Integrated Power and Device-to-Device Communications Simulator for Future Power Systems

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Kevin Shimotakahara, Medhat Elsayed, Melike Erol-Kantarci, Karin Hinzer

University of Ottawa

NSERC CRSNG

NSERC CREATE TOP-SET Un programme *FONCER* du CRSNG

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Desired Outcomes of Presentation

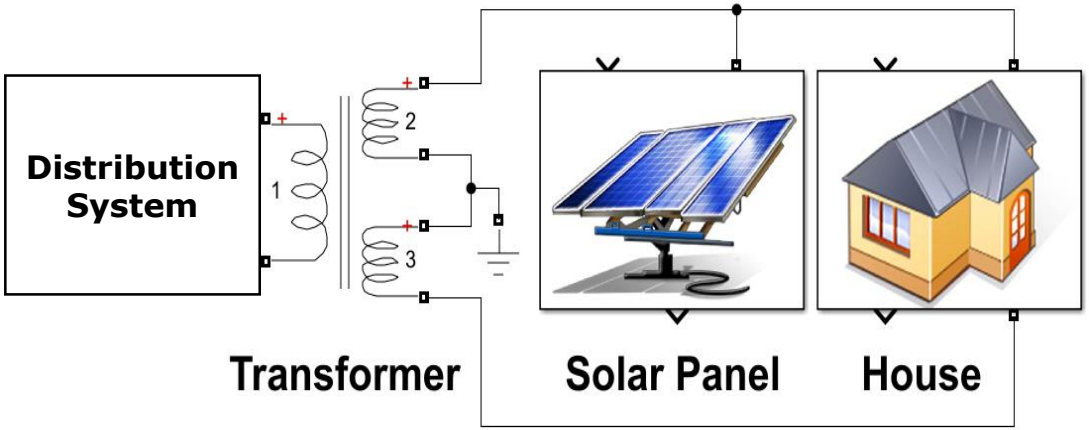
1. Identify "the point" of this simulation tool

2. Show that communication and power systems are in synch

3. Demonstrate some use cases of this simulation tool

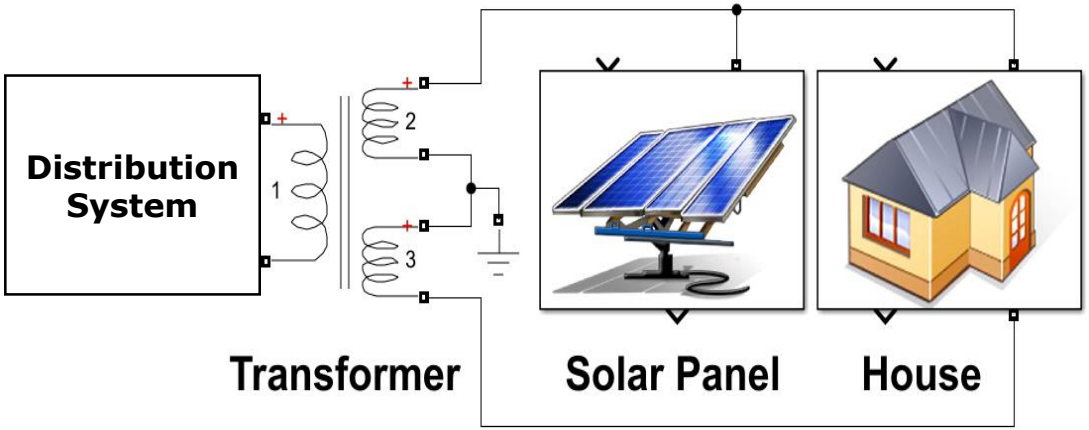
Case 1

- Designing microgrid that interfaces with distribution system



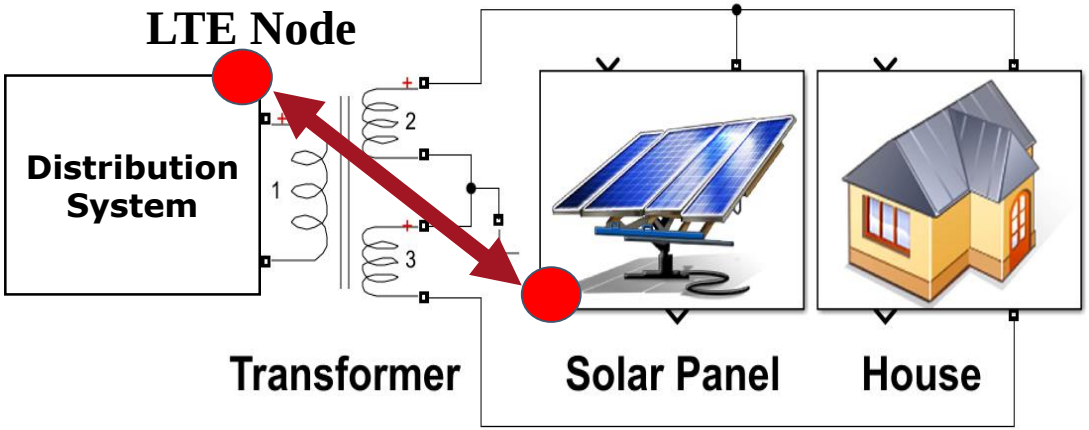
Case 1

- Designing microgrid that interfaces with distribution system
- **Simulation tools** available are Robust/mature (e.g. Simscape Power)



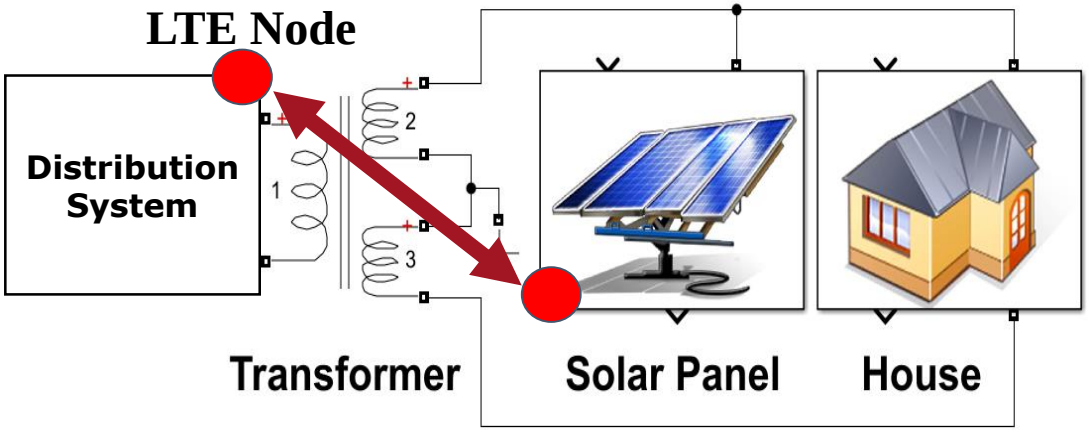
Case 2

- Introducing a communication link for smart grid application



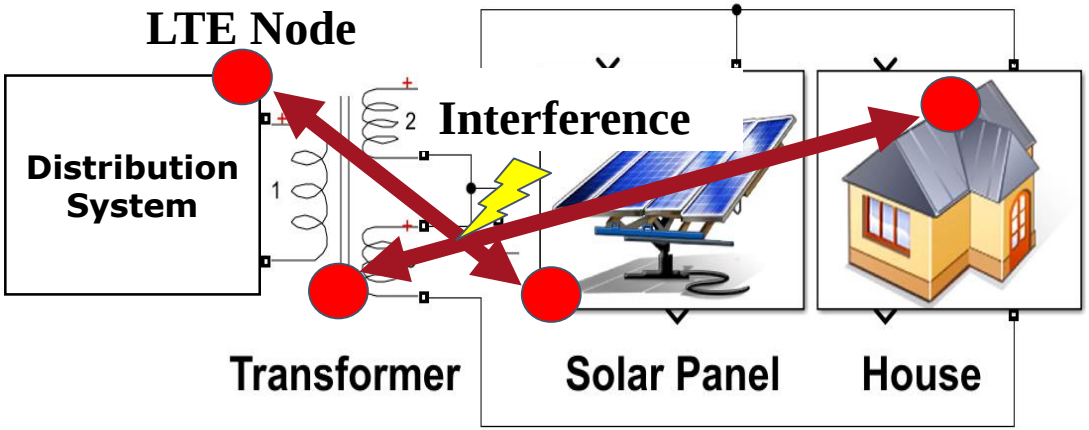
Case 2

- Introducing a communication link for smart grid application
- **Simulation tools** available are less mature, co-simulation approaches dominate literature



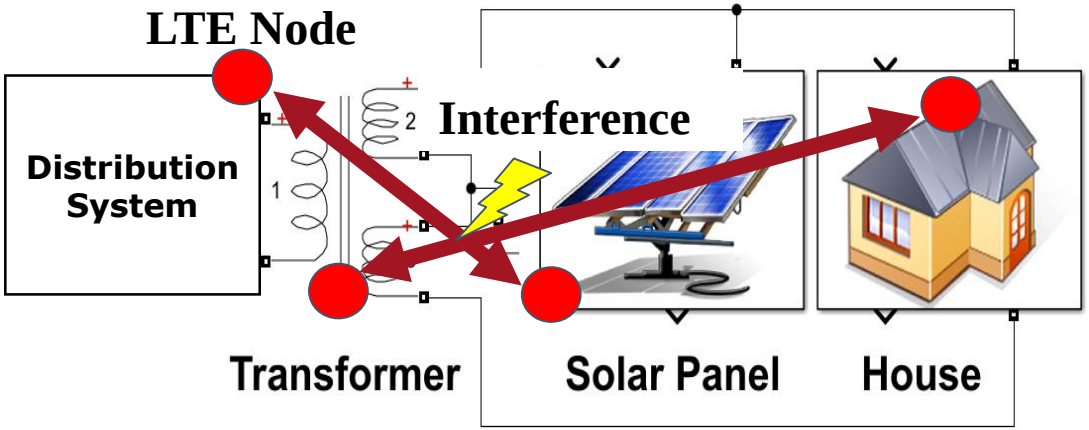
Case 3

- Observing impact of signal interference on performance of mission critical smart grid application



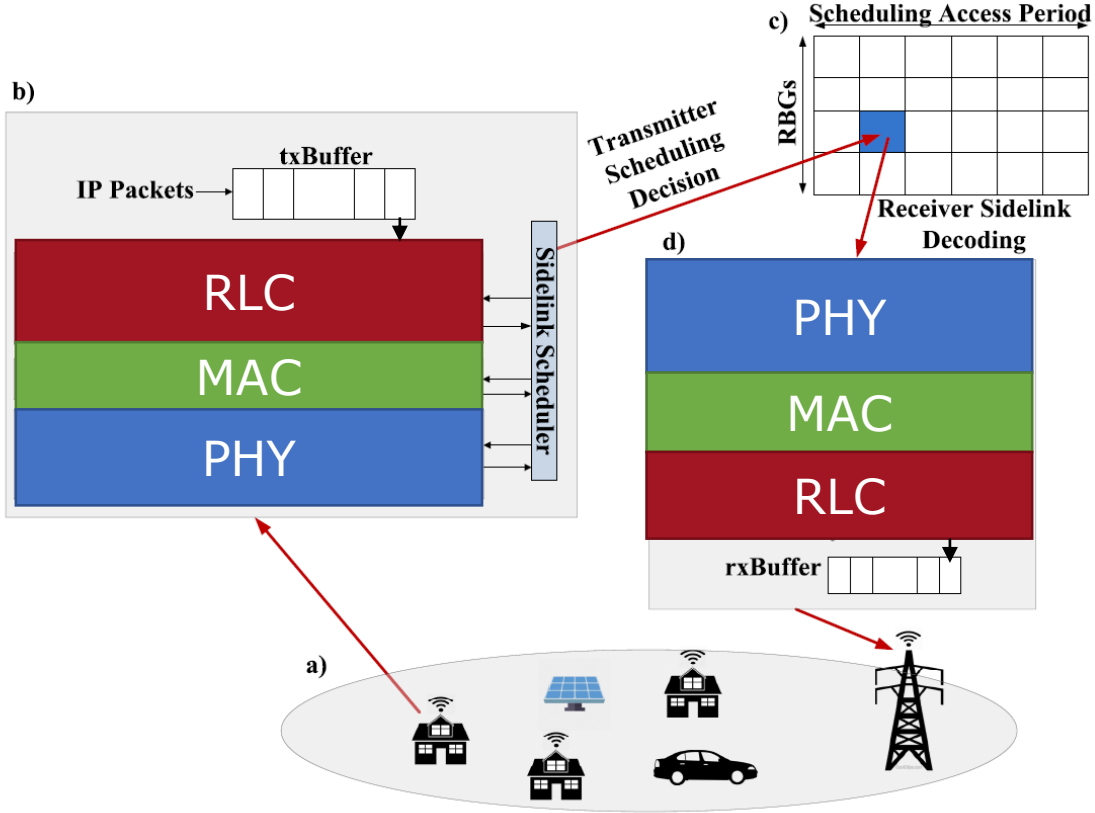
Case 3

- Observing impact of signal interference on performance of mission critical smart grid application
- **Simulation tools** available rarely model physical layer of communication network



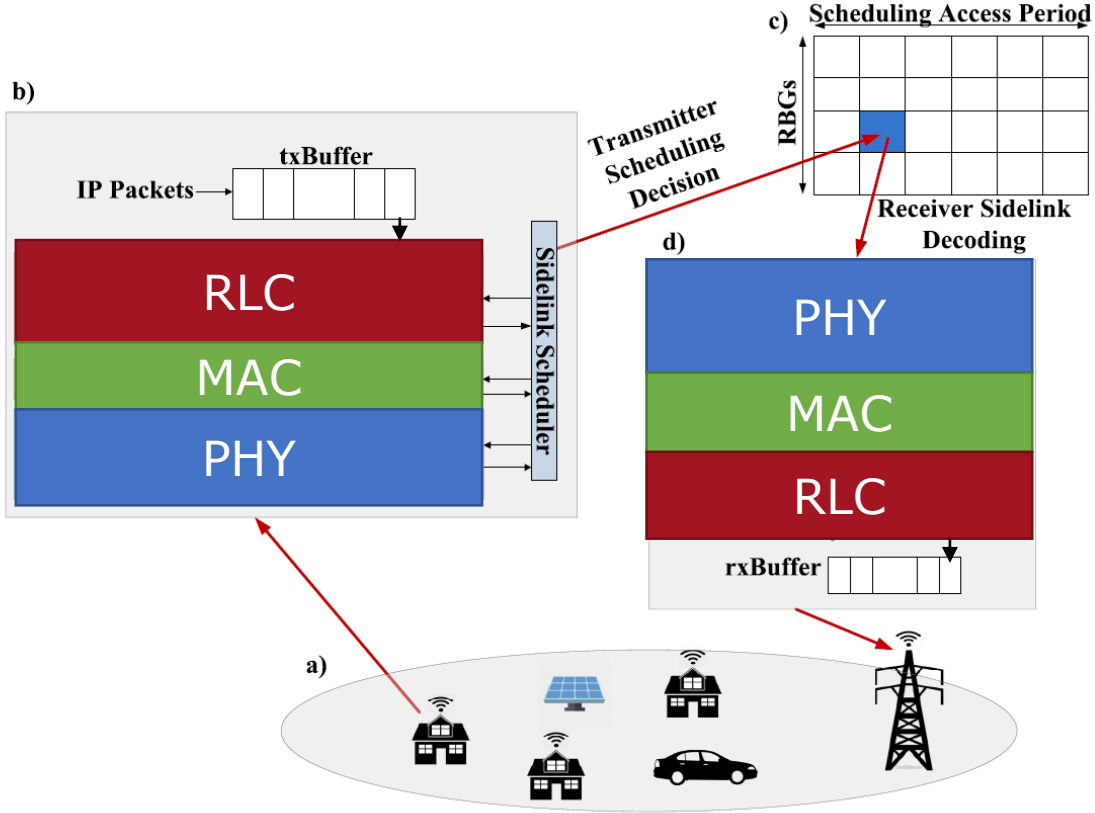
Scope of Simulation Tool

- Models LTE data plane from RLC layer down down to physical layer



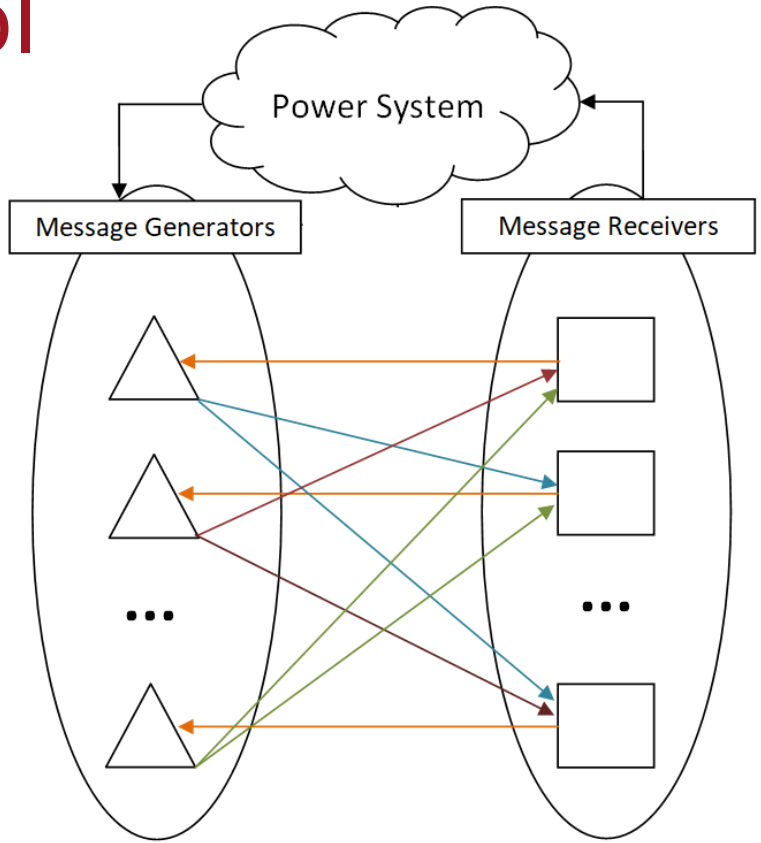
Scope of Simulation Tool

- Models LTE data plane from RLC layer down down to physical layer
- Captures effects of interference, fading, noise, physical resource allocation, etc. **these are key to accurate simulation of latency, packet loss**



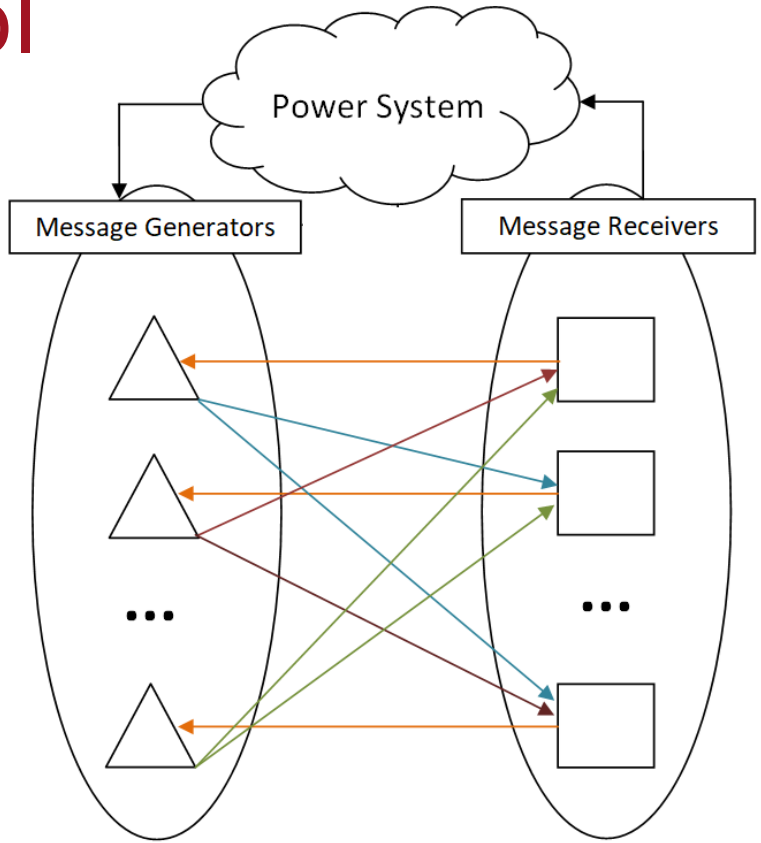
Scope of Simulation Tool

- Captures joint dynamics of electrical power systems and **LTE-compliant Device-to-Device (D2D) communications**



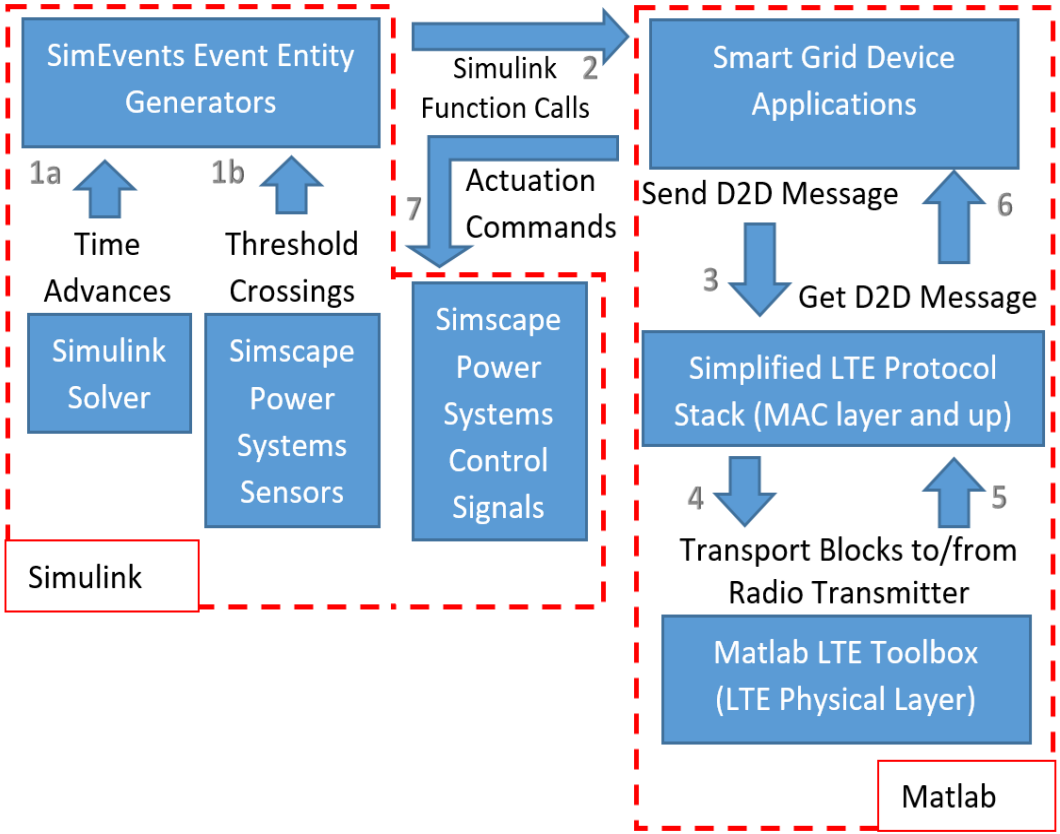
Scope of Simulation Tool

- Captures joint dynamics of electrical power systems and **LTE-compliant Device-to-Device (D2D) communications**
- **No core communication network** (Limited to Neighbourhood Area Network scale smart grid applications)



Simulation Architecture in MATLAB/Simulink

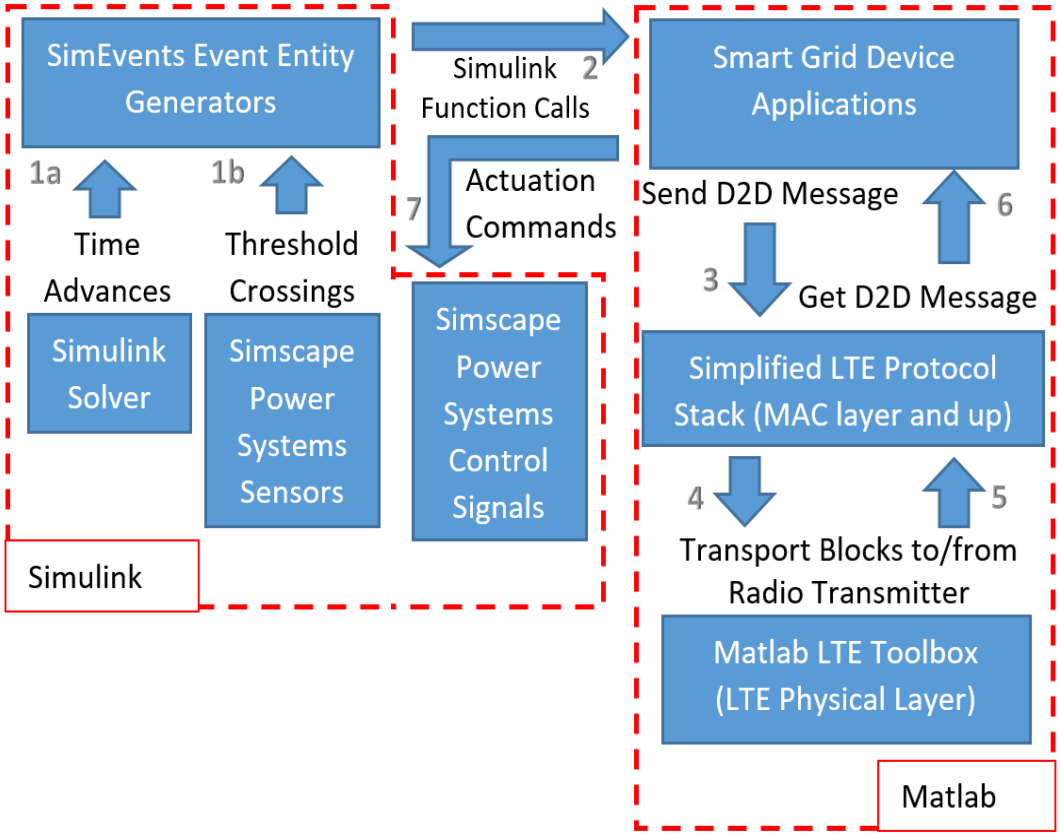
Simscape for power system



Simulation Architecture in MATLAB/Simulink

Simscape for power system

SimEvents to trigger execution of MATLAB scripts in response to discrete events



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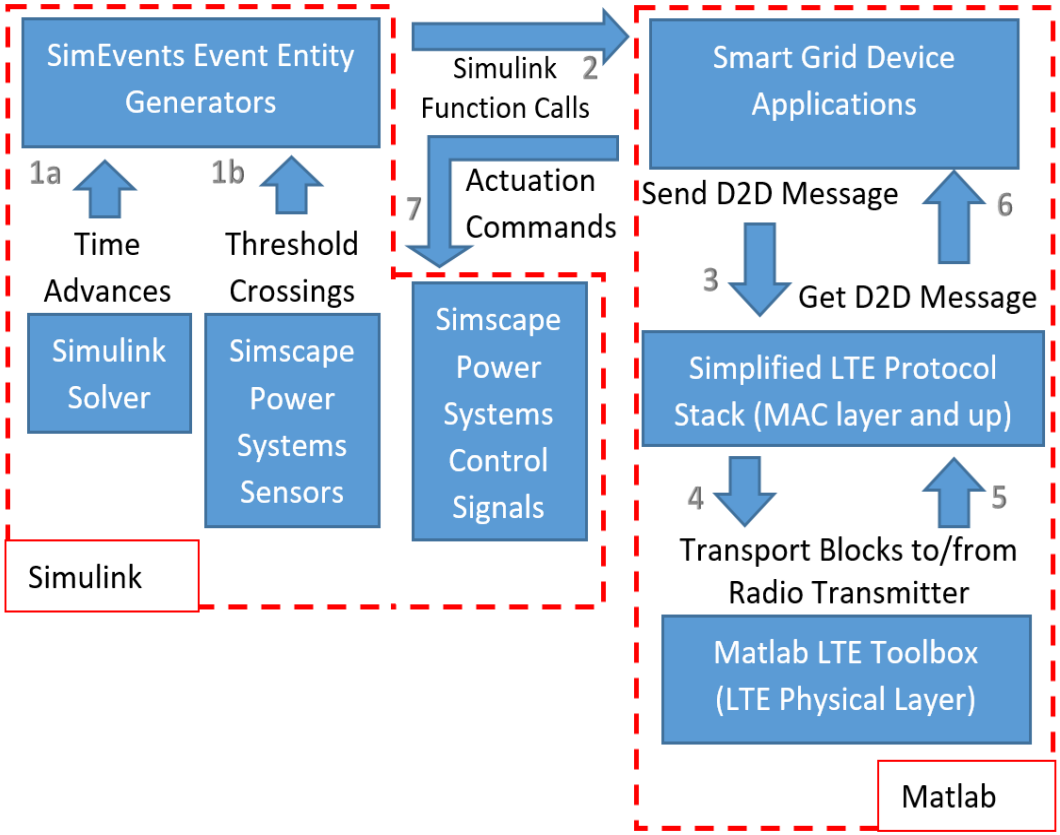
LTE System Toolbox to model LTE Physical layer



Simulation Architecture in MATLAB/Simulink

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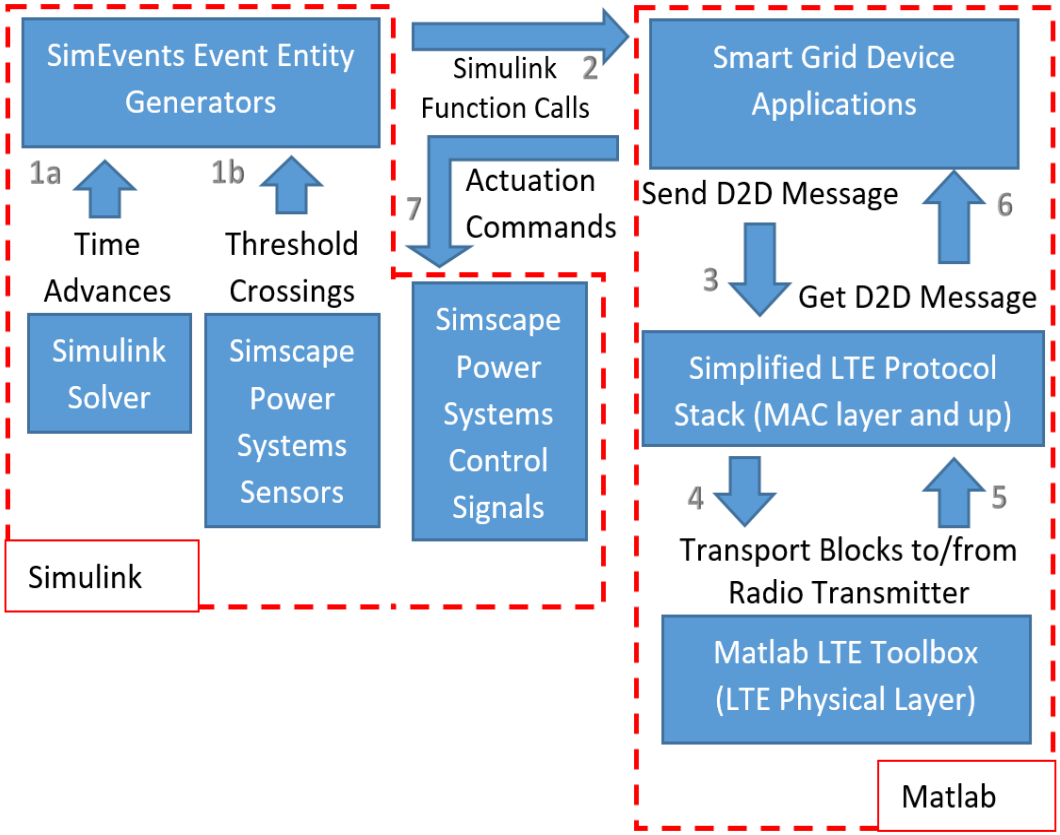
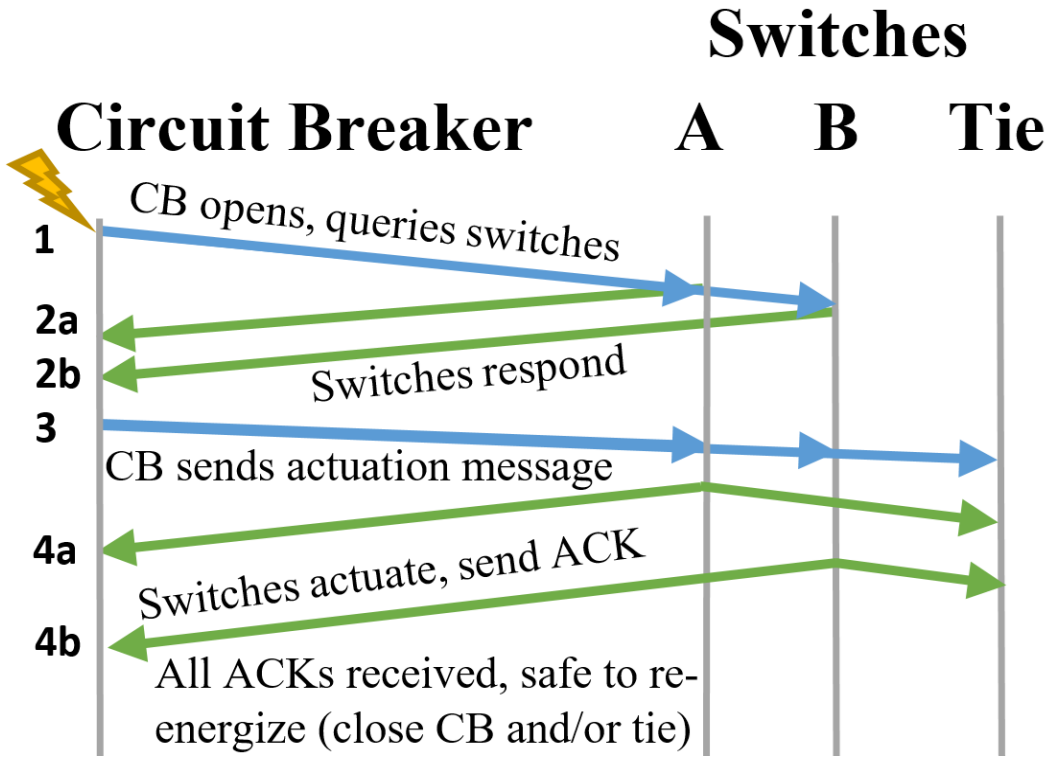
LTE System Toolbox to model LTE Physical layer

Custom Code to model LTE R14-Compliant RLC and MAC layers, physical resource mechanism, and smart grid device application scripts



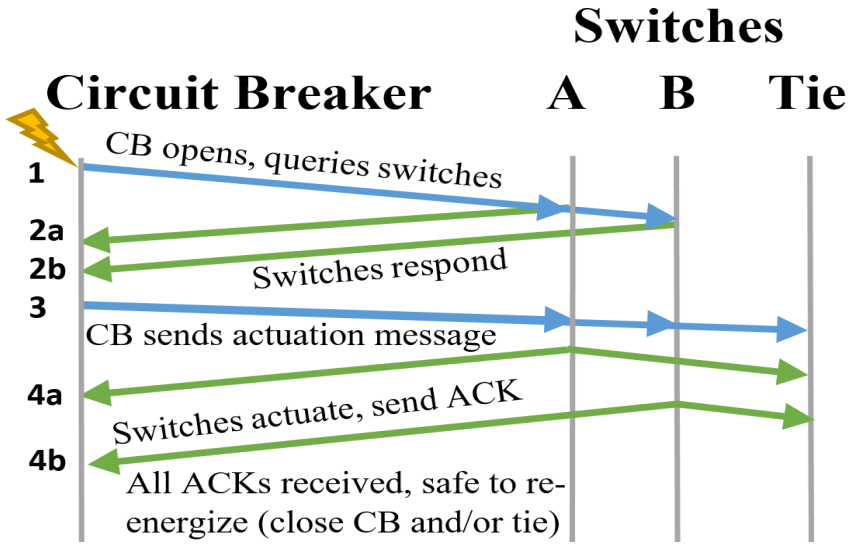
Testing Joint Dynamics

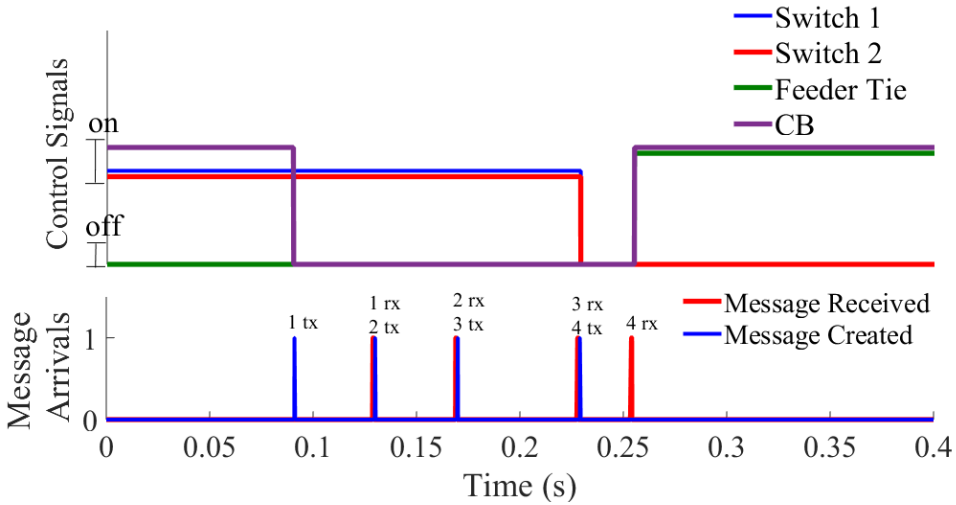
- Implemented fault location, isolation, restoration (FLISR) application
- Goal is to observe that control signal changes are synchronized to actuation messages



Testing Joint Dynamics

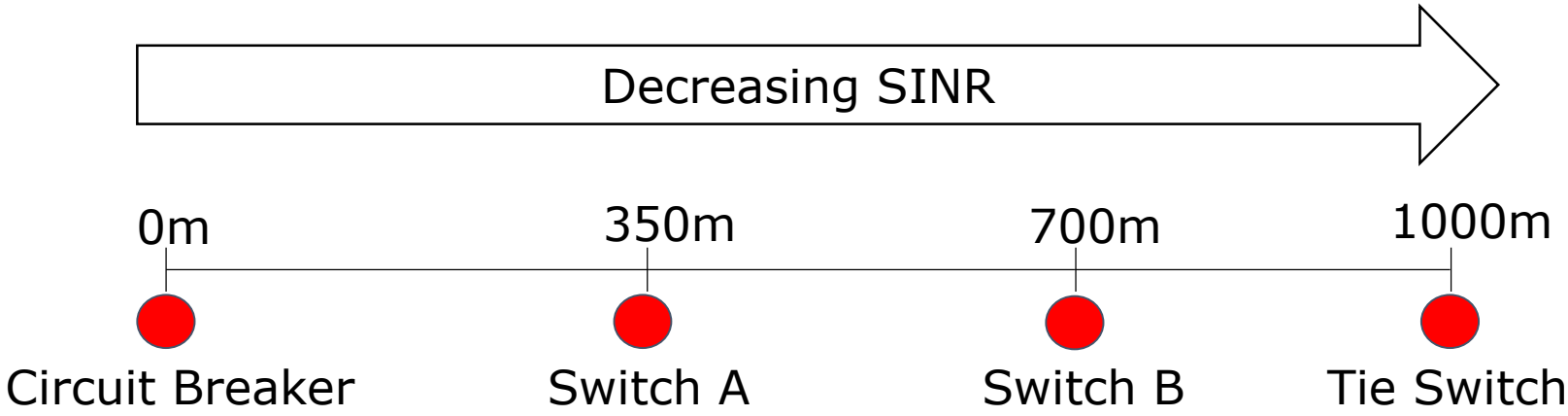
- Results show timing of messages line up with control signals





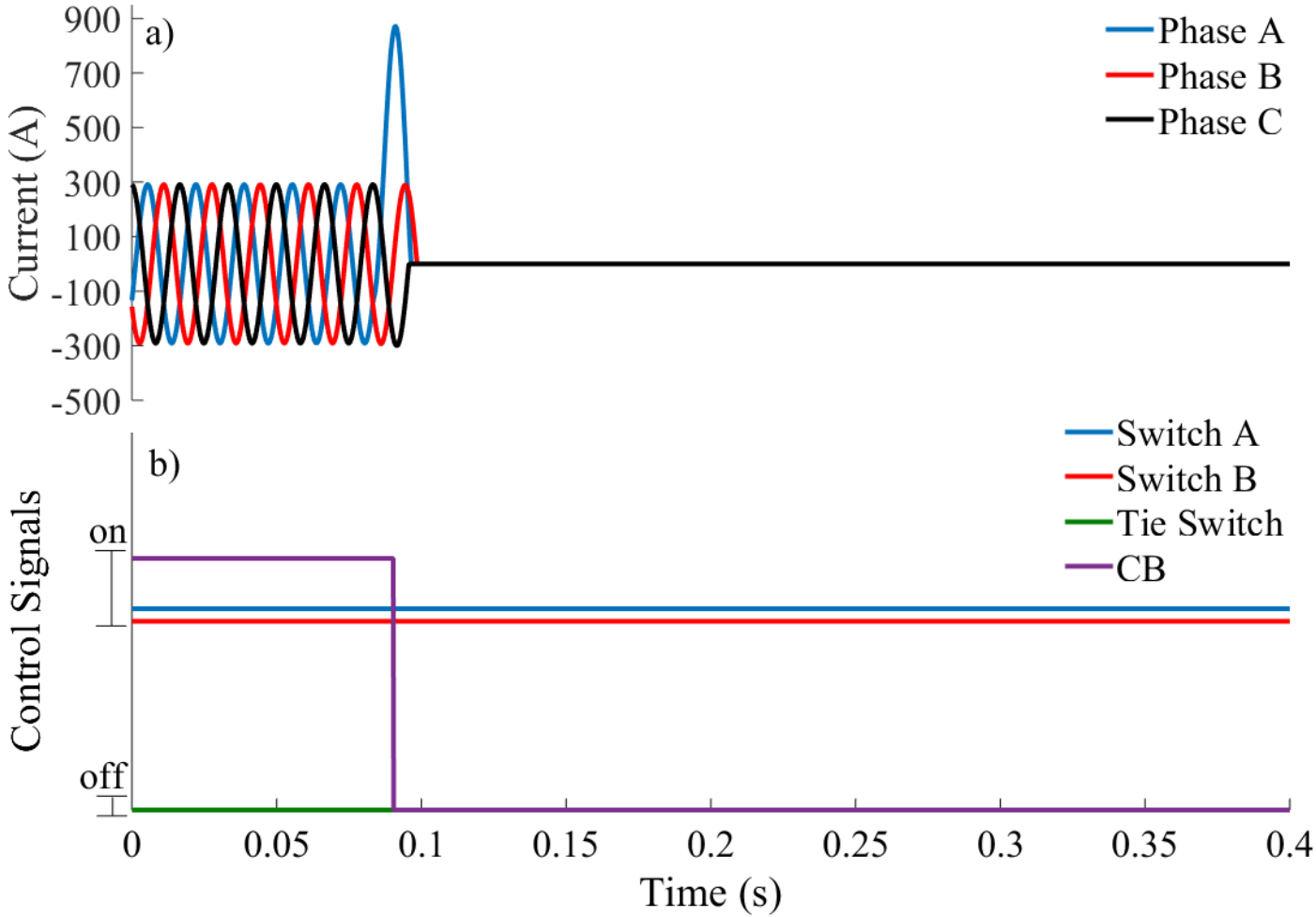
Example 1 Observing PHY Layer Performance

- Observe SINR for each D2D link in FLISR application as a function of Antenna Gain
- Simulation can determine antenna gains required for each node in smart grid



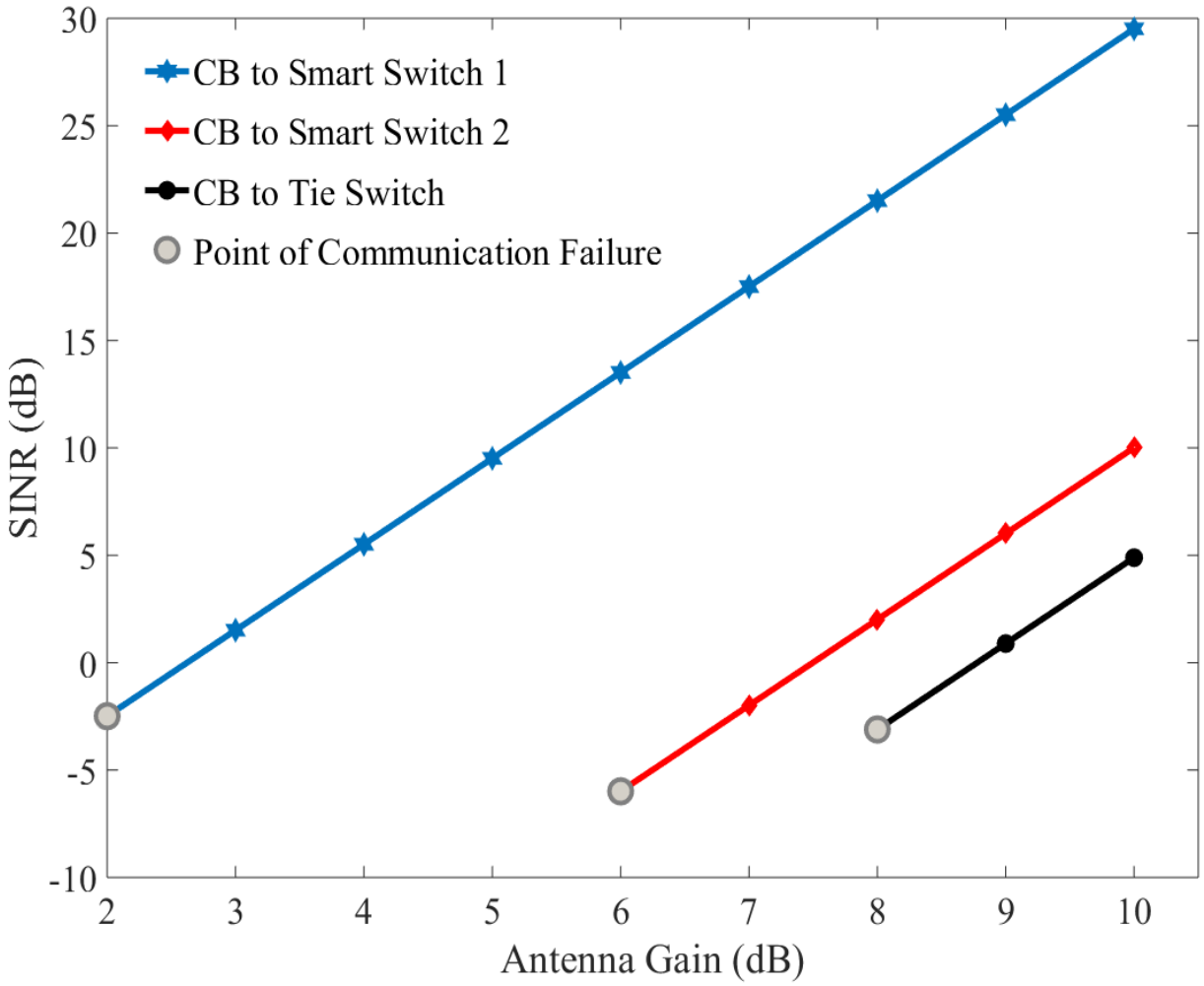
2dB LTE Antenna Gain

1. Switches fail to decode messages from circuit breaker
2. No Loads restored



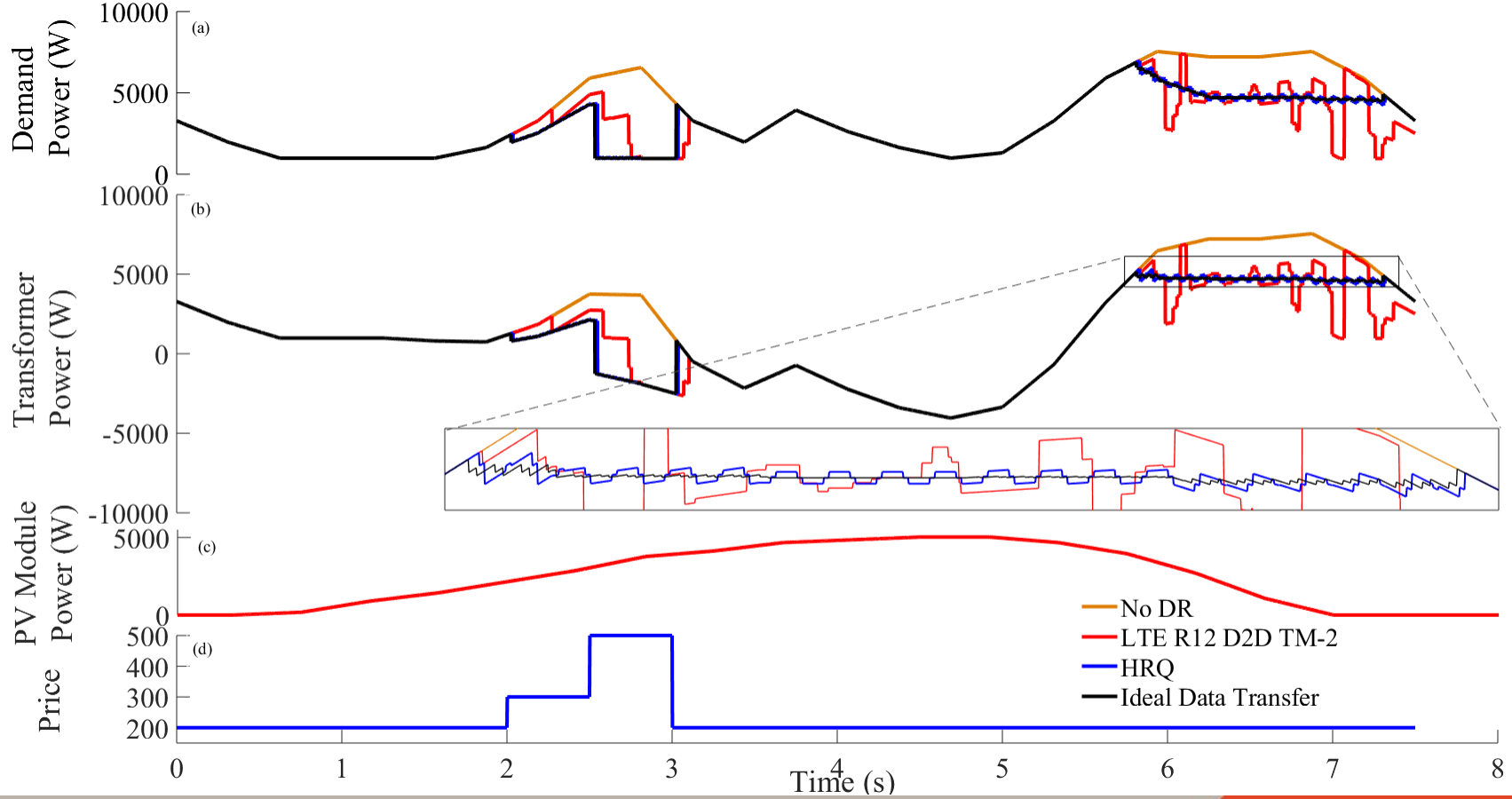
Sweep Antenna Gain Parameter

1. Process discovers minimum gains for various devices
2. Can observe SINR performance as well
3. Ensures reliable communication network design



Example 2 Physical Resource Allocation

10.1109/ACCESS.2019.2920662



Conclusions

1. Presented LTE D2D enabled smart grid simulator
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   - Enables physical layer dynamics of LTE communications
   - Provides smart grid simulator for MATLAB/Simulink
2. Tested synchronization of LTE and power simulators
3. Demonstrated how physical layer attributes can influence smart grid design
4. Future work:
   - Mathematically characterize LTE/power system interface
   - Incorporate 5G physical layer models into simulation