Information Design for Congested Social Services: Optimal Need-based Persuasion

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Joint work with **Krishnamurthy Iyer** (U. Minnesota) and **Vahideh Manshadi** (Yale)
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Motivation

Most social services face the challenge of severe congestion leading to long waiting times and inefficiency.

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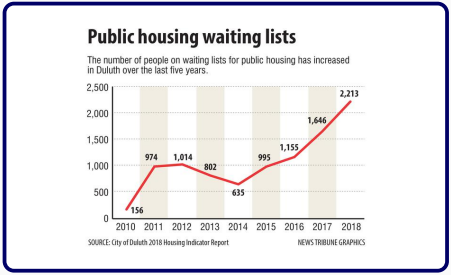

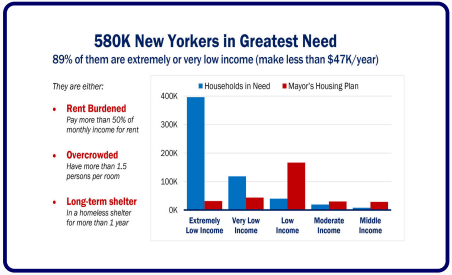

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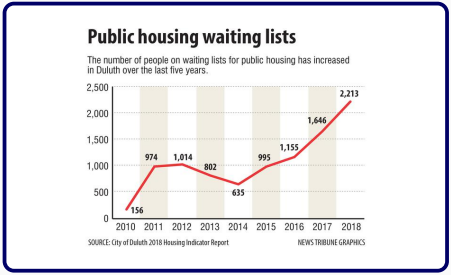

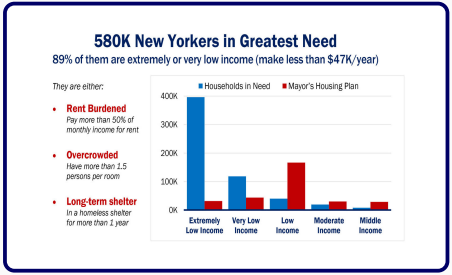

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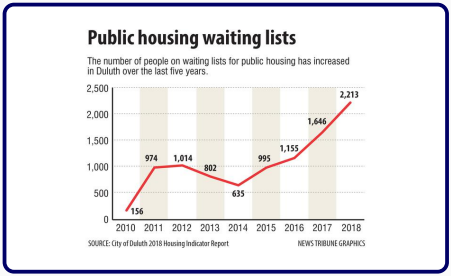

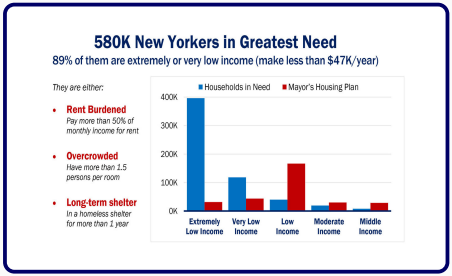

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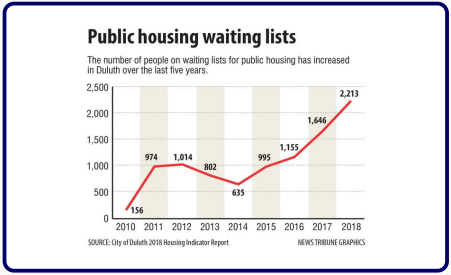

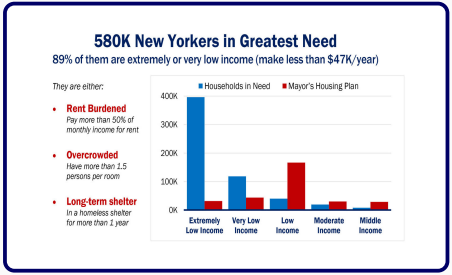

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Users have **heterogeneous needs** for the service.

Can't use: **pricing** (not fair) and **admission control** (not practical).

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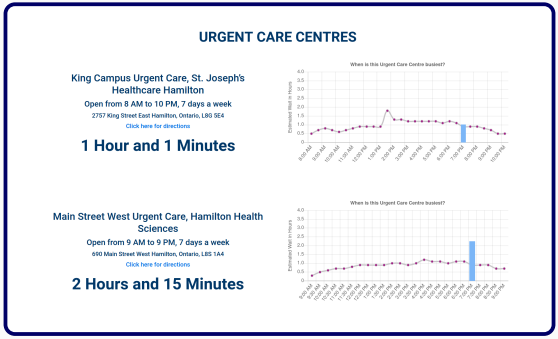

… especially useful for patients with less serious conditions who can use it to choose when and where to seek care. `[globalnews.ca]`

Summary

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In this talk:

- stylized queueing model serving users with heterogeneous needs.
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- welfare under info. design against simple benchmarks and centralized admission policies.

Take-away: With sufficient heterogeneity in need, information design can be powerful in improving overall welfare outcomes.

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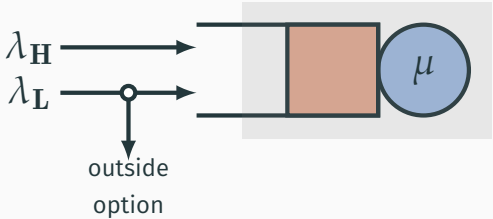
Social service provider:

- **unobservable** FCFS queue
- single server, rate μ



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Heterogeneous need for service:

- high-need ($\mathbf{H}$): must use the service
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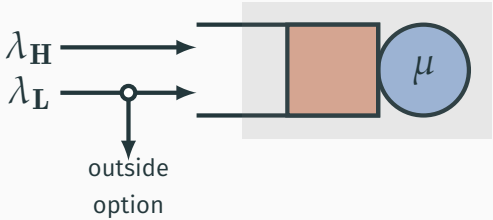

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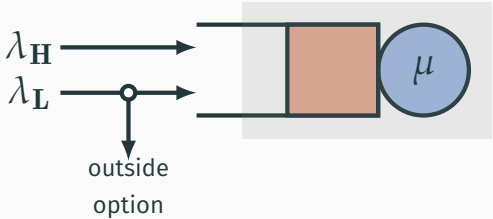

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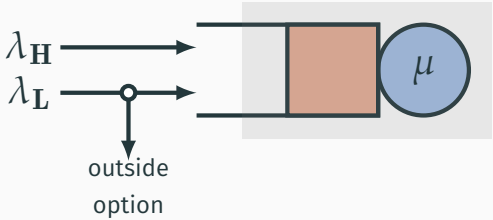

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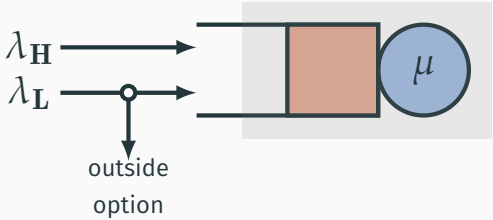

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Service provider's goal: **information design** (signaling) on queue length to improve welfare.

Model: Welfare

Expected welfare of each type in steady-state:

$$W_{\mathbf{L}}(\sigma) = \lambda_{\mathbf{L}} \cdot \mathbf{E}_{\pi}[u_{\mathbf{L}}(X) \cdot \mathbf{I}\{\mathbf{join}\}]$$
$$W_{\mathbf{H}}(\sigma) = \lambda_{\mathbf{H}} \cdot \mathbf{E}_{\pi}[u_{\mathbf{H}}(X)]$$

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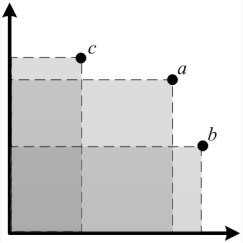
A signaling mechanism **Pareto-dominates** another if **welfare of both types are higher.**

A signaling mechanism is **Pareto-dominant** if **no other mechanism Pareto-dominates it.**



Comparing Signaling Mechanisms with Simple Benchmarks (Full-Info, No-Info, First-Best)

Comparing with full-info and no-info

Theorem (Homogeneous users, informal)

If there are only type-$\mathbf{L}$ users, then $W_{\mathbf{L}}(\mathsf{sm}) \approx W_{\mathbf{L}}(\mathsf{fi}) \gg W_{\mathbf{L}}(\mathsf{ni})$.

With only type-$\mathbf{L}$, signaling does not really improve over full-info.
(With only type-$\mathbf{H}$, nothing can be done.)

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Theorem (Heterogeneous users, informal)

If the type-$\mathbf{L}$ and type-$\mathbf{H}$ are "fairly balanced," then signaling dominates full-info and no-info.

Information design is Pareto-improving if population is **heterogeneous**.

Achieving first-best

Weighted welfare: $W(\sigma, \theta) = \theta \cdot W_{\mathbf{L}}(\sigma) + (1 - \theta) \cdot W_{\mathbf{H}}(\sigma)$

$$\mathsf{ap}(\theta) = \operatorname*{argmax}_{\sigma \in \mathcal{AP}} W(\sigma, \theta), \qquad \mathsf{sm}(\theta) = \operatorname*{argmax}_{\sigma \in \mathcal{SM}} W(\sigma, \theta).$$

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Theorem

For any $\lambda_{\mathbf{H}} > 0$, there exists a $\bar{\theta} = \theta(\lambda_{\mathbf{H}}) \geq 0$ such that

1. *for $\theta < \bar{\theta}$,* $\mathsf{sm}(\theta)$ *is independent of* θ
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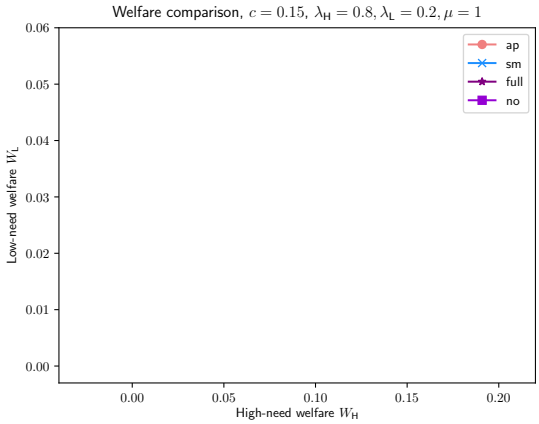
The second point means that first-best is achievable. This is good!

Incentives align; information design plays a purely **coordinating** role.

Numerics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full
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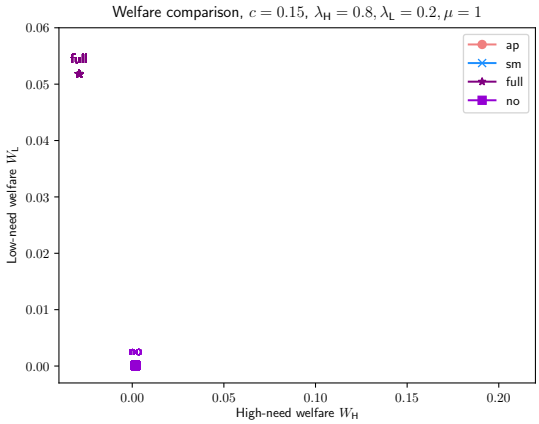
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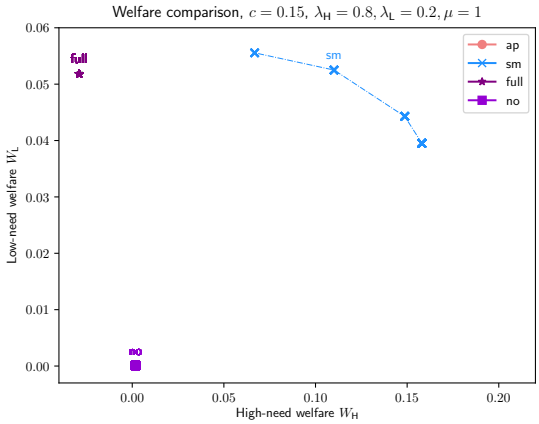
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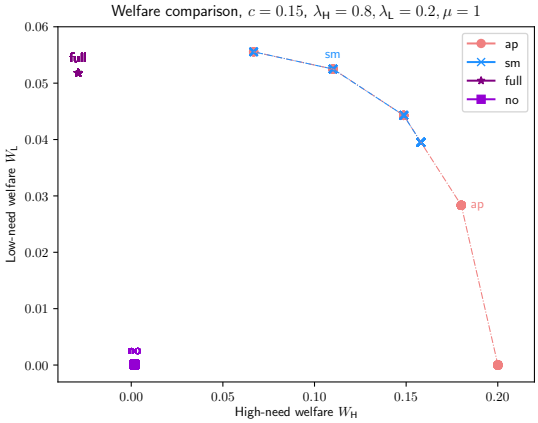
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Conclusion

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Information design provides Pareto improvement in welfare over `no-info` and `full-info` if there is sufficient heterogeneity in needs.

Under some regimes, information design can coordinate users' actions to achieve the **first-best**:

- same welfare outcomes as centralized admission policies

Signaling is useful when common levers are unavailable!

Full paper (+ extensions): `https://arxiv.org/abs/2005.07253`