min 2, max 3)
      - History window: 6
      - Reward function (increase/decrease the weight)

| Sensing Delay | PU-OFF | PU-50% DC No prediction | PU-75% DC No prediction | PU-50% DC Hypernets Prediction |
|---|---|---|---|---|
| 0 | 6.5Mbps | 3.2Mbps | 1.6Mbps | 4.3Mbps |
| 10ms | 6.1Mbps | 3Mbps | 1.3Mbps | 4Mbps |

Table-1: Achievable datarates with 802.11b MAC.

# Conclusion

- Independent/cooperative learning in CRAHN
- Secondary access must provide implicit QoS guarantees
- Spectrum abstraction algorithms can help provide such guarantees
- Hypernetworks are useful in predicting channel behavior

# Contact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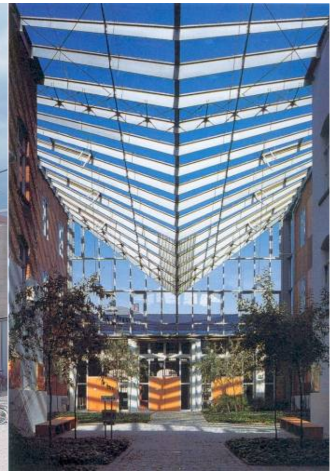


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