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

- 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
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Laboratory of Critical Embedded Systems

- Pri**MA**ry Use**R** Arr**I**vals Data Generat**O**r
- 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*

  $RAT \leftarrow \dfrac{-\ln(\mathbb{R} \cap [0,1])}{\lambda} + RTD$ // `Random Arrival Time`

  $RTD \leftarrow RAT + \mathbb{N} \cap [2, TD])$ // `TD is the Time Duration`

  for $x \leftarrow RAT$ **to** RTD **do** *Populate result array*

    if $x < MSD$ // `Maximum Simulation Duration`

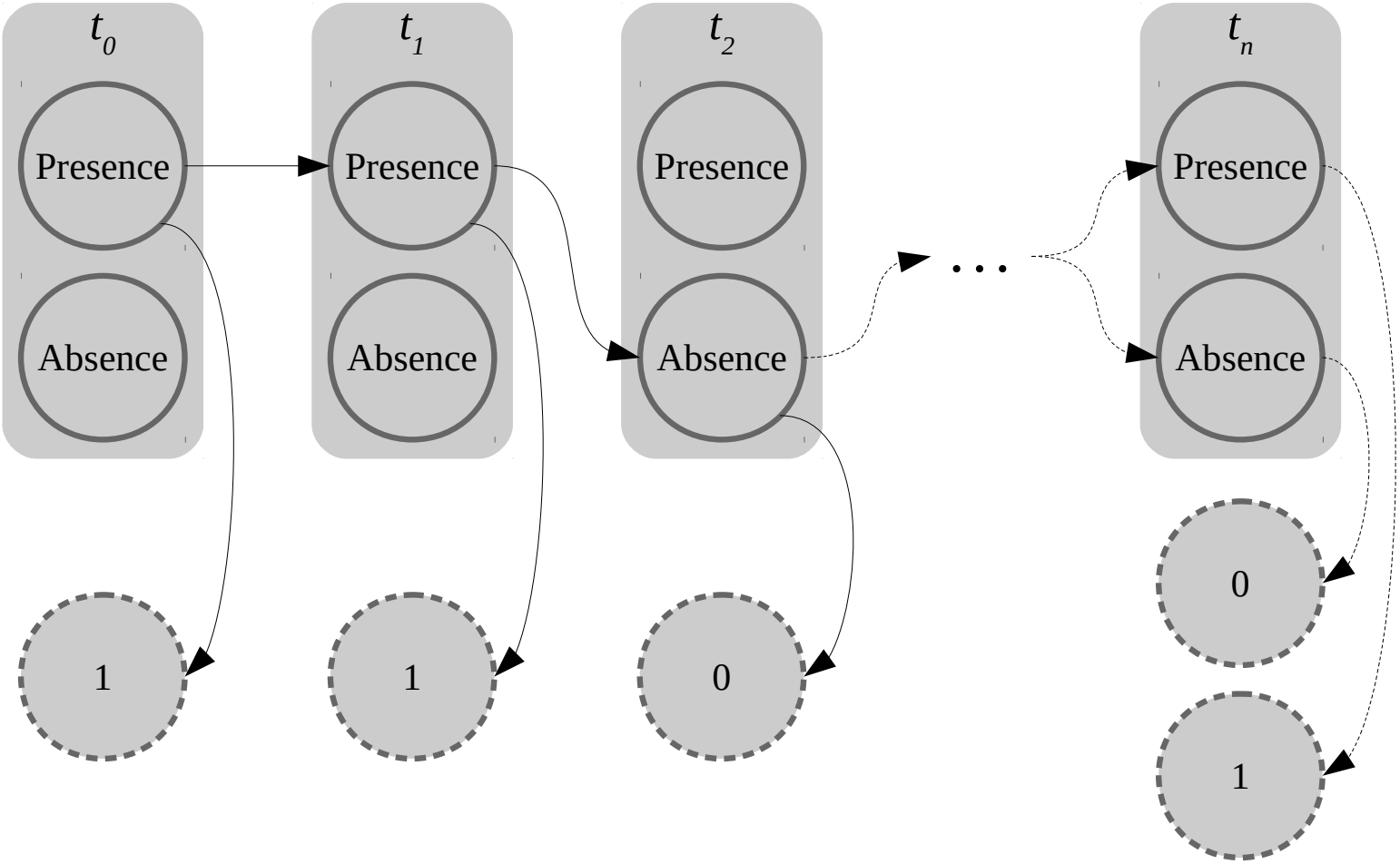
    then $ARV[x] \leftarrow 1$;

  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


t_0
Presence
Absence
1
t_1
Presence
Absence
1
t_2
Presence
Absence
0
...
t_n
Presence
Absence
0
1

Results

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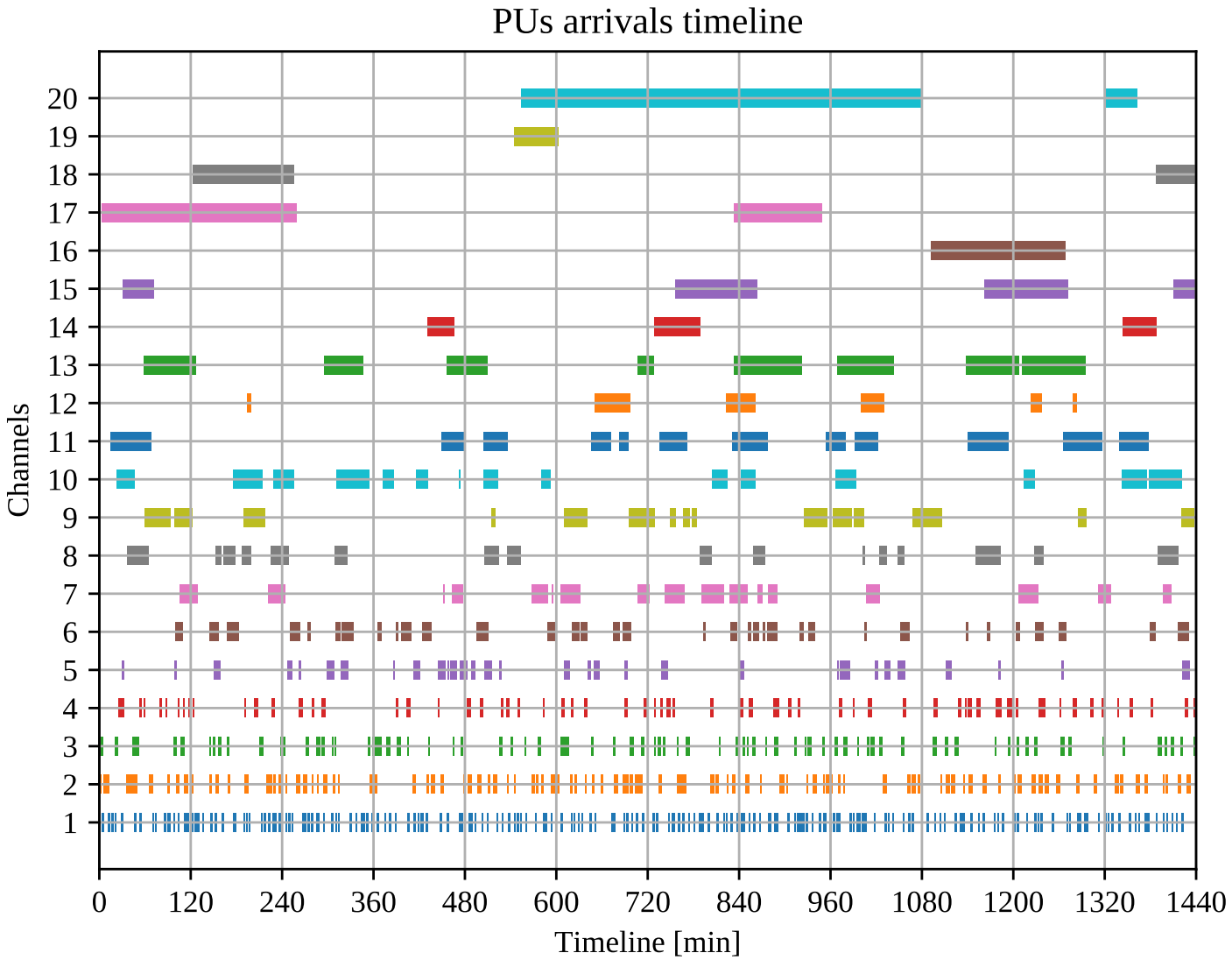
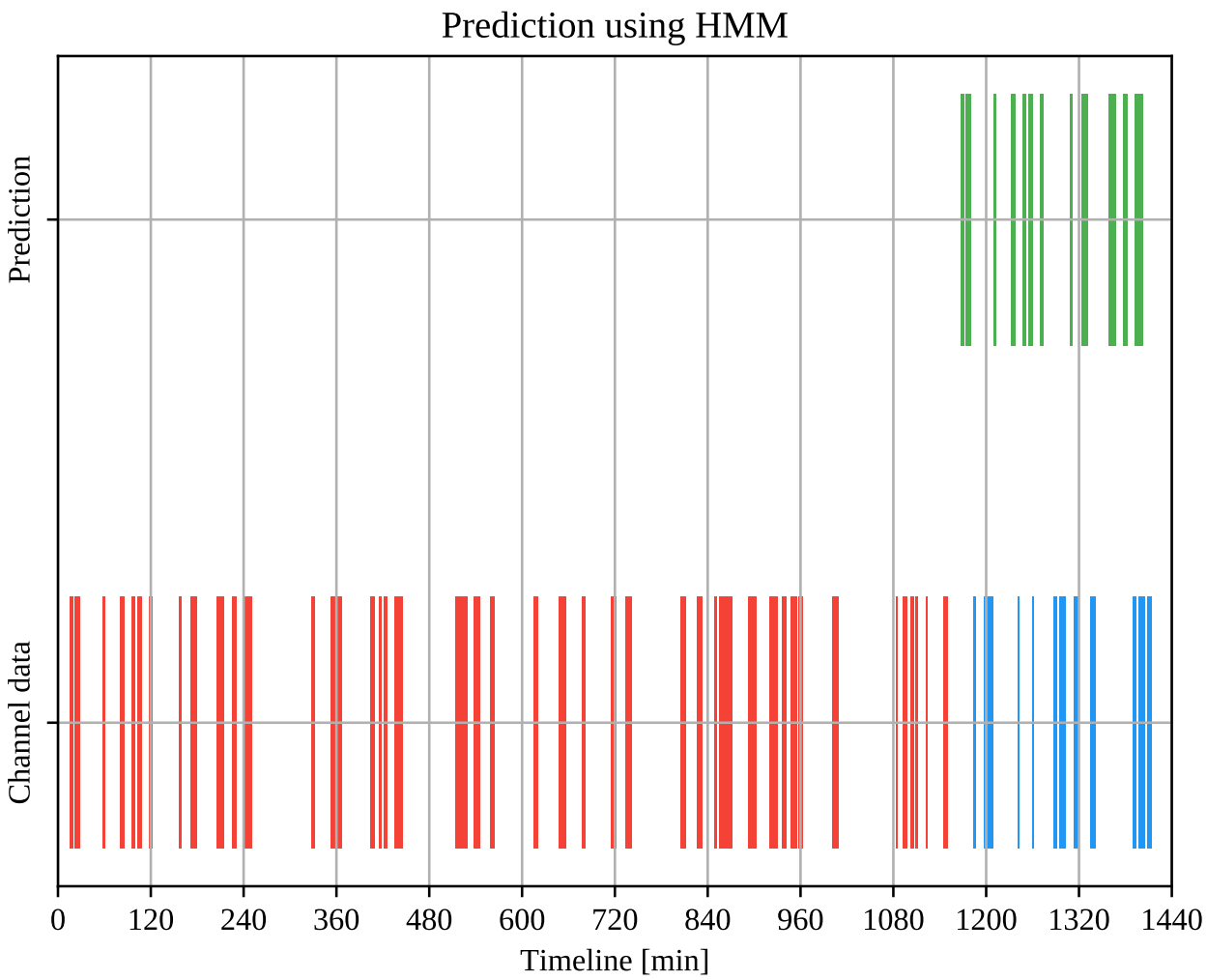
DATA GENERATION SETUP

Simulation duration: 24h		
Channel	**Avg. time between arrivals [min]**	**Avg. PU transmission duration [min]**
1	5	3
2	10	5
3	15	5
4	20	5
5	30	10
6	40	15
7	50	30
8	55	35
9	60	40
10	90	45
11	90	60
12	120	60
13	120	90
14	240	90
15	240	120
16	480	240
17	480	300
18	720	300
19	720	480
20	720	540

Results


PUs arrivals timeline
Channels
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
120
240
360
480
600
720
840
960
1080
1200
1320
1440
Timeline [min]

Results


Prediction using HMM
Prediction
Channel data
0
120
240
360
480
600
720
840
960
1080
1200
1320
1440
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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