

AIM

- Provide a homogeneous communications network for the Smart Grid that is able to adapt to real-time events.
- Optimally allocate resources between Smart Grid and pre-existing telecommunications traffic operating on a wireless network by using a Lotka-Volterra Population Dynamics
- Ensure Quality of Service (QoS) for all traffic classes

MOTIVATION

The Smart Grid will require a robust and efficient communications network

- Data transmitted by Smart Grid is vital to the security and reliability of the power grid.
- Increased integration of renewable energy resources warrants an increasing amount of monitoring and control due to their unpredictability.
- Previous solutions to optimal telecommunications resource allocation were inflexible to the dynamic nature of the telecommunications environment.

TRAFFIC MODEL

Wide Area Situational Awareness

- Set of applications such as Distribution Automation (DA) that draw their data from sensors such as Phasor Measurement Units (PMUs)

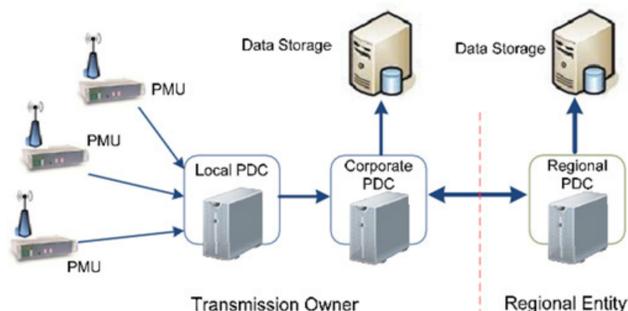


Figure 1 – Phasor Measurement Unit Data Collection Network

- The throughput, latency, & accuracy requirements of such applications are very stringent.

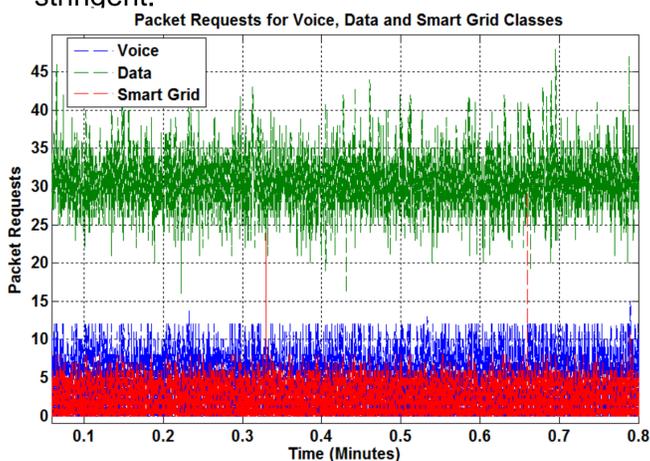


Figure 2 – Packet Requests for Smart Grid; Data; Voice Traffic

- The traffic model for the simulation was broken into three different classes: Smart Grid; Data; and Voice.
- The Smart Grid and Data classes were treated as TCP/IP packets with differing payload sizes. The Smart Grid and Data classes follow a random Erlang Distribution coupled with communications at regular intervals to better model bursty and program status/update traffic.

COMMUNICATIONS CHANNEL & SUBCARRIER POWER ALLOCATION

When modelling the communication channel it was important that the channel reflected the environment that a Smart Grid distribution grid would be located. The communication channel was therefore modelled to resemble a medium to high density urban environment. As such, a Multipath Rayleigh fading channel model was used, however, mobility of the UEs was not incorporated in the model due to complexity and the fact that Smart Grid UEs are stationary.

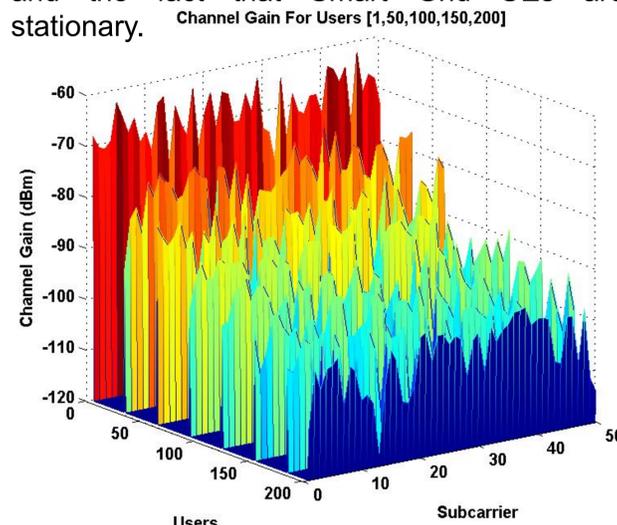


Figure 3 – Channel Gains in Multipath Rayleigh Fading Model

RESOURCE ALLOCATION & SCHEDULING

Lotka-Volterra (LV) Resource Allocation Algorithm

In this work we model the wireless telecommunications environment as a Lotka-Volterra system, with each 'species' defined by the Lotka-Volterra equations a telecommunications class in the wireless environment. Therefore we define the system as:

$$\dot{x}_i = x_i \left(r_i - \sum_{j=1}^n a_{ij} x_j \right) = F_i(x), \quad i = 1, \dots, n$$

x_i : population of species i

r_i : growth rate of species i

a_{ij} : Interaction Matrix: how species i and j interact with each other. By choosing a special condition, S1:

$$a_{ij} > 0 \quad \forall \quad 1 \leq i, j \leq n$$

we have defined the system as purely competitive where each species competes with all others and itself for the environments resources: available subcarriers.

Simulation Parameters

Parameter	Setting
Carrier Frequency	1800MHz
Bandwidth	10MHz
Modulation	MQAM
Subcarriers per RB (N_{SC}^{RB})	12
OFDM Symbols per RB ($N_{Symb}^{DL/UL}$)	7
RB Bandwidth	180kHz
Number of RBs (N_{RB})	50
Number of Active Users	200
Data Packet Size for Smart Grid UE	100 Bytes
Data Packet Size for Data	500 Bytes
Data Packet Size for Voice	128 Bytes

RESULTS & DISCUSSION

Throughput of Traffic per Subcarrier

- When optimizing individual class throughput, the class is divided into three categories defined by their SNR. These categories are SNR of {0-10} for UEs close to boundary; {10-20}; and {20+} for UES near the eNB.
- The throughput of the differing modulation modes follow an exponential distribution as their SNR increases. It is shown that the lower bound of the LV algorithm is higher than if the class was not fragmented into three categories. This slightly affected the maximum rate, however, it provided higher average rates to users with an SNR below 20dB.

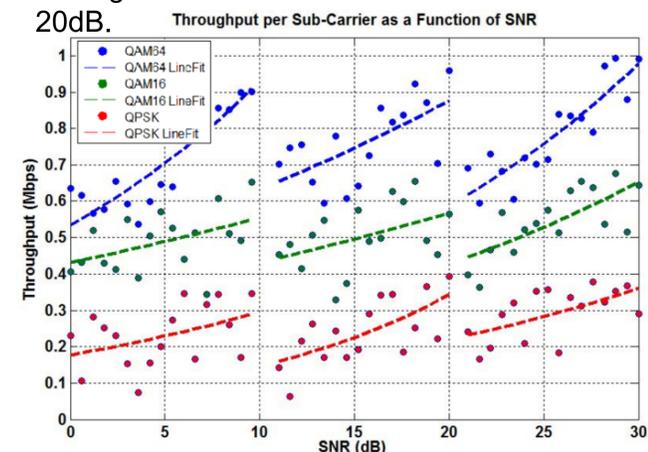


Figure 4 – Throughput of Subcarrier

Fairness of Lotka-Volterra Algorithm

- The Maximum Sum Rate algorithm performs best at high SNR
- The Proportional Rates Constraint algorithm produced a lower peak data rate and does not fully optimize QoS by exploiting the diversity of a multiuser environment.
- The Lotka-Volterra algorithm was found to share resources well between users,

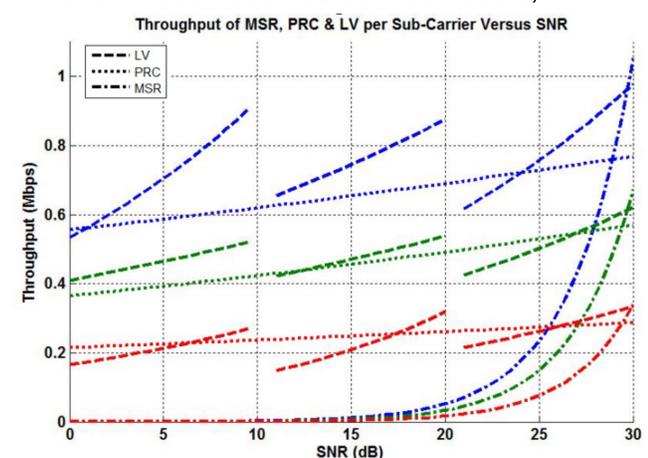


Figure 5 – Throughput Comparison

CONCLUSION

- The Lotka-Volterra Resource Allocation Algorithm was shown to model a communications environment effectively.
- The L-V algorithm provided the ability to quickly adapt to the changing requirements of UEs operating and allocate resources to ensure high QoS.
- This research has shown that current day telecommunications infrastructure can incorporate Smart Grid traffic without adversely affecting pre-existing data and voice communications in a large way.
- This research can also be used as a basis of increasing throughput of fixed position UEs.