Competitive Analysis for Service Migration in VNets

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Motivation

Potential for Flexibility

- VNet/Substrate resource decoupling facilitates...
  - Core network evolution
  - Sandboxing
  - Dynamic resource allocation

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$\Rightarrow$ Flexibility may be used for new dynamic service management schemes... e.g., Server migration

Problem

Management

- To migrate, or not to migrate...? (Online?)
- How to compare?

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Competitive Analysis

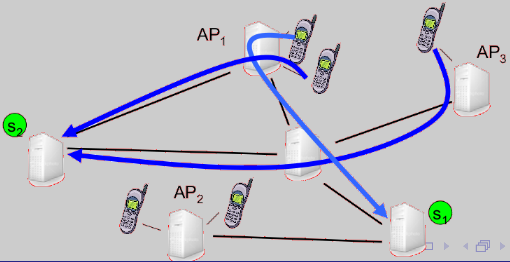
- ALGorithm to compare
- Criteria (e.g., cost function)
- OPTimal Value (or algorithm)

Formally, or empirically analyse ratio $\rho = \frac{ALG}{OPT}$

Scenario

Details

- Server migration
- Access costs, migration costs
- Multiple mgmt. roles
- Communication about requirements



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Formal model

- Substrate graph $G = (V, E)$
- Servers S, AccessPoints A
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- $Cost_{acc}(v, t) = \sum_{w \in A | r_t = (w,v) \in R_t} f(v, latency(r_t), load(v))$

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- $Cost_{acc}(v, t) = \sum_{w \in A | r_t = (w,v) \in R_t} f(v, latency(r_t), load(v))$
- Migration path p, No. of Transit Providers k
- Constant path bandwidth $\omega(p)$
- $Cost_{mig}(p, t) = \sum_{s \in S} f(\omega(p), size(s), k)$

MIG (online)

Approach

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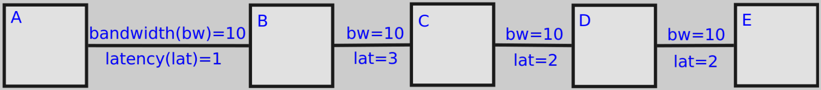
- When $L_v \geq \beta\ \forall v \in V$,
  end epoch ε, and reset $L_v\ \forall v \in V$

MIG - Example



$t_0 : size(S) = 100, \sigma_0 = \{B, D\}, v_0 = A$

A	B	C	D	E	MIG
(1*1)+(1*6) 7	0+5 5	3+2 5	5+0 5	7+2 9	0+7 7 (A)

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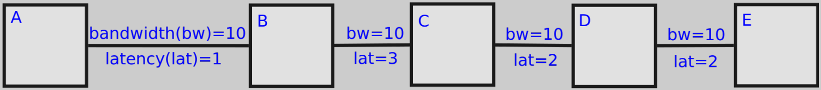

$t_1 : size(S) = 100, \sigma_1 = \{C, E\}, v_1 = A$

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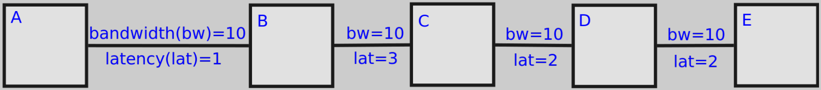

$t_2 : size(S) = 100, \sigma_2 = \{C, D\}, v_2 = C$

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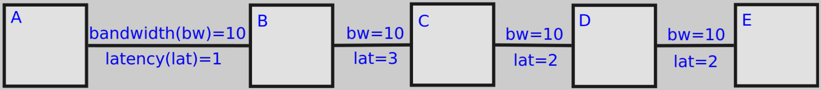

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0	0	0	0	0	23 (C)

MIG O(log n) competitive in const. bandwidth networks

H_n Expected Number of Migrations

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$$T_{j-1} \rightarrow T_j = 1 + \frac{1}{j}((j-1)\frac{1}{1} + (j-2)\frac{1}{2} + \cdots + (j-k)\frac{1}{k} + \cdots + (j-j)\frac{1}{j})$$

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$$= 1+\frac{1}{j}(\frac{j}{2}+\cdots+\frac{j}{k}+\cdots+\frac{j}{j}+j-1-\frac{2}{2}-\cdots-\frac{k}{k}-\cdots-\frac{j}{j})$$

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Proof

1. Def.(ε), Def.(β) $\Rightarrow \forall \varepsilon_i : OPT(\varepsilon_i) \geq \beta$

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2. $H_n + 1$ phases $\Rightarrow MIG(\varepsilon_i) \leq \beta H_n + \beta(H_n + 1) = \beta O(\log n)$
3. (1), (2) $\Rightarrow$ Ratio $\rho \leq \frac{\beta O(\log n)}{\beta} = O(\log n)$ $\square$

OPT (offline)

Approach: Dynamic Programming

- $opt[t][v]$ matrix with minimal cost
- remember predecessor $v_{t-1} \in V$
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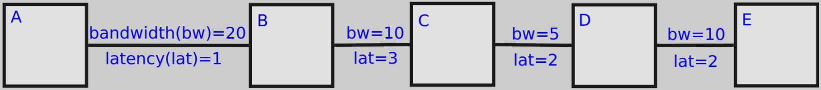
Cost Matrix

$$opt[0][v] = Cost_{mig}(v_0, v) + \sum_{w \in \sigma_0} Cost_{acc}(w, v)$$

$$opt[t][v] = min_{v, v_{t-1} \in V}(opt[t-1][v_{t-1}] + Cost_{mig}(v_{t-1}, v) + \sum_{w \in \sigma_t} Cost_{acc}(w, v))$$

OPT - Example



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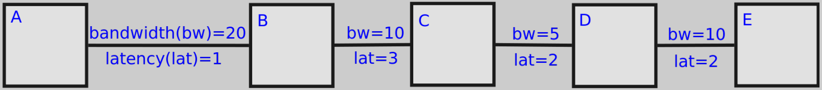

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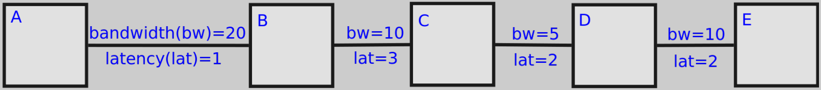

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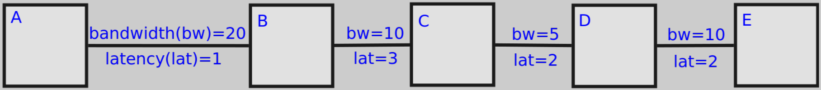

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Simulation

Scenario

- Linear topology
- Uniform constant bandwidth
- Uniform request distribution with exponential stayover time

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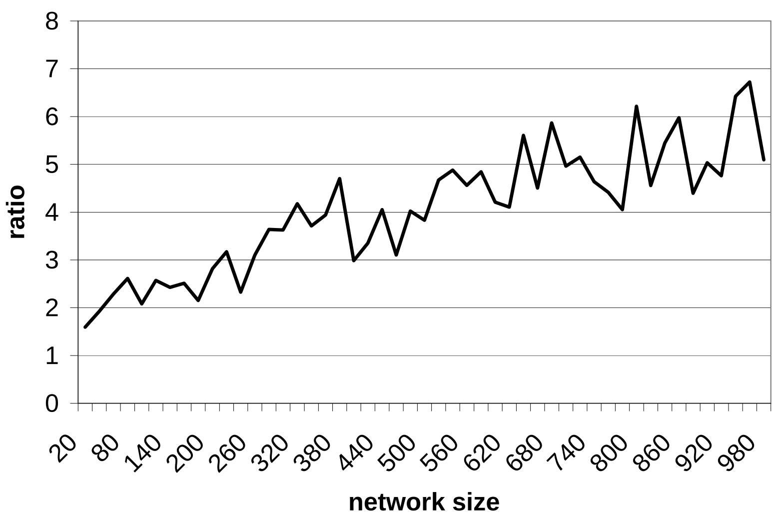

8
7
6
5
4
3
2
1
0
ratio
20
80
140
200
260
320
380
440
500
560
620
680
740
800
860
920
980
network size

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Outlook

- Extending the cost models
- Considering variable bandwidth scenarios

Questions?

Thank you for your attention!