ITU Kaleidoscope 2014

Living in a converged world - impossible without standards?

A Non Cooperative TV White Space Broadband market Model for Rural Entrepreneurs

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OVERVIEW

- INTRODUCTION
- PROBLEM
- SYSTEM MODEL
- NUMERICAL RESULTS
- CONCLUSION&FURTHER WORK

INTRODUCTION

ECONOMIC

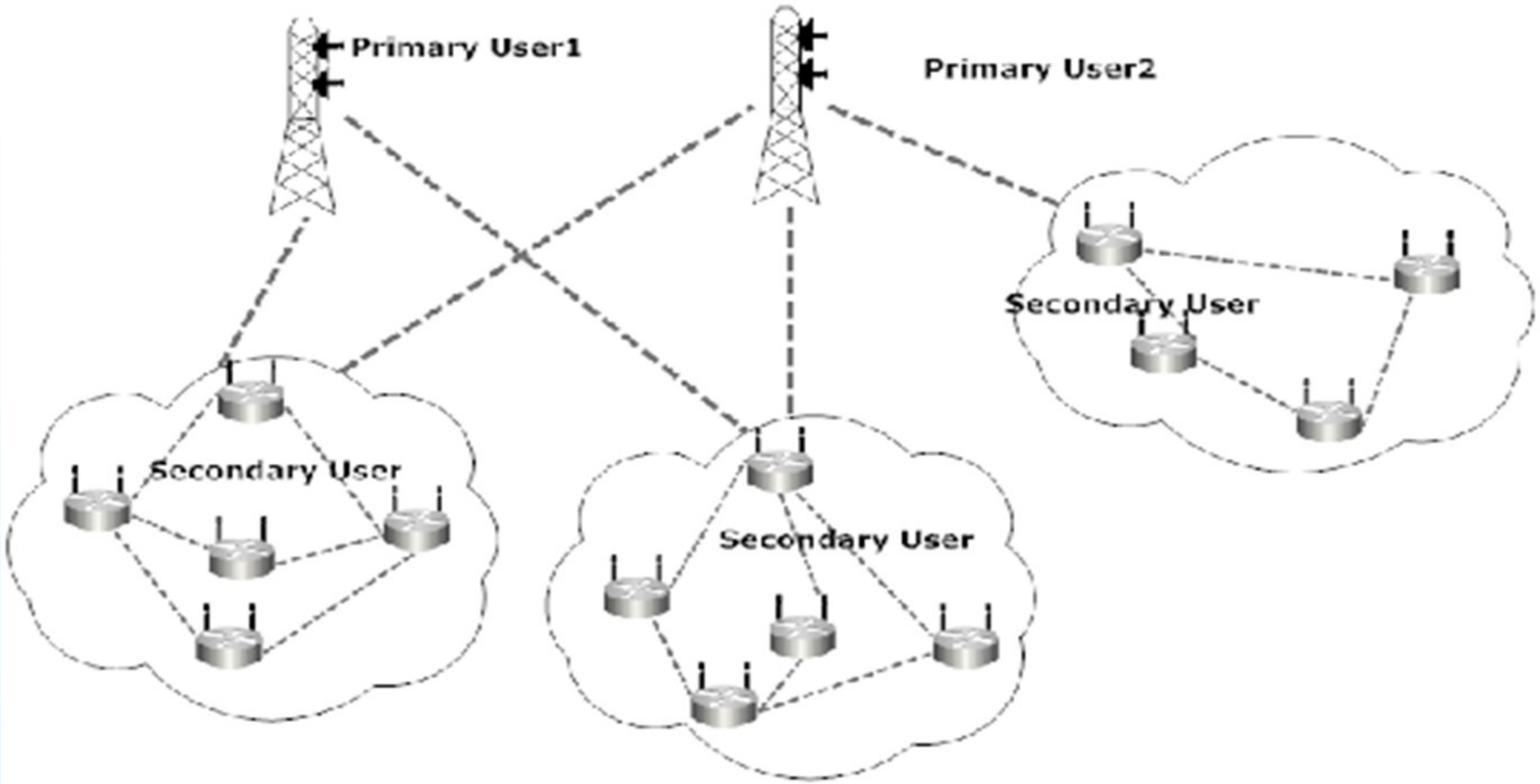
SOCIAL

- Better Access to Public Services
- More informed/engaged citizen
- Quality of Life
- Community

PROBLEM

- Dynamic spectrum sharing under competition.
- The challenge is that of analyzing and obtaining an equilibrium pricing scheme for a smart mesh network in which multiple primary services(Pus) are willing to share allocated spectrum with a secondary service.
- Catalyze decrease in costs and increased access

SYSTEM MODEL



SYSTEM MODEL

- A Non cooperative game theoretic approach
- Bertrand game adapted to address the problem of competitive pricing in a dynamic spectrum access where a few Primary users(Pus) services offer spectrum opportunities to a secondary service

SYSTEM MODEL

Players	Licensed Pus and an Unlicensed SU
Action	Pus Strategize in terms of prices
payoff	Profit of selling spectrum units to SU

Parameter	Description
λ	Traffic arrival rate
k_j^p	Spectral efficiency of Primary User
ϕ_i	payoff
k_i^s	Spectral efficiency of secondary User
W	Primary Spectrum
y_i	Channel quality
Q_i	Secondary Spectrum
D_i	Delay
T_i	Throughput
C_i	Cost due to QoS Metric
d	constant
P_i	Price

SYSTEM MODEL

The spectral efficiency of transmission for secondary user i is expressed as

$$k_i = log_2(1 + K y_i)$$

$$K = \frac{1.5}{\ln(\frac{0.2}{BER^{tar}})}$$

SYSTEM MODEL

A quadratic utility function

$$\psi = \sum_{i=1}^{M} Q_i k_i^s - \frac{1}{2}(\sum_{i=1}^{M} Q_i^2 + 2\Delta \sum_{i=1}^{M} Q_i Q_j) - \sum_{i=1}^{M} P_i Q_i$$

is implored to ascertain level of spectrum demand

SYSTEM MODEL

Parameter	Associated Cost	Revenue	Payoff
Delay, $D_i(Q_i) = \frac{\lambda_i}{2k_i^p(W-Q))^2 - \lambda_i k_i^p(W-Q)}$	$C_i = \mathrm{d}D_i(Q_i)$	R$(D_i) = Q_i P_i$	$\phi^D = P_i \frac{k_i^S - P_i - \Delta(k_j^S - P_j)}{1-\Delta^2} - \frac{d\lambda_i}{2(W_i-Q_i)^2 - 2\lambda_i(W_i-Q_i)}$
Throughput, $T_i(Q_i) = \sum_{i=1}^{N} \frac{\beta Q_i}{\sqrt{n \log n}}$	$C_i = \mathrm{d}T_i(Q_i)$	R$(T_i) = Q_i P_i$	$\phi^T = P_i \frac{k_i^S - P_i - \Delta(k_j^S - P_j)}{1-\Delta^2} - \frac{k_i^S - P_i - \Delta(k_j^S - P_j)}{1-\Delta^2}$

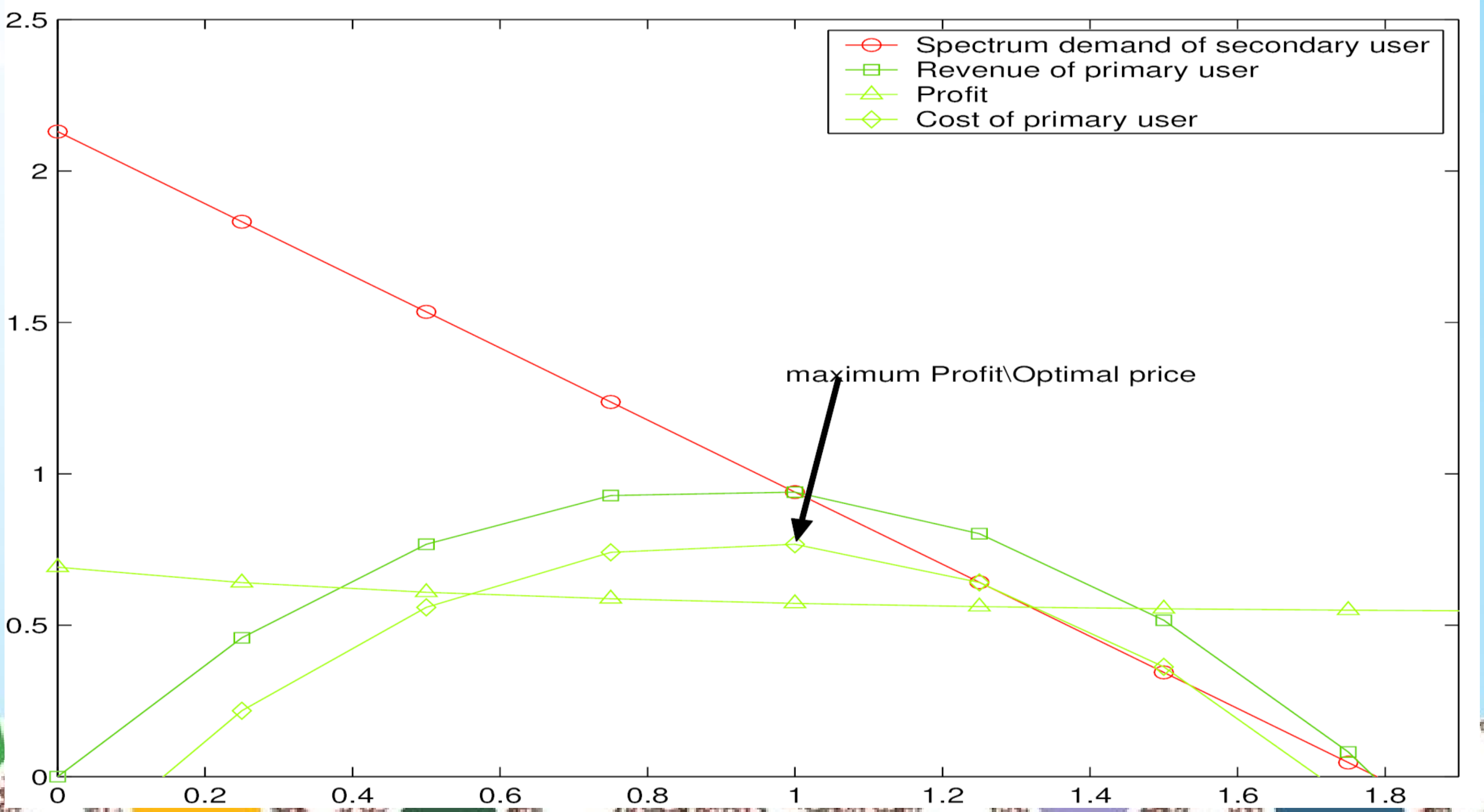
NUMERICAL RESULTS

Parameter	Value
PU spectrum	5MHz
BER	10^{-4}
Channel Quality range	10-20dB
d	1
Y(1)	15dB
Y(2)	18db
Δ	0.4
P(2)	1
λ	4

NUMERICAL RESULTS

Demand,Revenue,Profit and Cost

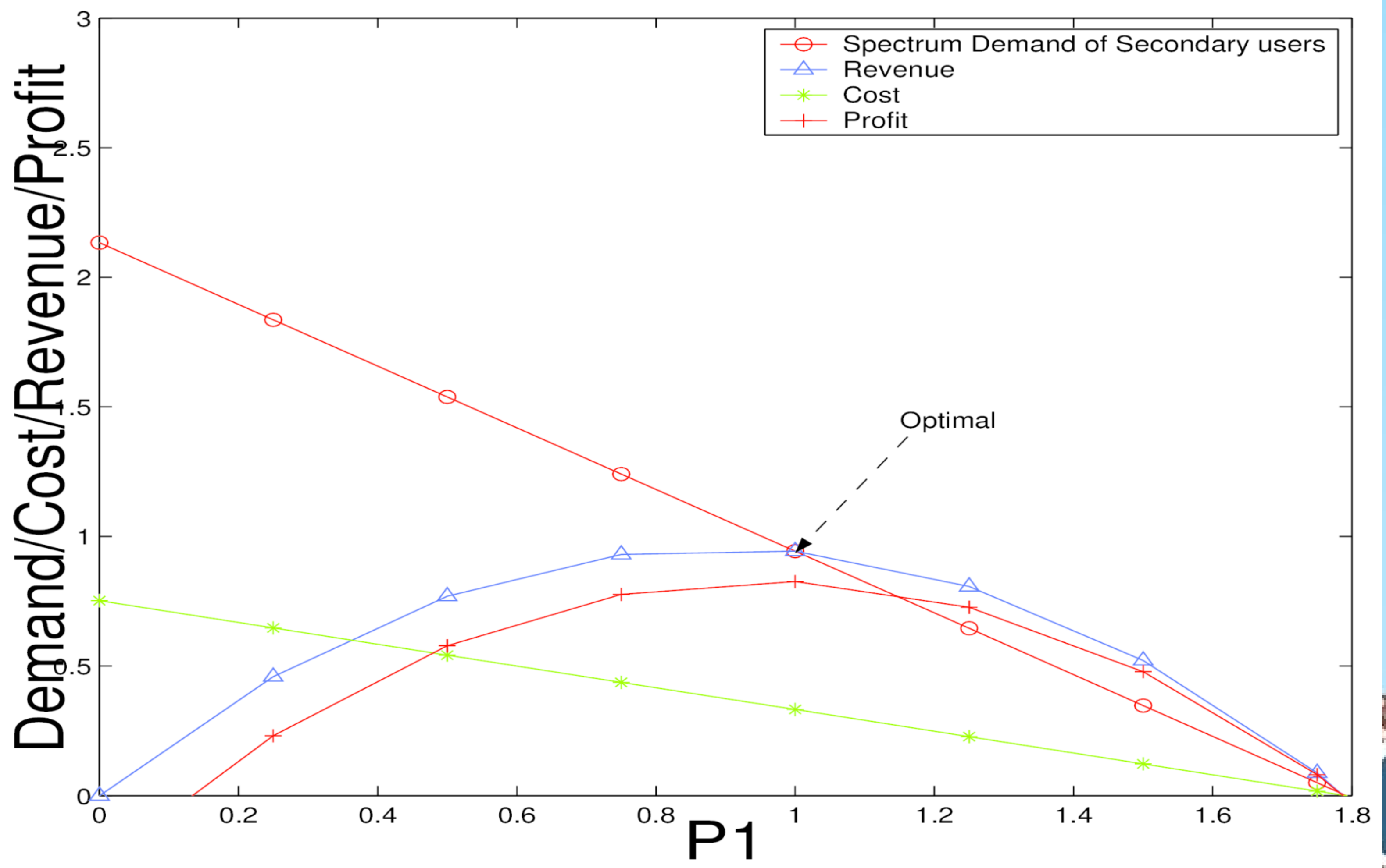
Delay



NUMERICAL RESULTS

Demand,Revenue,Profit and Cost

Throughput



NUMERICAL RESULTS

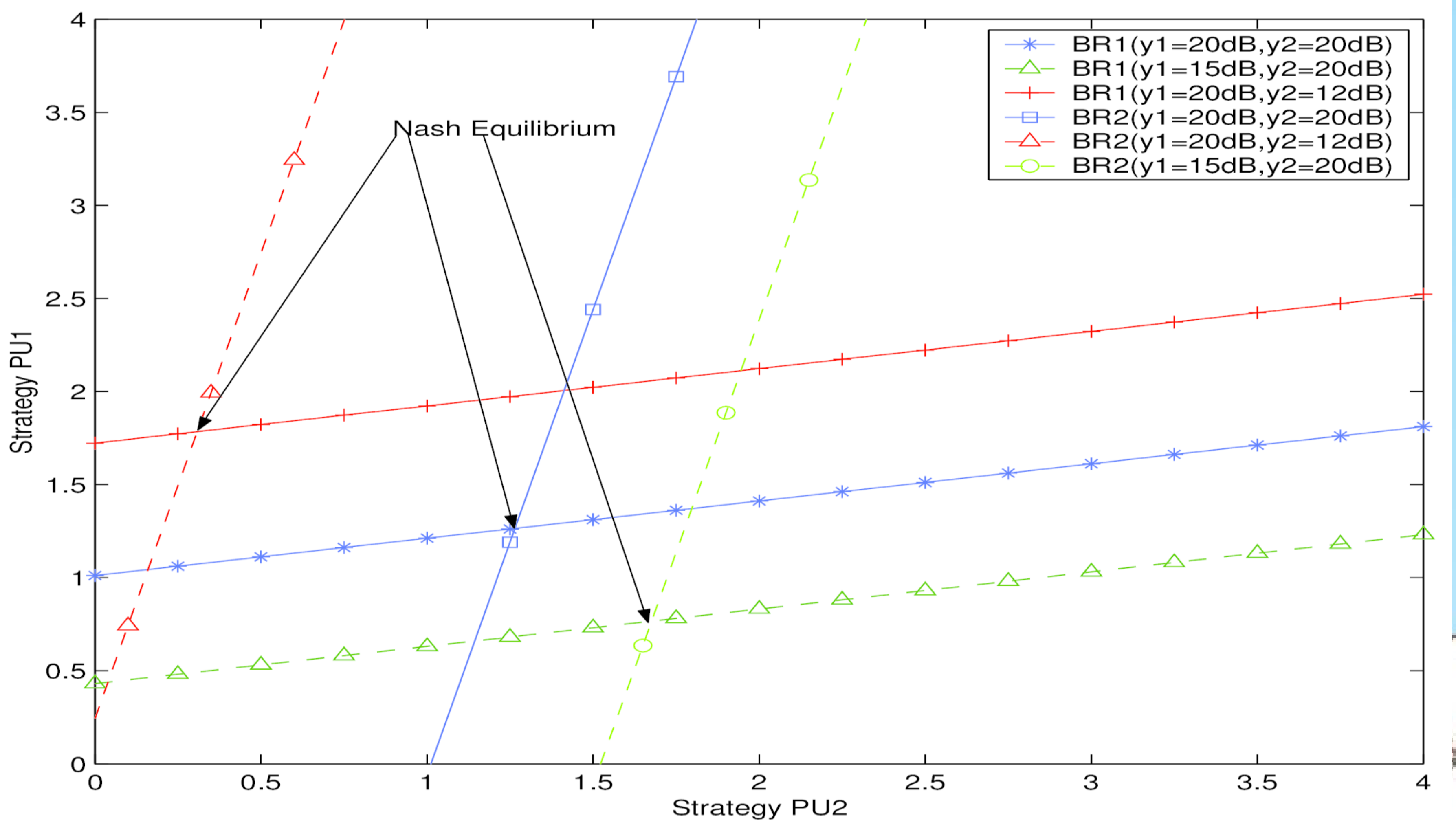
Demand,Revenue,Profit and Cost

- When the first PU increases its price, the SU demand decreases.
- The cost of the Primary user decreases since the SU demands less. Hence the size of the residual spectrum increases and this translates to a smaller delay.
- The revenue and profit initially increase and then begins to decline. At a smaller price a large amount of spectrum is sold and vice –versa resulting in a smaller revenue.
- Optimal price exists for the best response of PU

NUMERICAL RESULTS

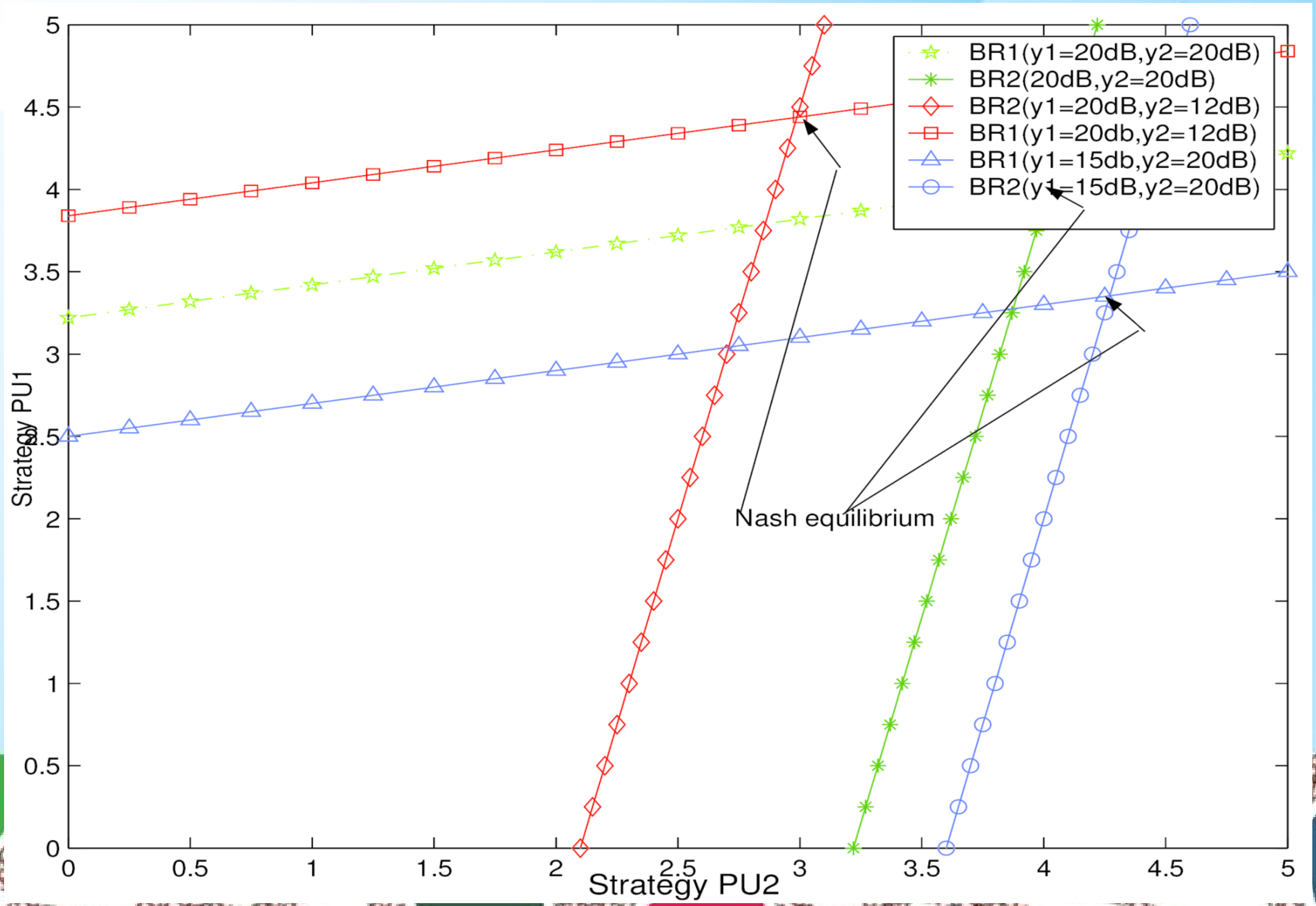
Delay

Best Response



NUMERICAL RESULTS

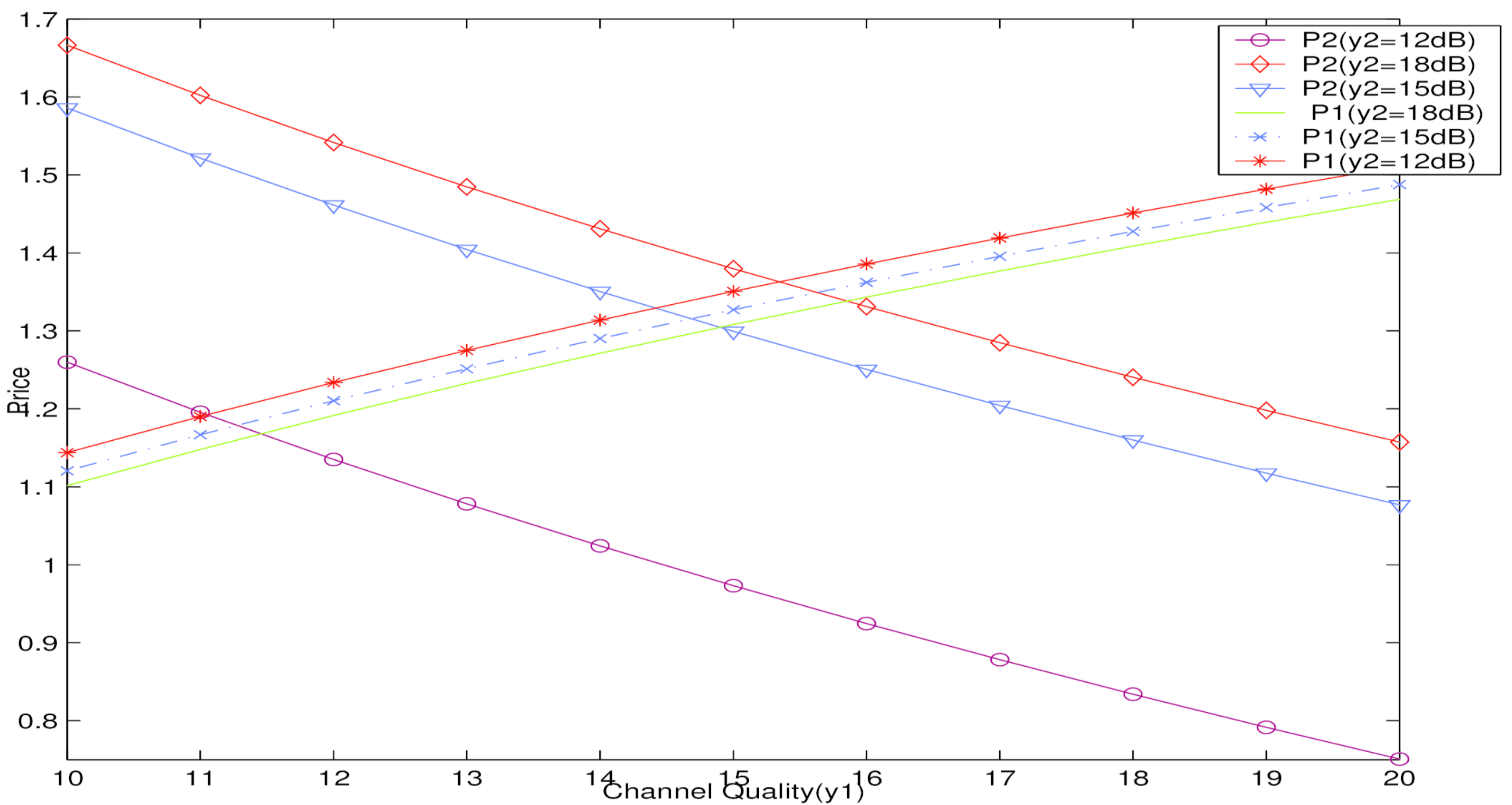
Best Response



Throughput

NUMERICAL RESULTS

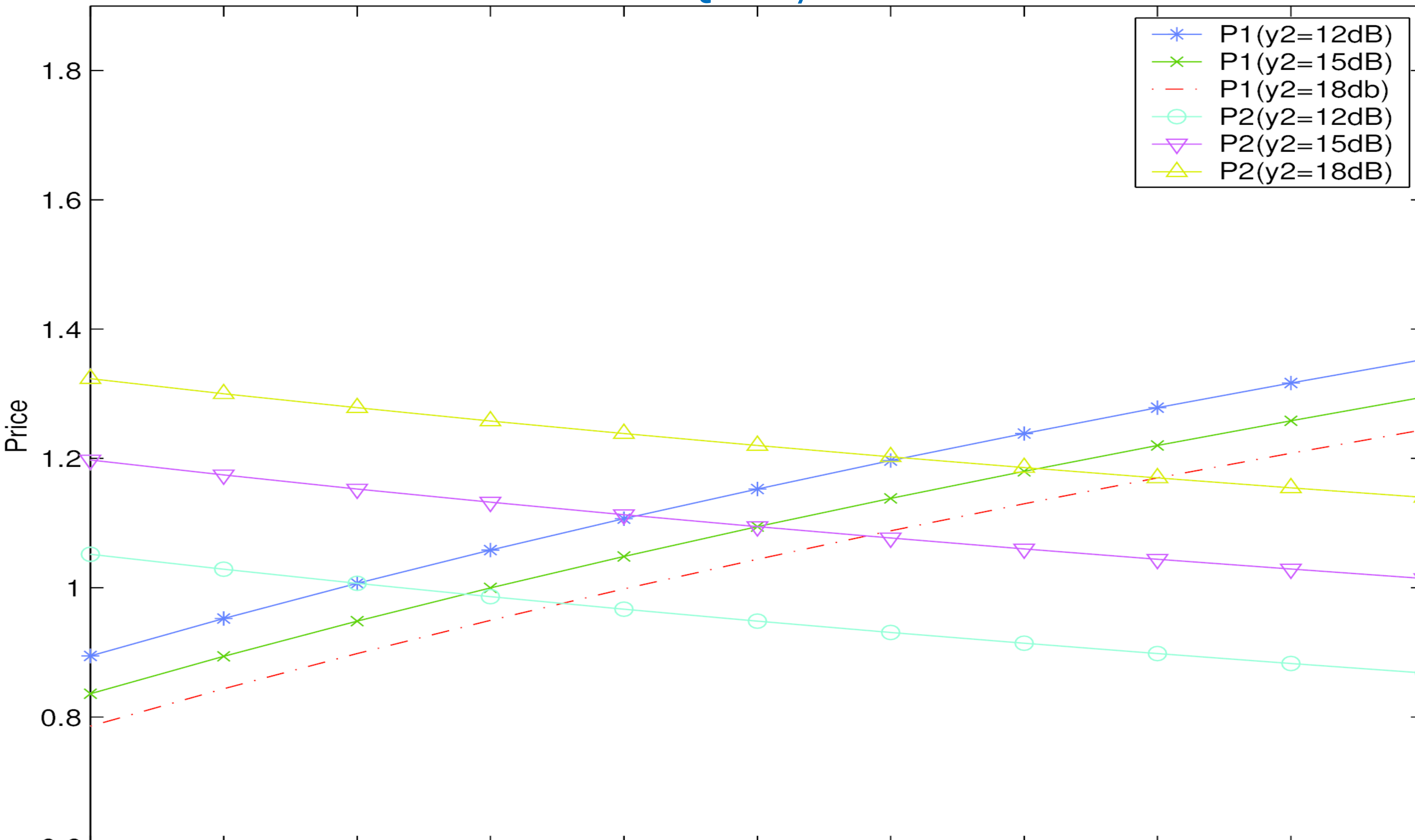
Channel Quality



NUMERICAL RESULTS

Throughput

Channel Quality



CONCLUSION & FURTHER WORK

- Non cooperative interaction of Pus and Sus
- Analytic models based on delay and Throughput
- Catalyze decrease in cost and increase access to broadband-rural and remote areas
- Extend model by coupling TV white space allocation with routing module

Thanks!
Questions?