MARIO
A Cognitive Radio Primary User Arrivals Data Generator

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Outline

1. Introduction
2. MARIO
3. Results
4. Conclusion
Rapid growth of devices connected to wireless networks

Future applications will demand billions of highly connected devices:
- Internet of Things
- Smart Cities

Most devices operate within unlicensed spectrum bands (IEE S-Band, IEE L-Band, ISM)

Overcrowded spectrum bands and spectrum scarcity
Introduction
Cognitive Radio

- Intelligent system built on a software defined radio
- Aware of its spectral environment
- Adapts to statistical variations

- Can improve communication
  - Security — mitigates jamming
  - Reliability — avoids overcrowded bands
  - Efficiency — licensed spectrum better utilized
• The Secondary User (SU) vacates the channel when a Primary User (PU) requests it
• Cognitive Radio should suspend its transmission and resume afterwards or change channels
• Spectrum Handoff strategies:
  • Non-handoff: the SU pauses its data transmission until the PU leaves the channel
  • Reactive handoff: the spectrum search for vacant channels is applied only when the SU detects a PU arrival in the current channel
  • Proactive handoff: the SU proactively looks for backup channels trying to predict the PU traffic pattern
  • Hybrid: the SU senses the environment looking for vacant channels and hops only when PU arrival is detected
• Proactive handoff relays on accurate PU arrival prediction
• Machine learning is used for PU arrivals prediction
• Difficult to simulate PU arrivals in existing simulators
  • GNU Radio
  • Omnet++/INET

A Poisson Process could be employed to achieve this simulation
MARIO
A Cognitive Radio Primary User Arrivals Data Generator

- PriMAry UseR ArrIvals Data GeneratOr
- Enables the production of spectrum traffic data in a simple way
- Data generated using a Poisson Process
- Validated using Hidden Markov Model
- Open-source: https://github.com/rogerscristo/MARIO
Algorithm 1: PU Arrivals data using a Poisson Process

\( RTD \leftarrow 0 \) // Random Transmission Duration

while \( RTD < MSD \) do
  Generate arrival spacing

  \( RAT \leftarrow -\ln(R \cap [0,1]) + RTD \) // Random Arrival Time

  \( RTD \leftarrow RAT + N \cap [2, TD] \) // TD is the Time Duration

  for \( x \leftarrow RAT \) to \( RTD \) do
    Populate result array
    if \( x < MSD \) // Maximum Simulation Duration
      then \( ARV[x] \leftarrow 1 \);
  end
end

return \( ARV \)
• MARIO was validated using the Hidden Markov Model (HMM)
• The HMM is an unsupervised machine learning model
• Mainly used on the prediction of events sequences
• Fits well for real-world problems
## Data Generation Setup

<table>
<thead>
<tr>
<th>Channel</th>
<th>Avg. time between arrivals [min]</th>
<th>Avg. PU transmission duration [min]</th>
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<td>3</td>
</tr>
<tr>
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<tr>
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</tr>
</tbody>
</table>
Results

PUs arrivals timeline

Timeline [min]

Channels

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MARIO
Results

Prediction using HMM

Channel data

Timeline [min]
Conclusion

- **MARIO**
  - Is open-source
  - Is an easy-to-use lightweight Python script
  - Abstracts the algorithmic and statistical details from the user
  - Does not require significant computing power

- **Future work will consider**
  - The application of real-data to enhance the generated-data fidelity
  - Mobility constrains
  - A graphical user interface
Thanks!

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