Traffic Dynamic in Modularity Structure of Complex Networks.

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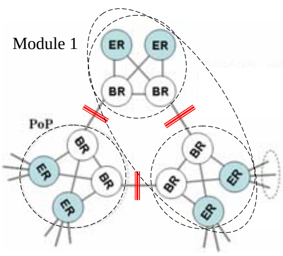
PRESENTATION OUTLINE

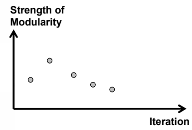
INTRODUCTION

- People have tried to understand robustness of a system from its topological properties such as degree distribution.
- However, this information mainly focuses on the connectivity of network components.
- This phenomenon is similar to a saying that people cannot see the forest for the trees.
- Forest? -> Topological structure such as modularity or hierarchy.
- We are going to talk about how modularized structure impacts on network robustness from a traffic fluctuation point of view.

Modularity: Discover & Quantification

- Split a network into many sub-networks.
- M.E.J. Newman and M. Girvan, PRE 2003.



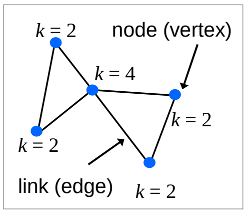


$$Q_{\_M} = \sum_i (e_{ii} - a_i^2)$$

Two different types of topologies for simulation.

- **Degree of a node (k):**
  Number of links that a node has
- **Scale-free property:**
  Probability distribution of degree follows the POWER LAW

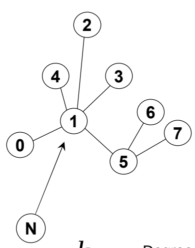
$$P(k) \propto k^{-\gamma}$$



- **BA model:** Preferential attachment mechanism.
- **FKP model:** Optimization mechanism.

Scale free models: BA & FKP models

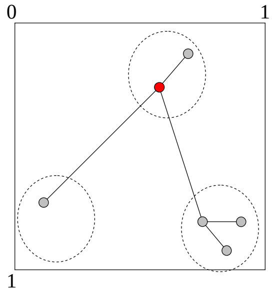
BA

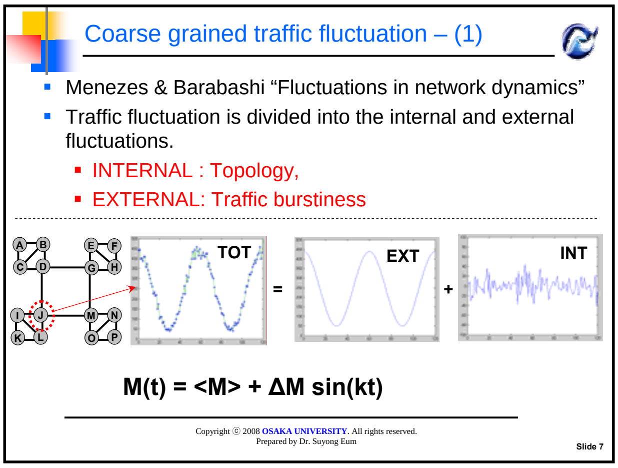


k_i Degree of node i

$\sum_{i=N} k_i$ Total degree

FKP




Coarse grained traffic fluctuation – (1)
Menezes & Barabashi "Fluctuations in network dynamics"
Traffic fluctuation is divided into the internal and external fluctuations.
INTERNAL : Topology,
EXTERNAL: Traffic burstiness
TOT
=
EXT
+
INT
M(t) = <M> + ΔM sin(kt)
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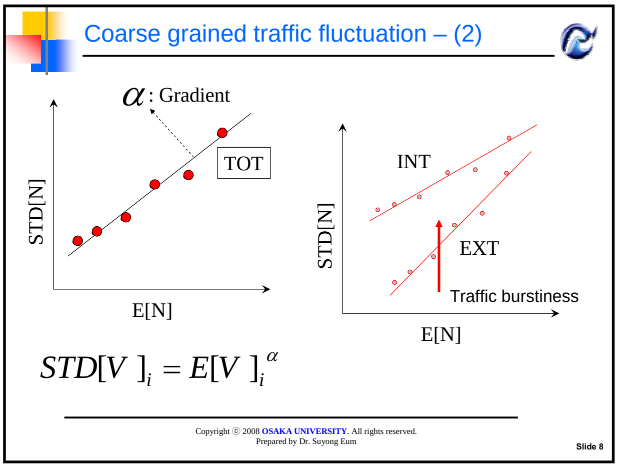
Coarse grained traffic fluctuation – (2)
α : Gradient
TOT
STD[N]
E[N]
INT
EXT
Traffic burstiness
STD[N]
E[N]
STD[V]_i = E[V]_i^α
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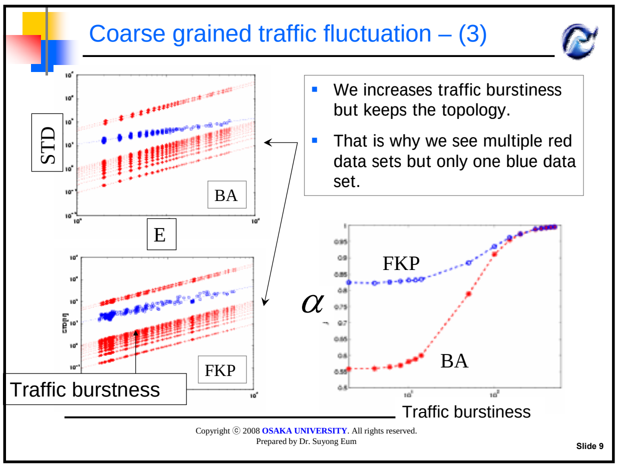
Coarse grained traffic fluctuation – (3)
STD
BA
E
FKP
Traffic burstness
We increases traffic burstiness but keeps the topology.
That is why we see multiple red data sets but only one blue data set.
α
FKP
BA
Traffic burstiness
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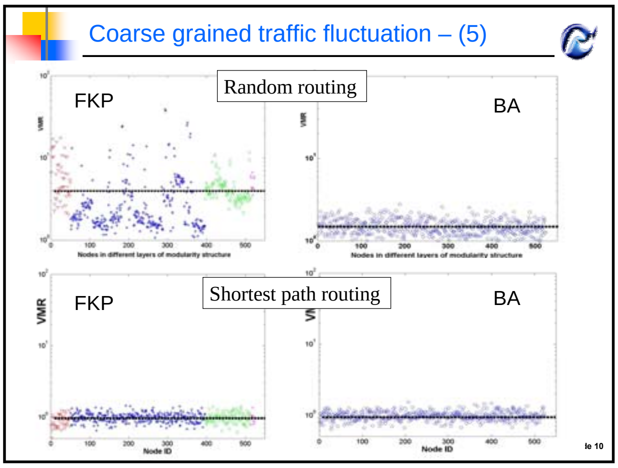
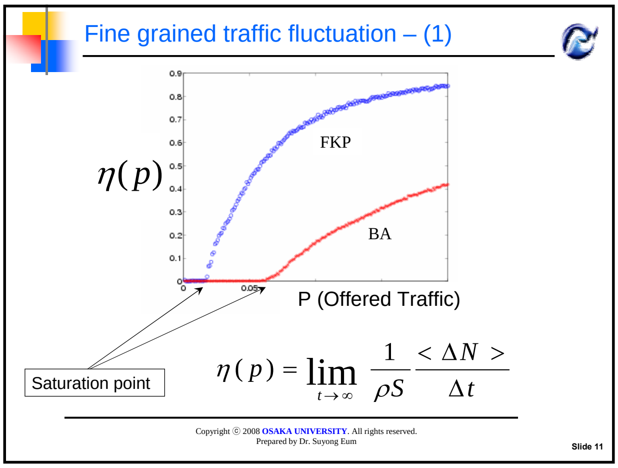

Coarse grained traffic fluctuation – (5)
FKP
Random routing
BA
FKP
Shortest path routing
BA
VMR
Node ID
Node ID


Fine grained traffic fluctuation – (1)
η(p)
FKP
BA
P (Offered Traffic)
Saturation point
η(p) = lim_{t→∞} (1/ρS) (<ΔN>/Δt)
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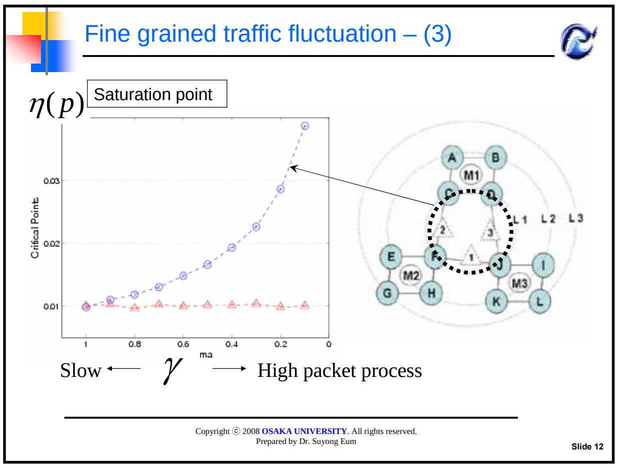
Fine grained traffic fluctuation – (3)
η(p)
Saturation point
Critical Points
Slow ← γ_ma → High packet process
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CONCLUSIONS.

- We investigated traffic fluctuation in modularized and non-modularized topologies with two different simulation scenarios, viz coarse and fine.
- In the coarse traffic scenario, we found that a topology with strong modularity structure tends to experience high traffic fluctuation. However, this fluctuation is observed only when traffic is routed randomly. (Robust against intruder)
- With fine traffic, we found that a topology with high modularity structure becomes saturated earlier as traffic load increases than one with non-modularized structure. (Bottleneck)

QUESTIONS?

Thanks for your attention

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