Performance of Smart Grid Dynamic HAN with RQAM and GMSK Modulation

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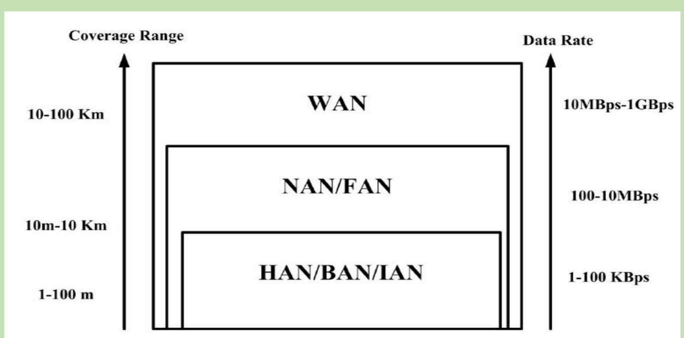
National Science Day
10th Research Scholars' Day 2020
IIT Bhubaneswar

INTRODUCTION

Smart grid

Electricity grid + Advanced sensing technology, Control method, Communication



HAN : Home Area Network
BAN: Building Area Network
IAN: Industrial Area Network
NAN: Neighbourhood Area Network
FAN: Field Area Network
WAN : Wide Area Network

Data communication:

- Device data acquired and transmitted to the smart meter through the HAN
- Several HAN can be connected through the NAN and send it to the local data centres.
- Communication of all the smart grid component in a vast area through the WAN

Communication technology
- WiFi (802.11)
- Bluetooth
- Wireless LAN
- Zigbee (802.15.4)

HAN

Applications
- Smart home
- Automatic meter reading
- Power demand management

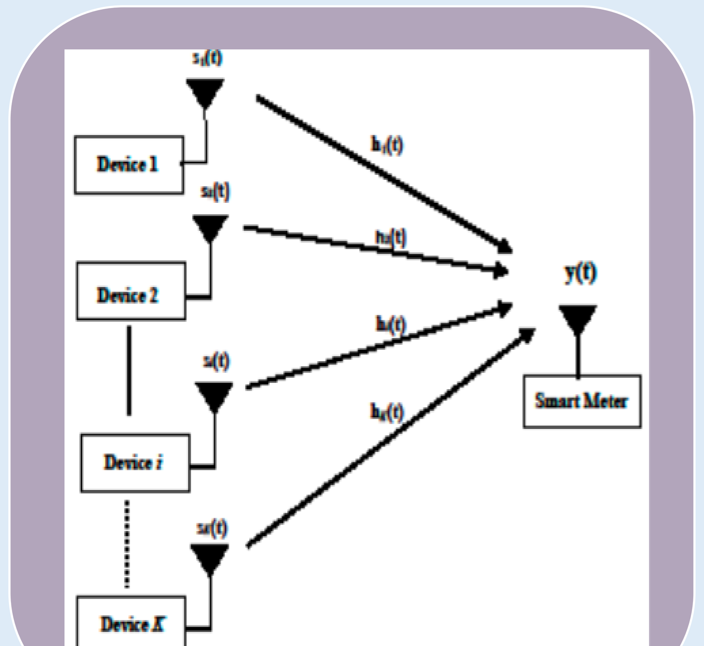
WiFi direct technology:

- Efficient energy utilization for different data size by enabling Wi-Fi devices to connect with each other without needing of access points (APs)
- Smart grid devices switches between active state and doze state
- Markov chain can be used to model the number of active states

OBJECTIVE

- Saleh-Valenzuela (S-V) and Weibull fading channels can be modelled for indoor communication channels.
- Due to the constraint of latency, bandwidth efficient RQAM and GMSK modulation schemes can be used in smart grid communication

SYSTEM MODEL



$y_i(t) = h_i(t)s_i(t) + n_i(t)$

$y_i(t)$ = Received signal at the Smart Meter.

$h_i(t)$ = Channel gain between i^{th} device and Smart Meter.

$s_i(t)$ = Transmitted symbol from i^{th} device.

$n_i(t)$ =zero-mean complex additive white Gaussian noise (AWGN)

K = Number of active devices.

CHANNEL MODEL

In this work, selection combing (SC) diversity technique is used at receiver. Hence the output SNR is given by

$$\gamma_{sc} = \max(\gamma_1, \gamma_2, \dots, \gamma_i, \dots, \gamma_K).$$

The average PDF of γ_{sc} for S-V fading channel in dynamic HAN can be given as

$$\bar{f}_{\gamma_{sc}}(\gamma) = \sum_{k=0}^{N_d} \frac{KP_K}{\bar{\gamma}_{sc}}\left[1-\exp\left(-\frac{\gamma}{\bar{\gamma}_{sc}}\right)\right]^{K-1}\exp\left(-\frac{\gamma}{\bar{\gamma}_{sc}}\right).$$

Where N_d is the total number of devices, P_K is the steady state probability.

The average PDF of γ_{sc} for Weibull fading channel in dynamic HAN can be given as

$$\bar{f}_{\gamma_{sc}}(\gamma) = \frac{\beta}{(b\bar{\gamma}_{sc})^{\beta/2}}\sum_{k=0}^{N_d} KP_K \sum_{n=0}^{K-1}\binom{K-1}{n}(-1)^n\gamma^{\beta/2-1}\exp\left[-(n+1)\left(\frac{\gamma}{b\bar{\gamma}_{sc}}\right)^{\beta/2}\right].$$

Where β is the fading parameter, b = 1/Γ(1+2/β) and Γ(·) is the gamma function.

The conditional SER performance of M = M_I X M_Q -ary RQAM AWGN noise channel is given by

$$P_s(e|\gamma) = 2\left(u\,Q(p\sqrt{\gamma}) + v\,Q(q\sqrt{\gamma}) - 2uv\,Q(p\sqrt{\gamma})\,Q(q\sqrt{\gamma})\right).$$

Where u=1/MI, v=1-1/MQ, q = λp, λ=dI/dQ is the quadrature to in phase decision distance ratio, Q(·) is the Gaussian Q function and

$$p=\sqrt{\frac{6}{(MI^2-1)(MI^2-1)\lambda}}$$

In GMSK modulation the SER depends on α, i.e. the product of bandwidth and symbol time period, the conditional SER is given as,

$$P_s(e|\gamma) = Q\left(\sqrt{2\,\alpha\gamma}\right).$$

PERFORMANCE ANALYSIS

Mathematically, the ASER of a communication system using certain modulation technique can be given as

$$P_s = \int_0^\infty P_s(e|\gamma)\bar{f}_\gamma(\gamma)d\gamma.$$

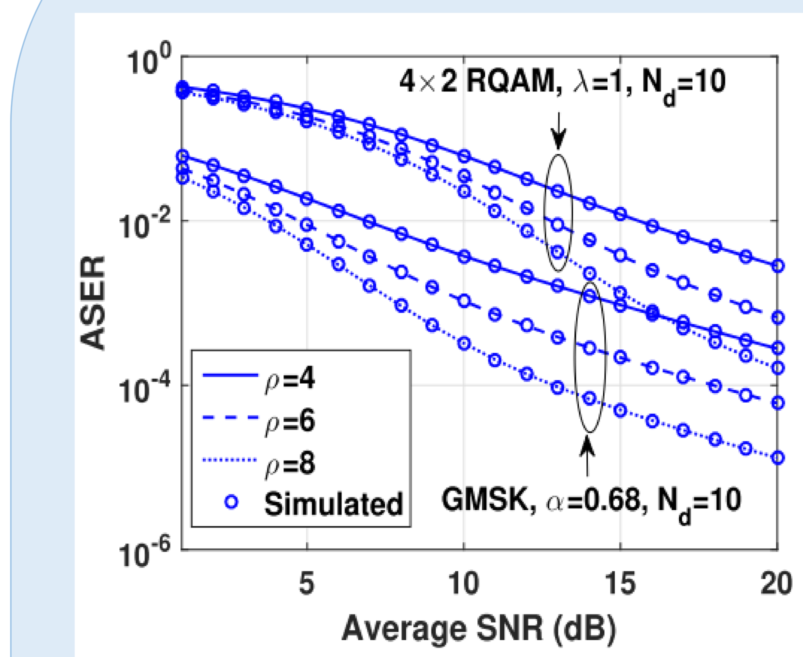
Where $P_s(e|\gamma)$ is the conditional symbol error rate (SER) and $\bar{f}_\gamma(\gamma)$ is average PDF of the received SNR.

The ACC of a communication system is denoted by C and it is written as

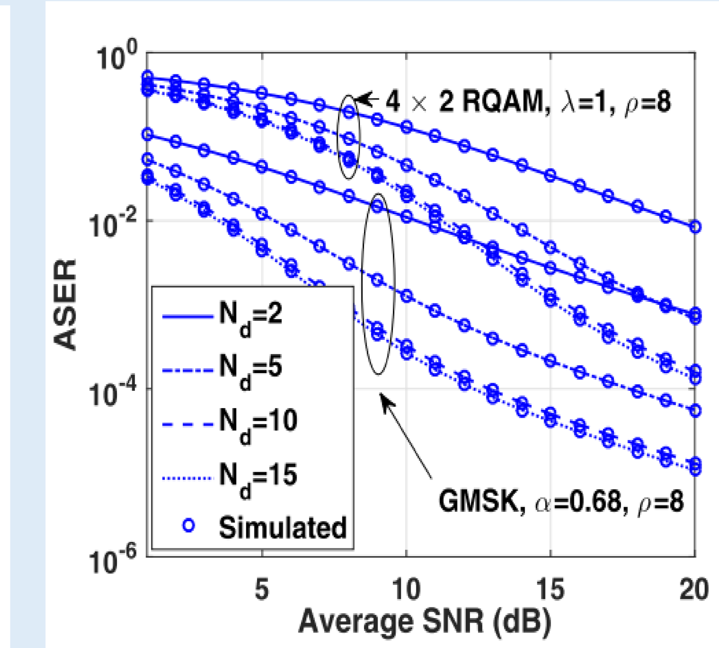
$$C = W\int_0^\infty \log_2(1+\gamma)\bar{f}_\gamma(\gamma)d\gamma.$$

Where W is the bandwidth.

RESULTS

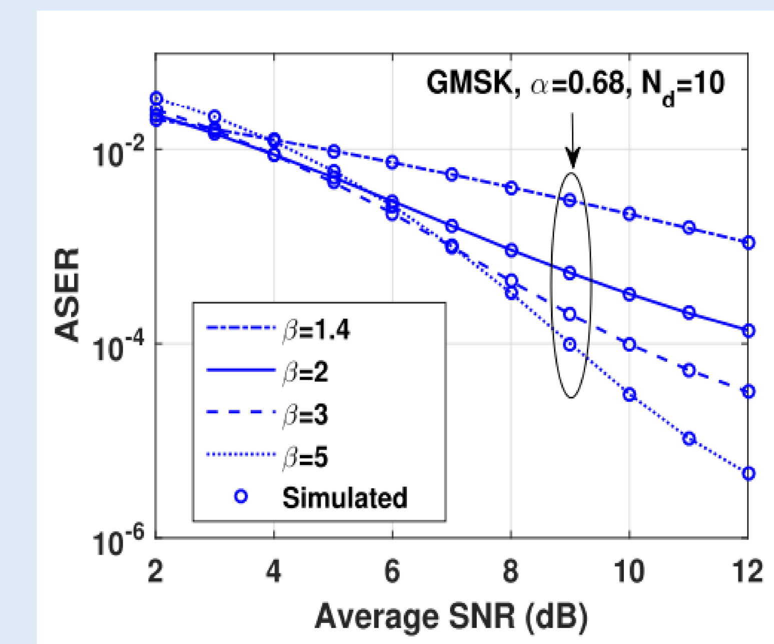


(a)

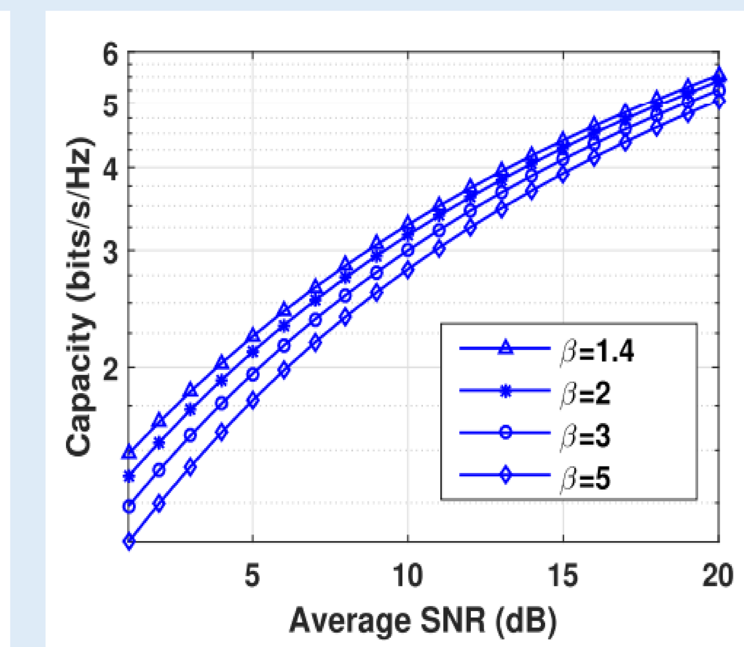


(b)

Fig. 1. ASER comparison by varying different parameter in S-V channel (a) ρ (b) N_d.



(a)



(b)

Fig. 2. (a) ASER comparison by varying β in Weibull channel. (b) Capacity (bits/s/Hz) by varying β with N_d =10 in Weibull channel.

CONCLUSION

- ASER and ACC performance for dynamic HAN smart grid communication system are analyzed.
- Mathematical expressions for ASER are derived using RQAM and GMSK modulation over S-V channel.
- Closed-form expression for ASER is presented for GMSK modulation over Weibull fading channel.
- Results demonstrate that the system exhibits improved performance with the increasing values of ρ and N_d but saturates for larger values.

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