Modelling of Smart Grid From a Communications Perspective

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Introduction

1. Overview of Smart Grid
2. Challenges
3. Communication Architecture
4. Multi-dimension Markovian model
5. Future Work

What is Smart Grid?

1. Smart Grid is an intelligent electricity network that uses advanced ICT.
2. It is an effort to save energy, reduce cost and increases the utilization and reliability and transparency.
3. It is the transformation of older electric grid.
4. Services like AMI, Demand response, DER etc. are crucial for successful deployment of Smart Grid.
5. Communication technologies is a key enabler for data exchanges between the device and the central utility that contains the big information.

Challenges to Communication Modelling

1. Heterogeneous Communication Network. It requires proper interfaces and interoperability
2. Home Networking Challenges.
3. Multi-source and Multi-user

Communication Architecture

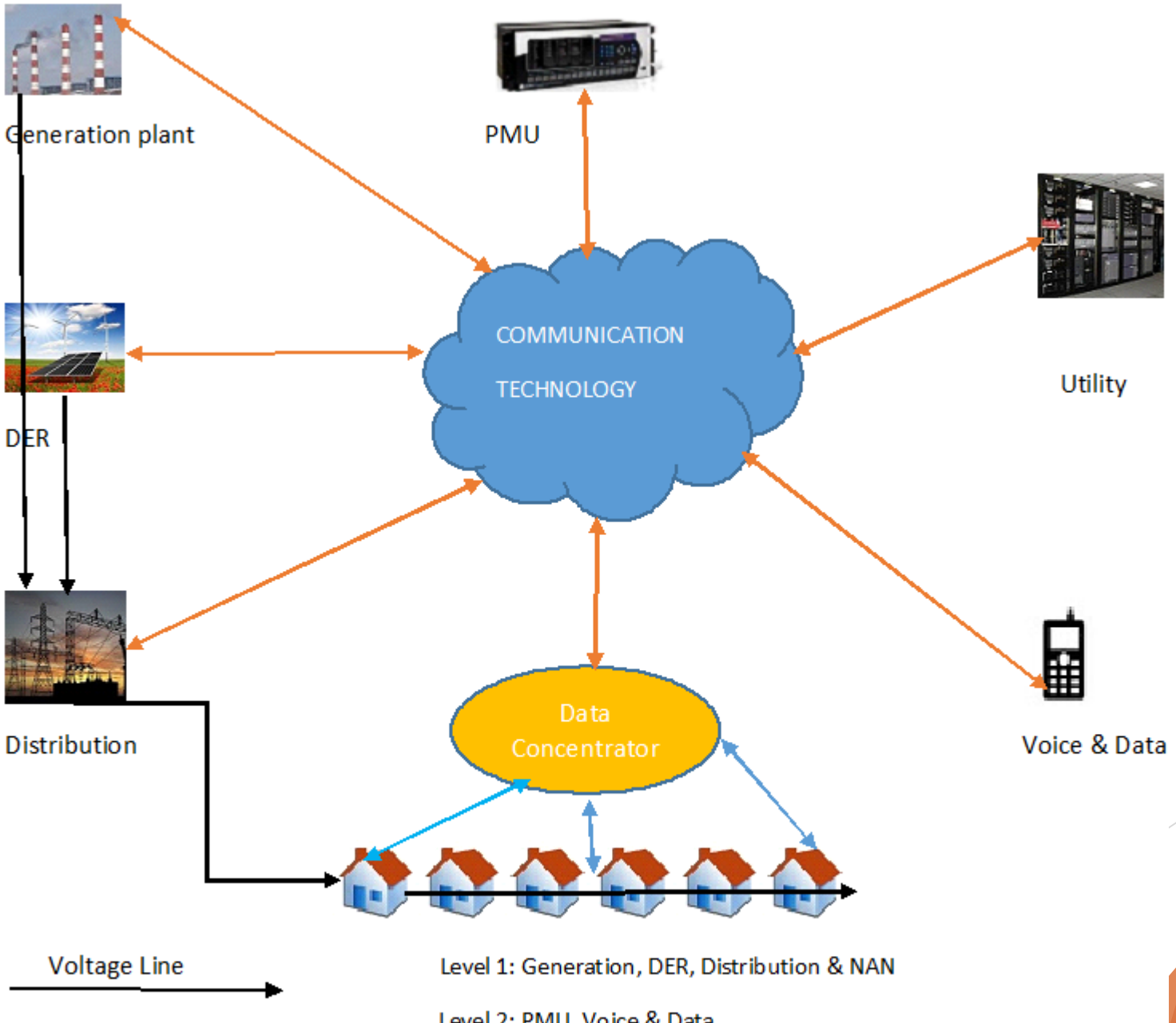
1. We focus on cellular technologies to make the system cost effective for Smart Grid Application.

2. Data concentrator transmits the data collected from HANs to the base station which is transmitted to Utility center for various purposes like billing, etc.

3. Utility will send the control signal or information to customers as a feedback or command.

4. As it uses the existing cellular technology, the concept of the cell pattern, coverage analysis etc. will be the same but difference lies in the traffic pattern and handling capacity, throughput, blocking probability.

BLOCK DIAGRAM of Smart grid architecture

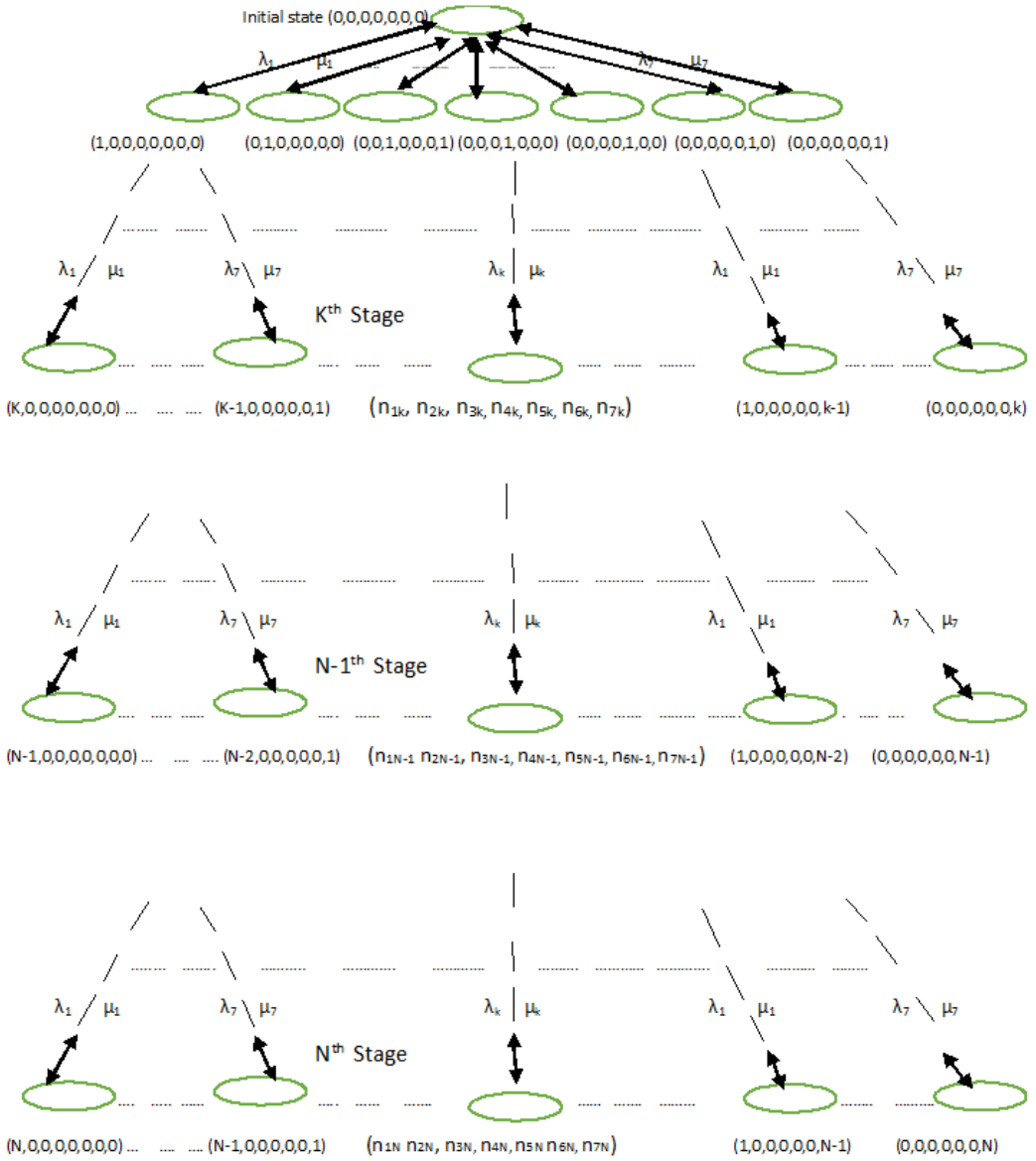


Markovian Model

1. Multidimensional markovian model is being used to do the traffic analysis with state showing the number of channels occupied by each services which in turn signifies the number of customers in each state.

2. Customer/Service is blocked if the total number of free channel is less than total arrival of the service.

3. If system works fast i.e. service time is less then more customers can be served. This depends on type of service(packet size) and frequency of data transmission and type of cellular technology(GSM).



λ_i and μ_i are arrival & departure rate of class i.

$(n_{1k}, n_{2k}, n_{3k}, n_{4k}, n_{5k}, n_{6k}, n_{7k})$ is the state description of k^{th} stage

Stability from a Queuing Perspective

1. A single queue system is stable if (**packet arrival rate** λ **) < (service Rate** μ **)**

2. For a single queue, the ratio of (**packet arrival rate** λ **) < (service**

3. It describes the performance of a queue in terms of traffic handling.

4. Stable systems with time-stationary arrival traffic approach a steady-state

Multidimensional stability

- λi is the arrival rate of class i.
- μi is the service rate of class i.

- For stability $\sum_{i=1}^{k} \lambda i/\mu i <= 1$

- where K is total number of class
- Arrival and service rate are distributed as Poisson distribution.

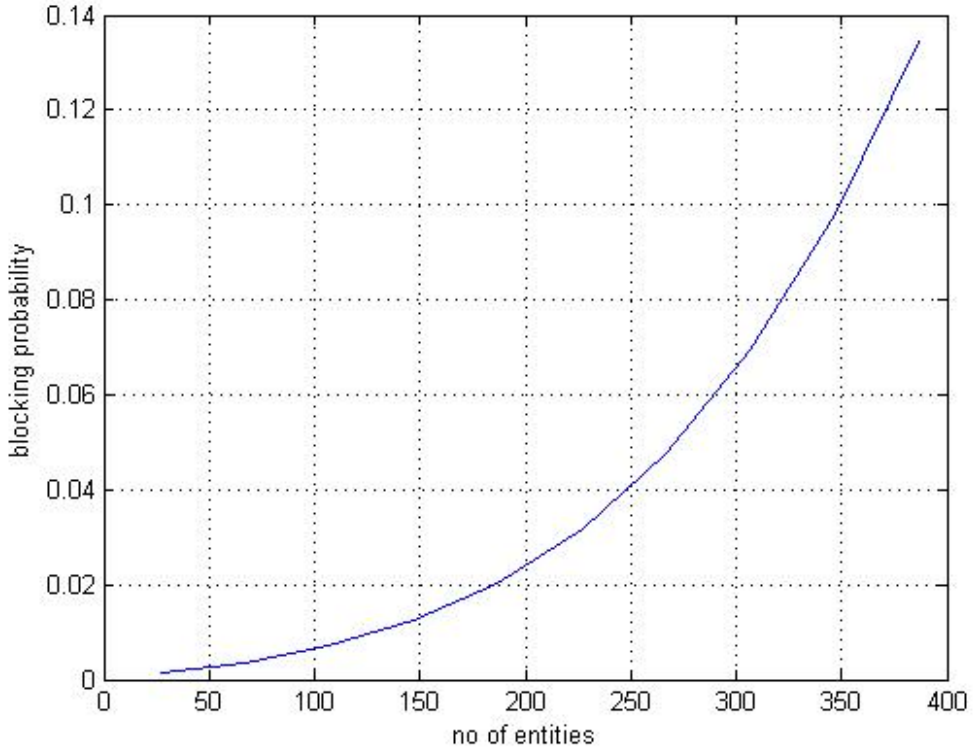
Analysis

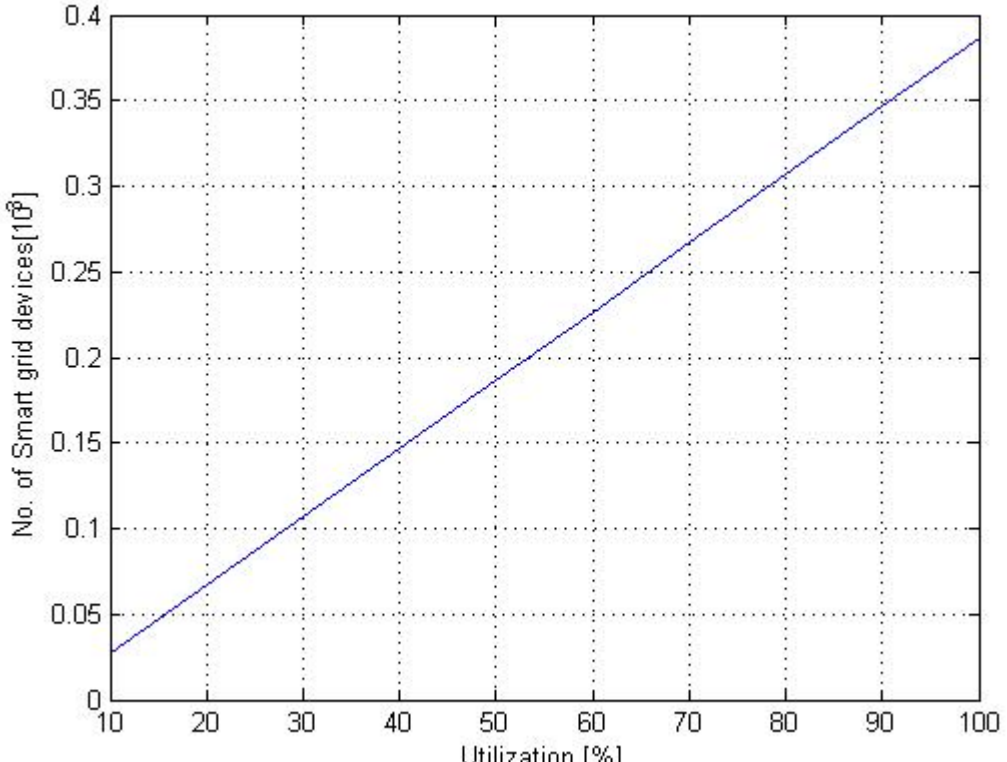
1. Distribution is calculated from the reference of Kauffman & Aien papers.
2. Distribution is used recursively for calculating traffic parameters.
3. For each channel the distribution is calculated and then blocking probability.

Future Scope

- Multi-Source Modelling
- Cognitive Radio in Smart Grid
- Incorporating Probability of Error in Markov Models
- Stability Analysis from a Control and System Perspective

Results


0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
blocking probability
0
50
100
150
200
250
300
350
400
no of entities


0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
No. of Smart grid devices[10³]
10
20
30
40
50
60
70
80
90
100
Utilization [%]

THANKS