On the Network Throughput Under Delay and Burstiness Constraints

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Motivation & Goal

- Capacity limits of wireless networks well-understood,
  - Courtesy Information Theory
- Rapid growth of delay sensitive applications, VOIP, IP video
- Capacity limits of wireless networks under QoS constraints (e.g. delay) not so well-understood
- Goal
- Quantify the traffic carrying capacity of communication networks with bursty sources under delay constraints
- We call it "Delay Constrained throughput"

Focus: Delay Constrained Throughput (λ_d)

- The maximum traffic* (λ) carried by the network for a given delay guarantee requirement(d^g) and burstiness constraint (σ)

$$\lambda_d = \max\left\{\lambda \;\middle|\; d^{\varepsilon}_{\lambda,\sigma} \le d^{g}\right\}$$

where, $d^{\varepsilon}_{\lambda,\sigma}$ is delay bound with violation **Pr**obability (ε)

$$\Pr\left[d(t) > d^{\varepsilon}_{\lambda,\sigma}\right] \le \varepsilon$$

Stochastic Service Guarantees (SSG)
Wireless channels only provide SSG

*In bits/sec

Modus Operandi…

- Given the
  - Input Traffic
  - Service Elements
  - Delay Guarantee (d^g)
- What is the throughput?

- Solution Steps:
  - traffic and server model.
  - Delay bound ($d^{\varepsilon}_{\lambda,\sigma}$)
  - Using $d^{\varepsilon}_{\lambda,\sigma} \leq d^g$, we find Throughput

Delay Constrained Throughput of Correlated MIMO wireless channels in spatial multiplexing mode using MGF Stochastic Network Calculus

Recap: Modus Operandi…

- Given the
  - Input Traffic
  - Service Elements
  - Delay Guarantee (d^g)
- What is the throughput?

- Solution Steps:
  - traffic and server model.
  - Delay bound ($d^{\varepsilon}_{\lambda,\sigma}$)
  - Using $d^{\varepsilon}_{\lambda,\sigma} \leq d^g$ and other constraints (if any) we find Throughput

MGF Based Network Calculus

$d^{\varepsilon}_{\lambda,\sigma}$

$$d^{\varepsilon}_{\lambda,\sigma} = \inf_{\theta>0}\left[\inf\left[\tau : \frac{1}{\theta}\left(\ln\sum_{s=\tau}^{\infty}\mathsf{M}_A(\theta, s-\tau)\widehat{\mathsf{M}}_S(\theta, s) - \ln\varepsilon\right) \leq 0\right]\right]$$

MGF Based Network Calculus $d^{\varepsilon}_{\lambda,\sigma}$

- Markov Chain is used to model MIMO channel.
- States are based on degree of Freedom (DOF)

$$\widehat{\mathrm{M}}_S(\theta,t) = \boldsymbol{\pi}(\mathbf{R}(-\theta)\mathbf{Q})^{t-1}\mathbf{R}(-\theta)\mathbf{1}$$

- Periodic traffic source with period τ produces σ units of workload at times U $\tau + n\,\tau$

$$\mathrm{M}_A(\theta,t) = e^{\theta\sigma\lfloor\frac{t}{\tau}\rfloor}\left(1+\left(\frac{t}{\tau}-\left\lfloor\frac{t}{\tau}\right\rfloor\right)(e^{\theta\sigma}-1)\right)$$

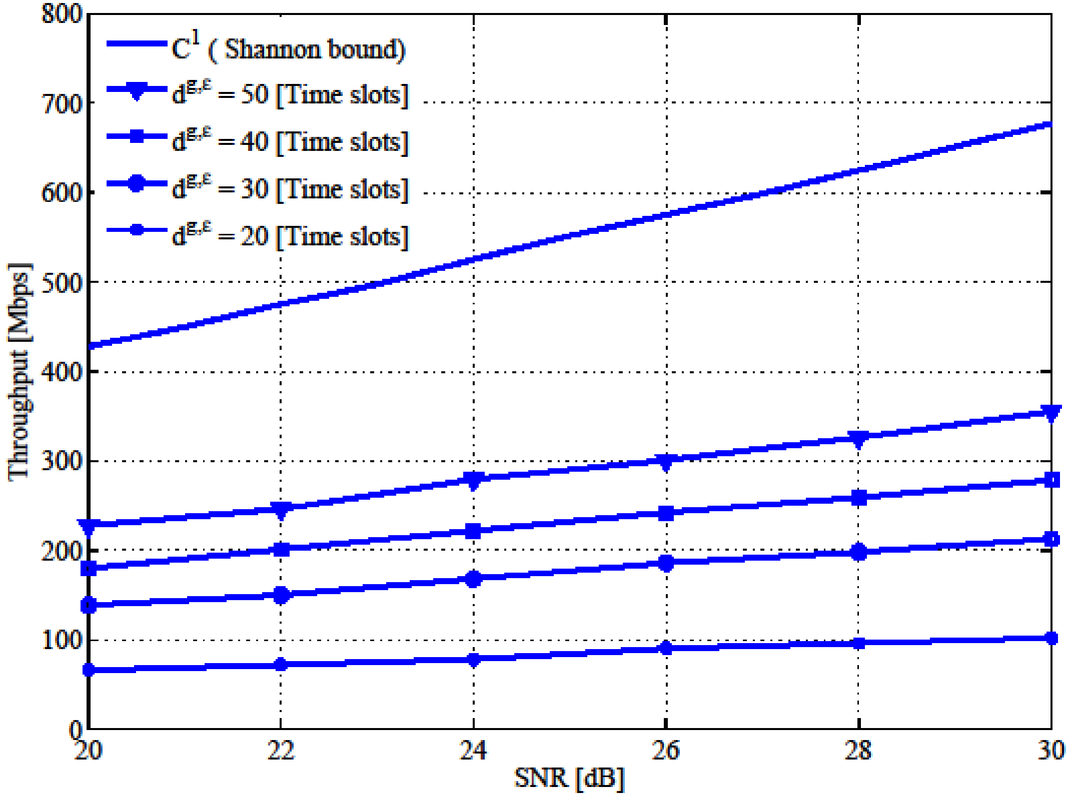
$$d^{\varepsilon}_{\lambda,\sigma} = \inf_{\theta>0}\left[\inf\left[\tau : \frac{1}{\theta}\left(\ln\sum_{s=\tau}^{\infty}\mathrm{M}_A(\theta,s-\tau)\widehat{\mathrm{M}}_S(\theta,s)-\ln\varepsilon\right)\le 0\right]\right]$$

$$d^{\varepsilon}_{\lambda,\sigma} \le d^{g}$$

Numerical Results

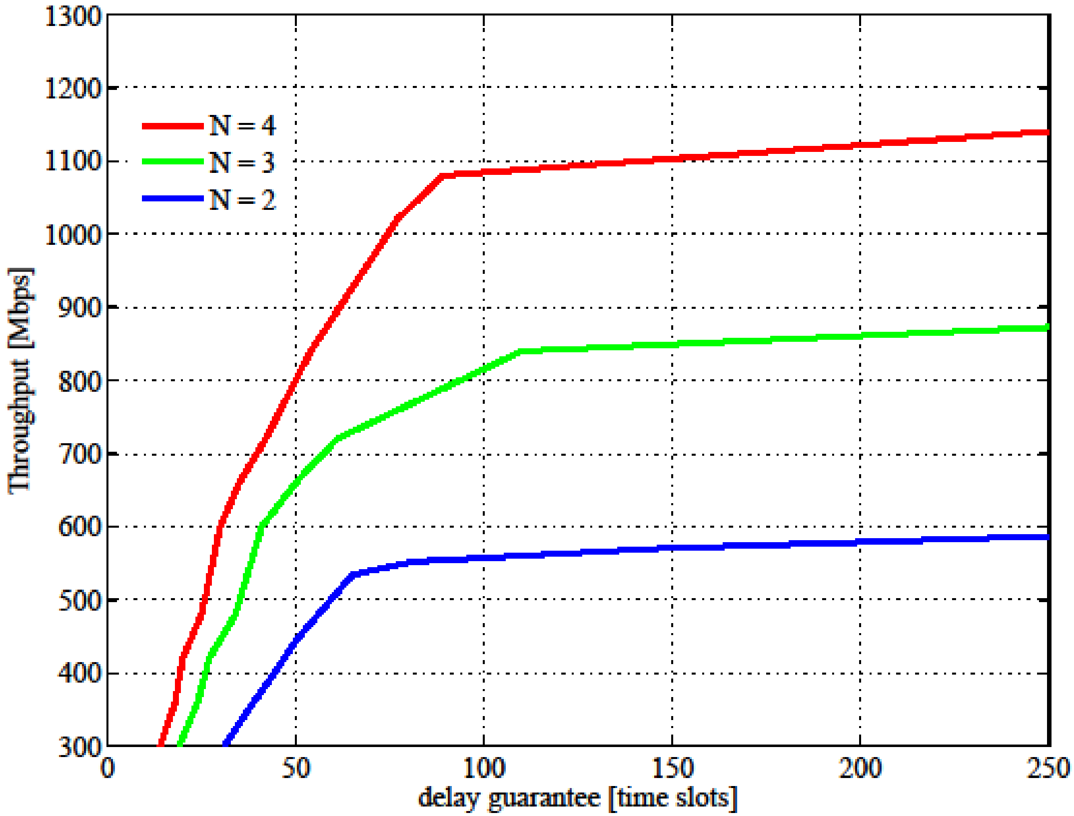
Shannon Bound

N = 2
$\epsilon = 10^{-6}$



effect of # of antennas

$\epsilon = 10^{-3}$
SNR = 25 dB



Conclusion

Motivation

Focus

Modus Operandi

Application

Throughput of MIMO Channel

References

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- Delay Constrained throughput Analysis of a Correlated MIMO wireless Channel
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  - (To be Submitted)

Sincerely Yours

Suggestions are most welcome