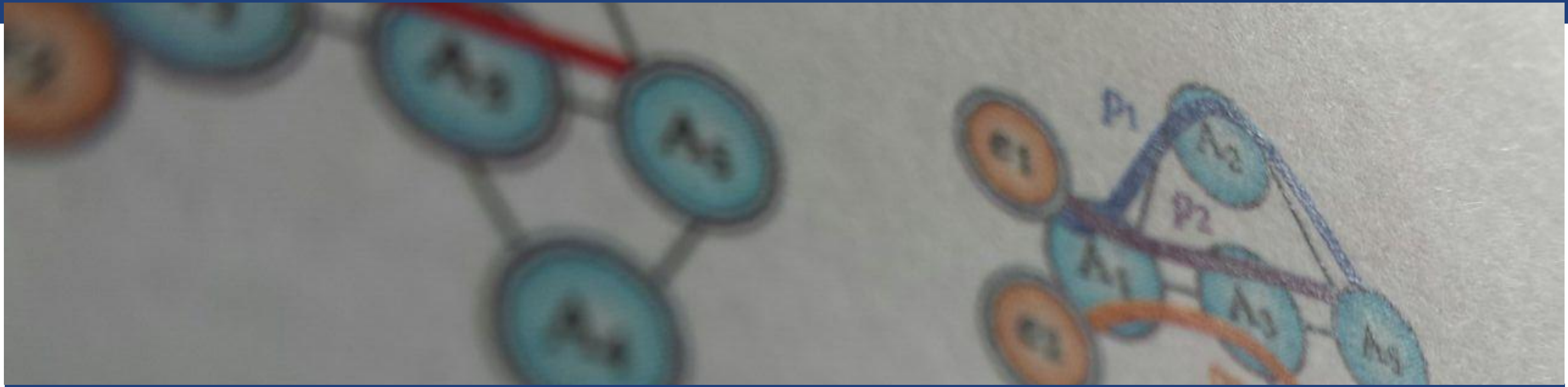
ETH zürich

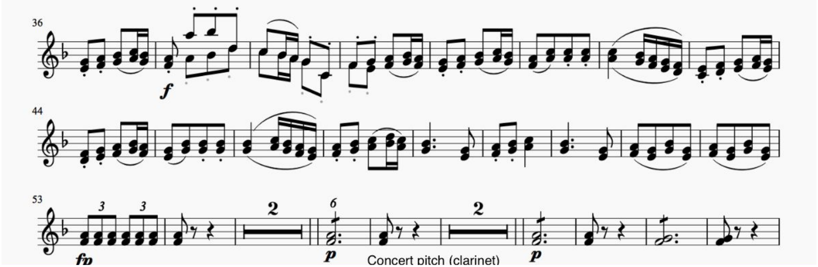


On the Efficiency of Source-Based Path Selection

Simon Scherrer, ETH Zurich

22 February 2019, KU Leuven

Network-based path selection: The network operator view



Source-based path selection: The network operator view

Research questions

- **How inefficient** is the traffic allocation resulting from selfish end-host decisions?
- Can we reduce the inefficiency by **providing appropriate information** to end-hosts?

Price of Anarchy: Three components

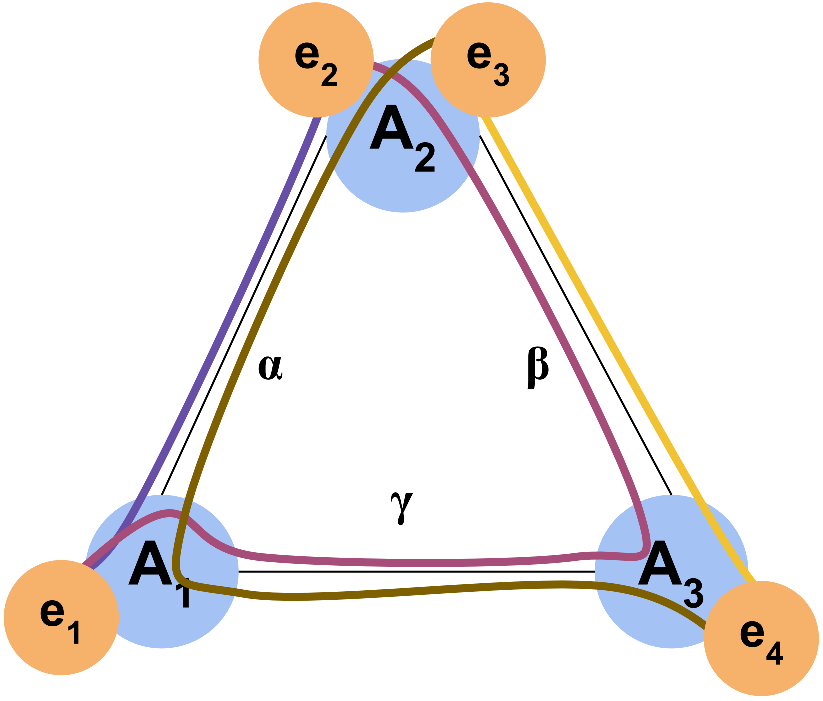
C Total cost function

F^{opt} Social optimum

F^{eq} Nash equilibrium

$$PoA = \frac{C(F^{eq})}{C(F^{opt})}$$

A model of source-based path selection



$$\mathbf{d} = (d_{1,2}, d_{3,4}) = (1, 1)$$

$$\mathbf{F} = (F_{\alpha}, F_{\gamma\beta}, F_{\beta}, F_{\alpha\gamma})$$

$$\mathbf{f} = (f_{\alpha}, f_{\beta}, f_{\gamma})$$

$$c_{\alpha}(f_{\alpha}) = 1$$
$$c_{\beta}(f_{\beta}) = f_{\beta}^{2}$$
$$c_{\gamma}(f_{\gamma}) = f_{\gamma}$$

$$C_{\pi}(\mathbf{F}) = \Sigma_{\ell \in \pi} c_{\ell}$$

Total cost functions and social optima

End-host cost function: $C^* = \Sigma_{\text{end-hosts}} \Sigma_{\text{paths}} \text{ flow on path} \cdot \text{path cost}$

End-host optimum: $\mathbf{F}^* = \text{argmin}_{\mathbf{F}}\, C^*(\mathbf{F})$

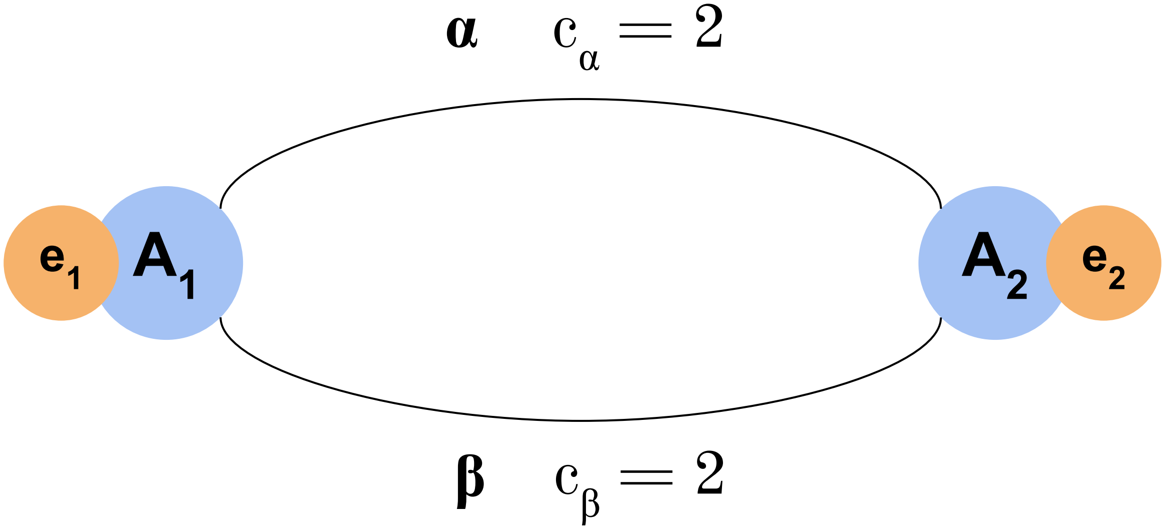
Network operator cost function: $C^\# = \Sigma_{\text{links}} \text{ link cost}$

Network operator optimum: $\mathbf{F}^\# = \text{argmin}_{\mathbf{F}}\, C^\#(\mathbf{F})$

Equilibrium with latency-only information (LI equilibrium)

$$\mathbf{d} = (d_{1,2}) = (1)$$

$$\mathbf{F} = (F_\alpha, F_\beta) = (1, 0)$$

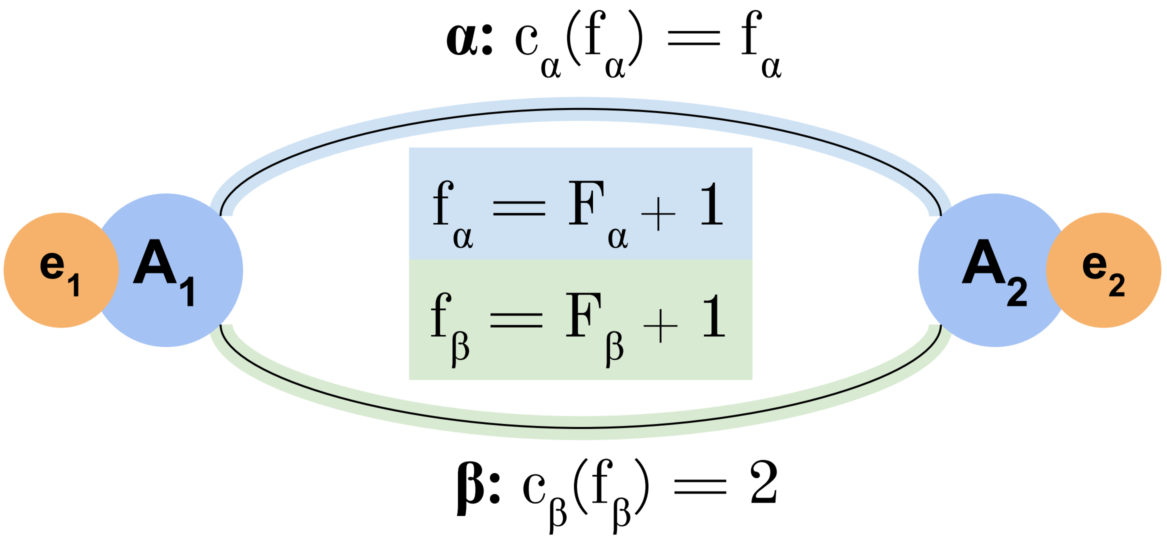


$c_\alpha = c_\beta \quad \Rightarrow \quad \mathbf{F} = (1,0)$ is an LI equilibrium

Equilibrium with perfect information (PI equilibrium)

$$\mathbf{d} = (d_{1,2}) = (1)$$

$$\mathbf{F} = (F_\alpha, F_\beta)$$



Minimize $F_\alpha \cdot (F_\alpha + 1) + (1 - F_\alpha) \cdot 2$

$\Rightarrow (F_\alpha, F_\beta) = (2/3, 1/3)$ is a PI equilibrium

Capturing the value of information

Information assumption	Latency-only Information (LI)	Perfect Information (PI)
Equilibrium	$\mathbf{F}^0$	$\mathbf{F}^+$
Price of Anarchy	$\mathrm{PoA}^0 = \frac{\mathrm{C}(\mathbf{F}^0)}{\mathrm{C}(\mathbf{F}^{\mathrm{opt}})}$	$\mathrm{PoA}^+ = \frac{\mathrm{C}(\mathbf{F}^+)}{\mathrm{C}(\mathbf{F}^{\mathrm{opt}})}$

$\Delta =$ Value of Information (VoI)

Interesting results

- End-host optimum and network operator optimum can differ substantially
- The price of anarchy can be bounded given a class of latency functions.
- Additional information can be both beneficial *and harmful* to overall performance
- Additional information becomes *irrelevant* with scale of network

Questions?