

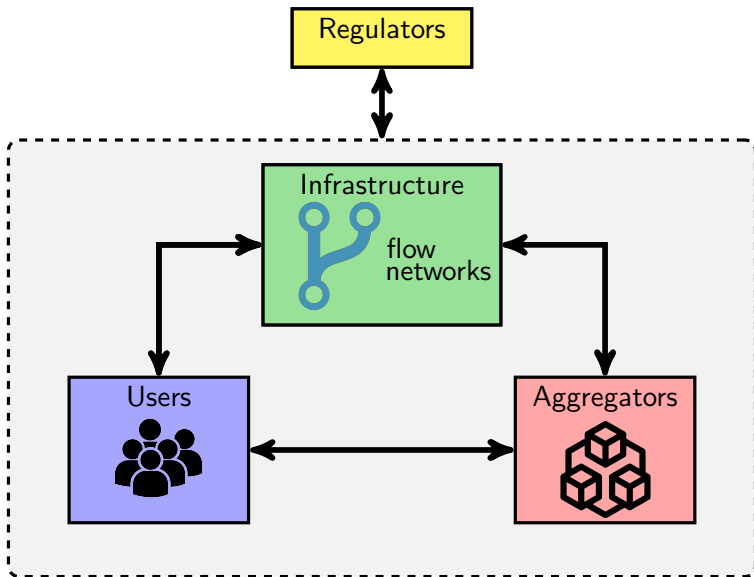
The Emerging Data Market

Lillian J. Ratliff and Roy Dong

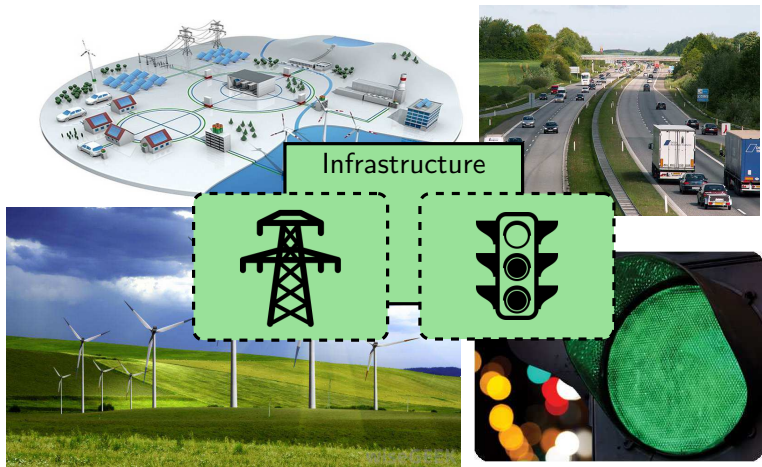
UC Berkeley

2015.11.04

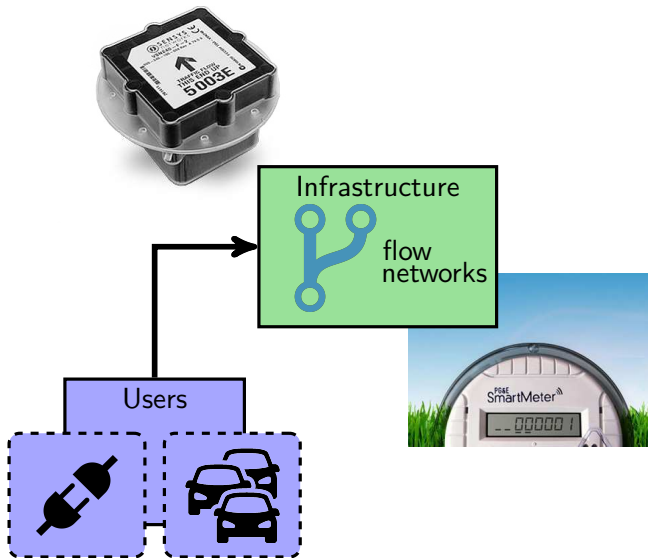
Emerging Data Market



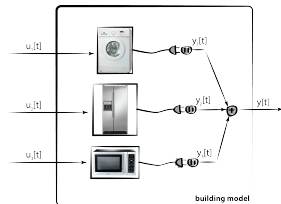
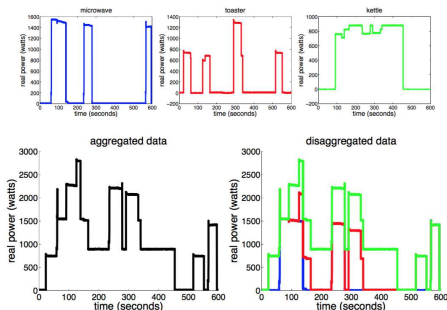
Smart, Connected Infrastructure



Operational Efficiency Informed by Usage Patterns

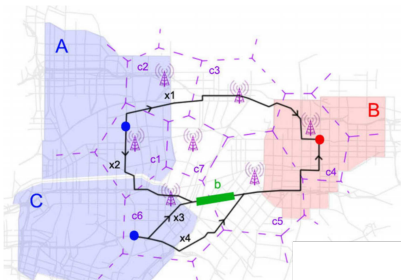
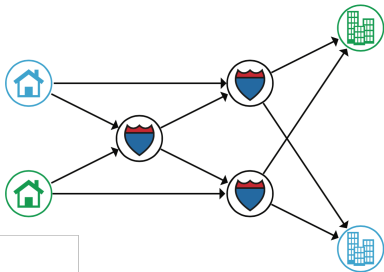
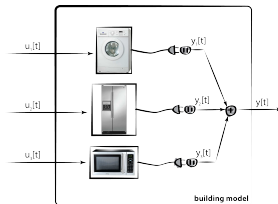
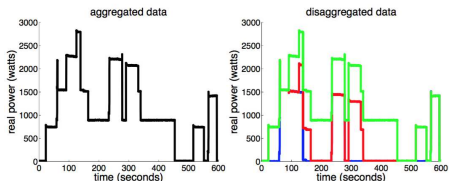
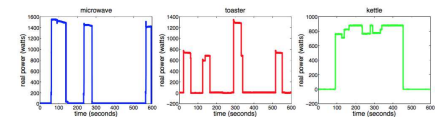


Data Disaggregation



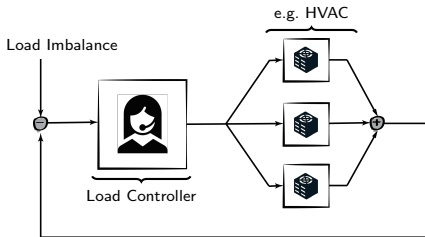
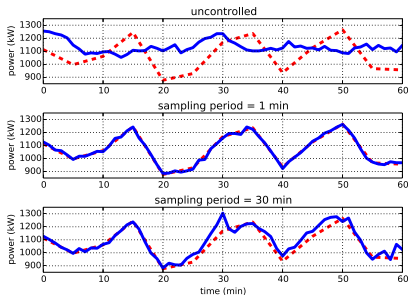
We develop algorithms to make inferences based on aggregate signals and side information.

Data Disaggregation



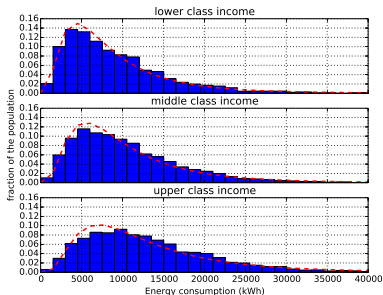
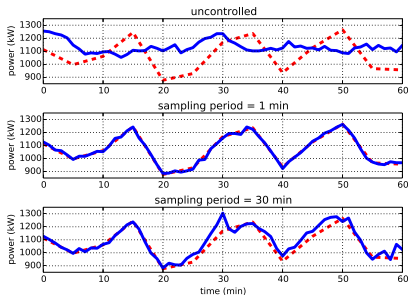
R. Dong, et al., IFAC, 2014.; R. Dong, et al., Allerton, 2013; R. Dong, et al., IEEE CDC, 2013; C. Wu, et al., TRB-C, 2015

Informational Content of Data



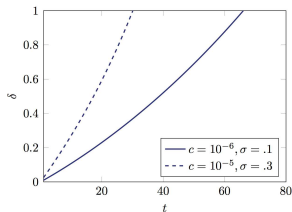
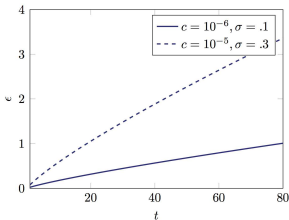
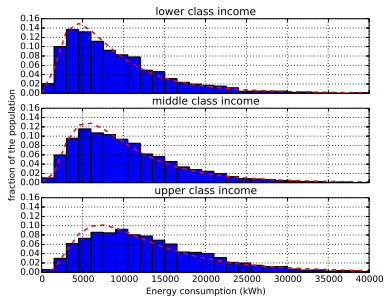
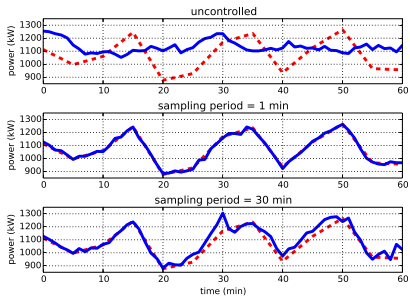
There is a trade-off between the *operational efficiency* of the system, which benefits from more data, and *exposure* of the user's data, which may lead to a privacy breach.

Informational Content of Data



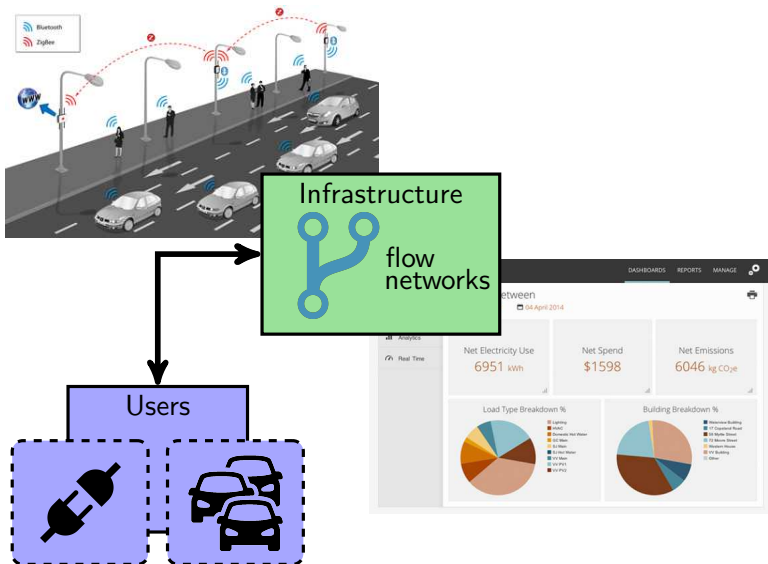
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Informational Content of Data



R. Dong, et al., arXiv:1406.2568 (under review IEEE TSG, 2014; R. Dong, et al., IEEE CDC, 2015

Closing the Loop — Integrating the User



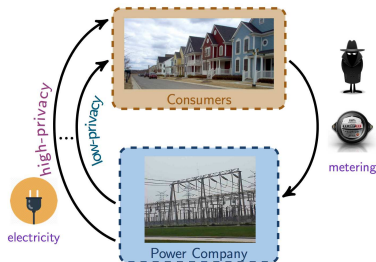
How do people value their data? — Privacy as Good

Designed service contracts differentiated by value of data to balance efficiency-vulnerability tradeoff

Characterized contracts with *privacy loss risk* modeled using *privacy metric* and abstraction of loss.

- High-type free-rides \Rightarrow regulation to realize the social optimum.
- Privacy loss risk \Rightarrow incentive for investing in insurance.

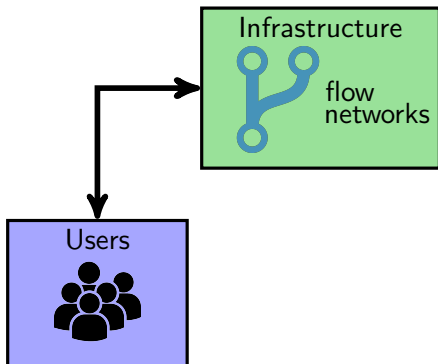
Designed insurance contracts for risk-averse utility company/consumer.



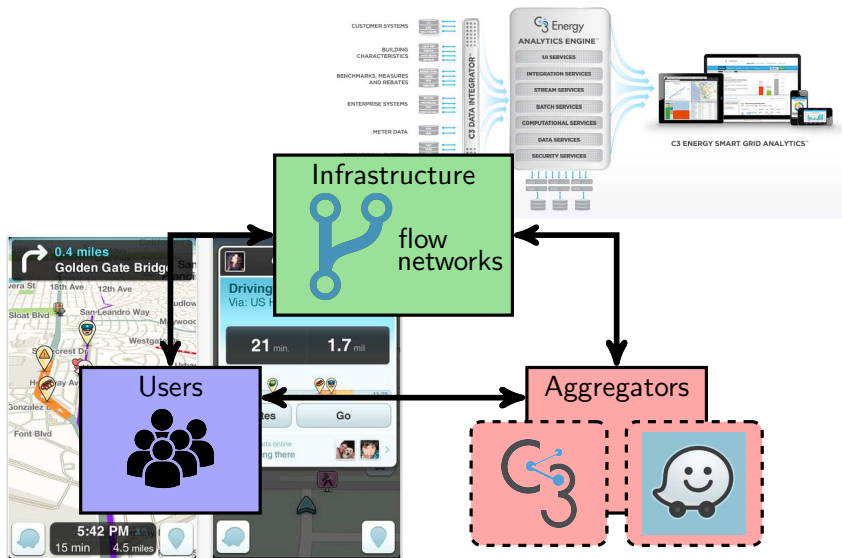
Impact:

- Privacy loss risk motivates study of *security-insurance* investment.
- User valuations of data need to be factored in to improve efficiency.

Data as a Commodity

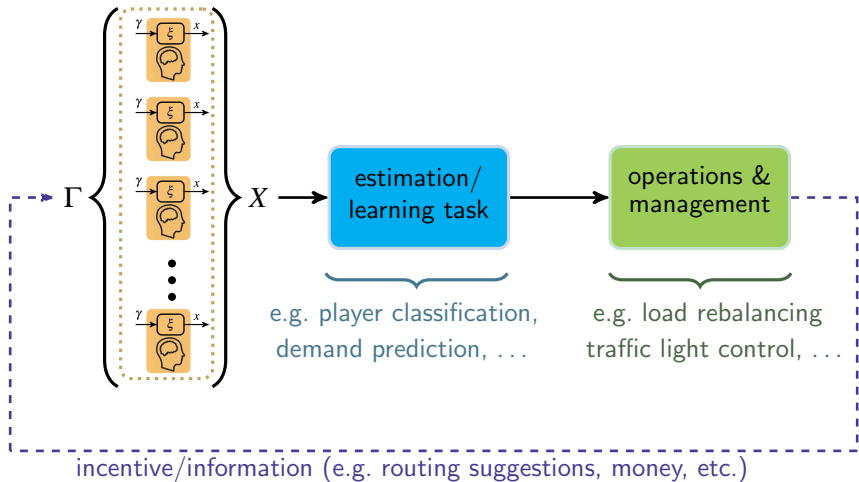


Data as a Commodity



Learning & Optimization with Strategic Data Sources

Strategic Sources



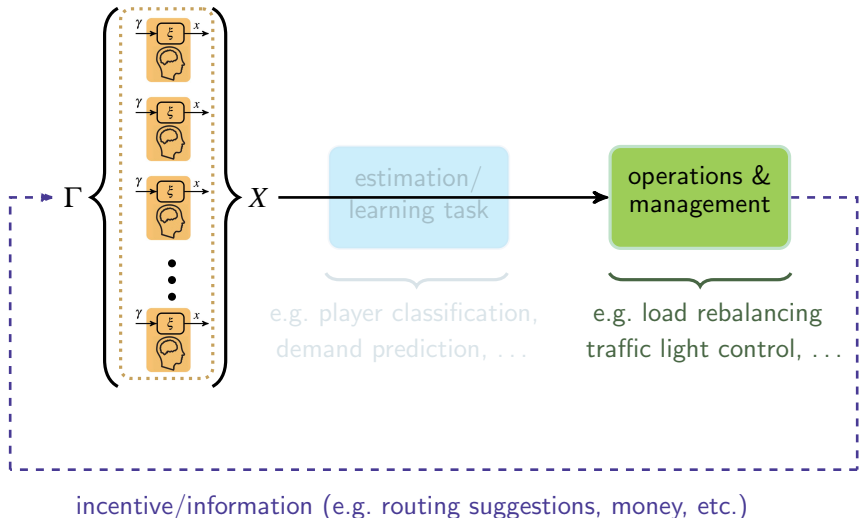
Shared Economy

A smart infrastructure empowered by the Internet of Things (IoT) has at its core an ecosystem consisting of a *shared economy*.

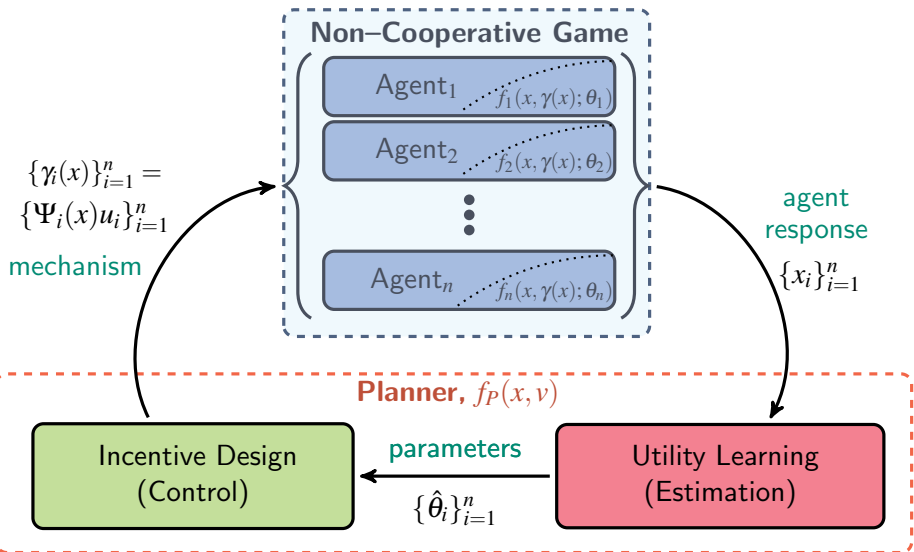


Optimization with Unknown Strategic Sources

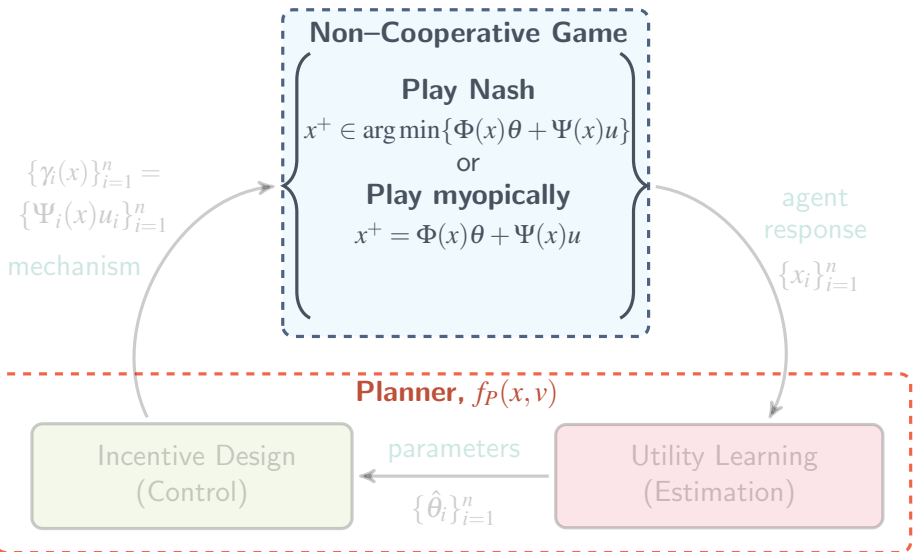
Strategic Sources



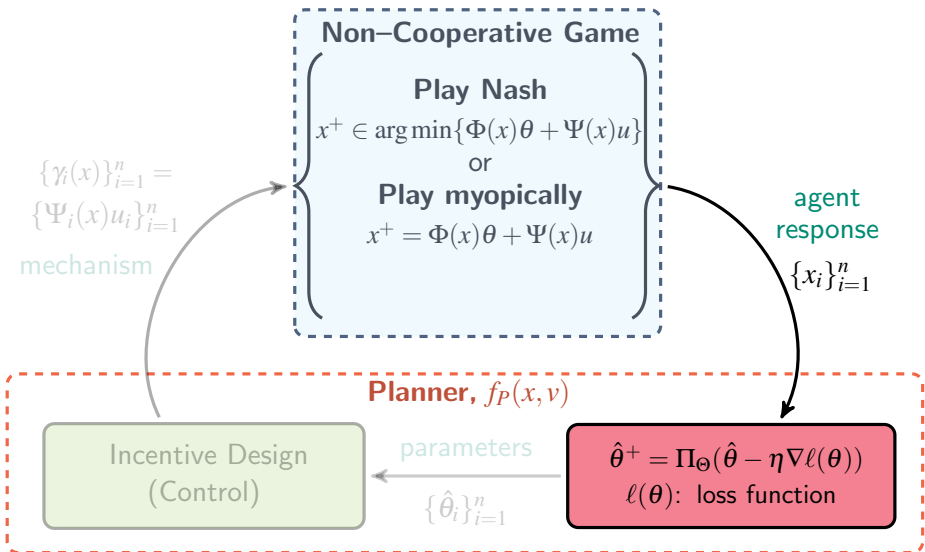
Adaptive Incentive Design — Adverse Selection



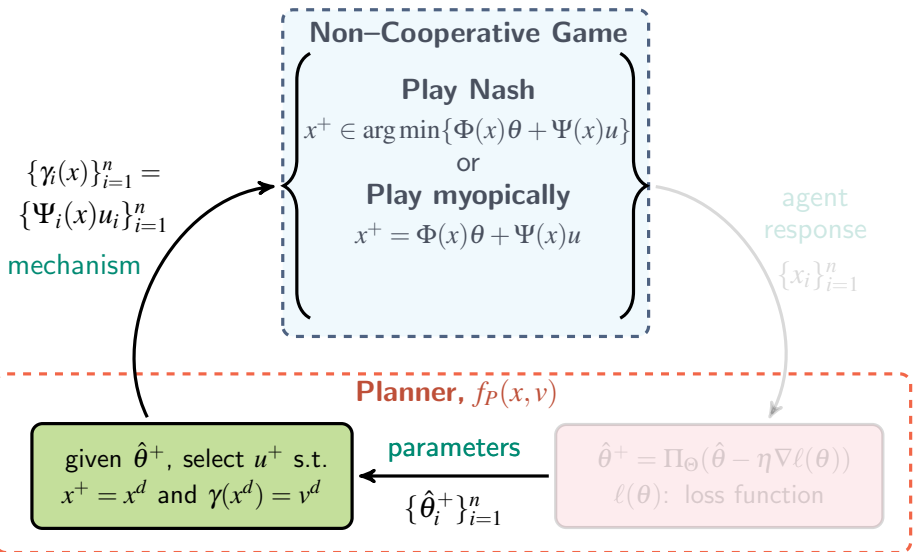
Abstraction of an Algorithm — Agent Response



Abstraction of an Algorithm — Update Estimate



Abstraction of an Algorithm — Design Incentive & Feed it Back



Convergence Results – Adaptive Control/Online Learning

Under reasonable assumptions, i.e. observations have enough *information* (*persistence of excitation*) and are not *too volatile* (*stable*), then user models converge: $\hat{\theta} \rightarrow \theta$.

} parameter convergence

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Thm: Suppose x^d is a non-degenerate differential Nash equilibrium. For $\|\hat{\theta} - \theta\|$ sufficiently small, there is a Nash equilibrium of the incentivized game near x^d .

Nash

i.e. $\exists \varepsilon > 0$, s.t. $\forall \hat{\theta}^{(k)} \in B_\varepsilon(\theta)$, if $\|(D_2\omega)^{-1}(\theta, x^d) \circ D_1\omega(\theta, x^d)\|$ is uniformly bounded by $M > 0$ on $B_\varepsilon(\theta)$, then $\|x^* - x^d\| \leq M\|\hat{\theta}^{(k)} - \theta\|$.

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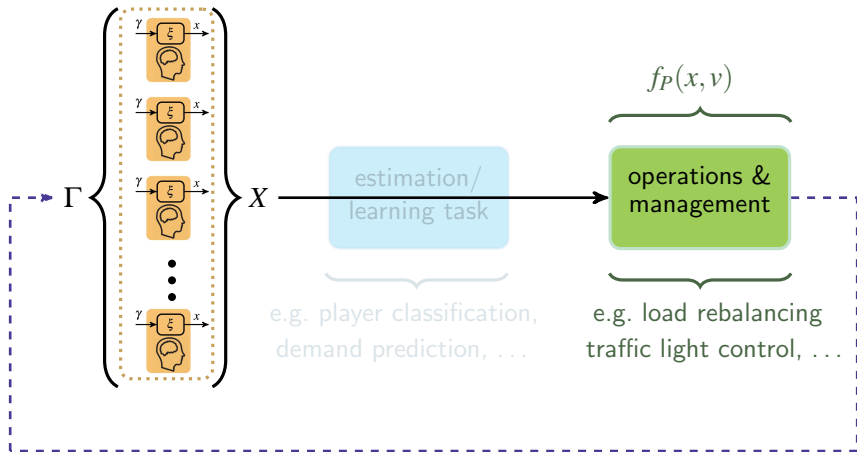
Nash

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- We can add additional constraints/costs such as *voluntary participation* and *budget balanced* to the incentive design step
- Persistence of excitation: e.g. *radial basis functions*

Future Directions — Learning & Optimization

Strategic Sources

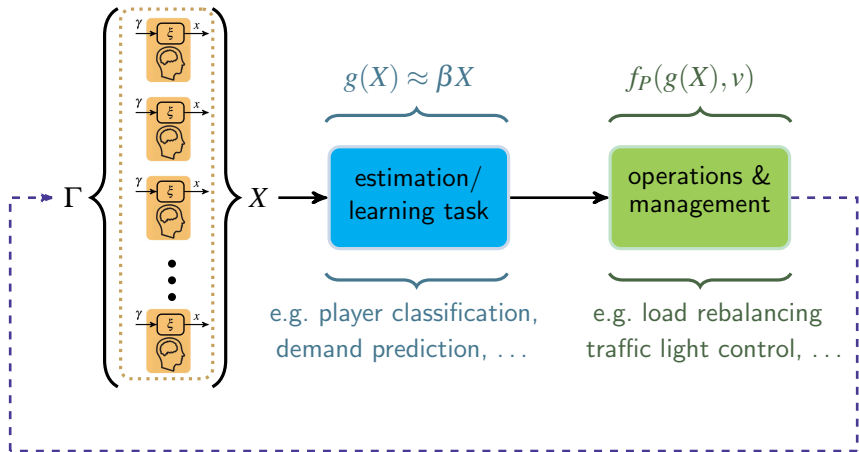


incentive/information (e.g. routing suggestions, money, etc.)

Can we provide similar guarantees in this more general case?

Future Directions — Learning & Optimization

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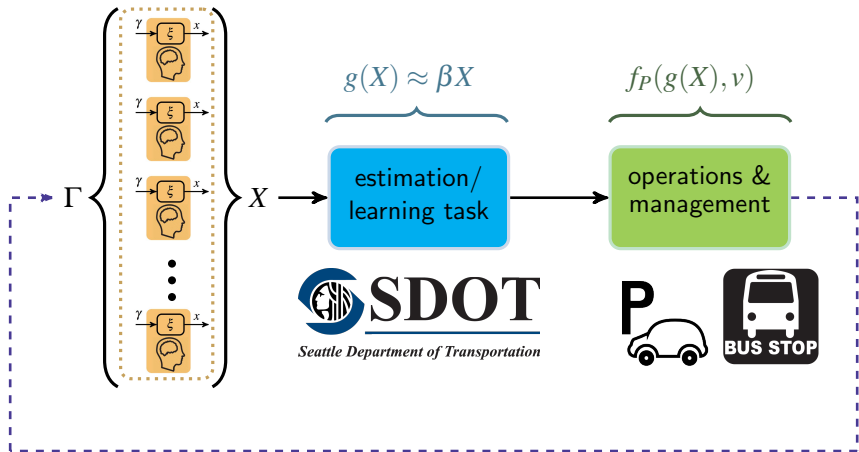


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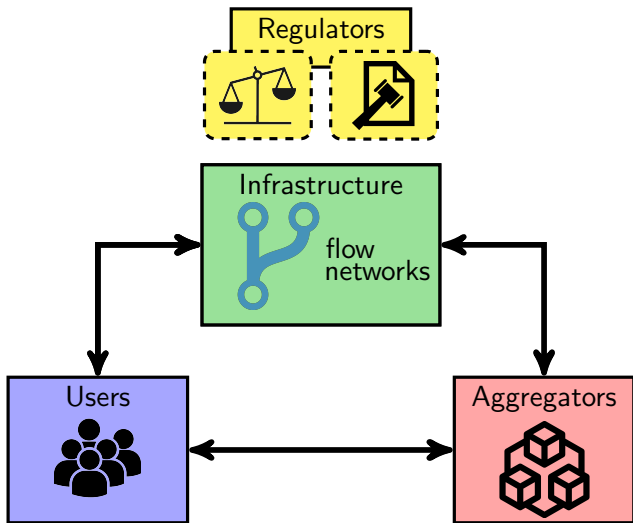
Strategic Sources



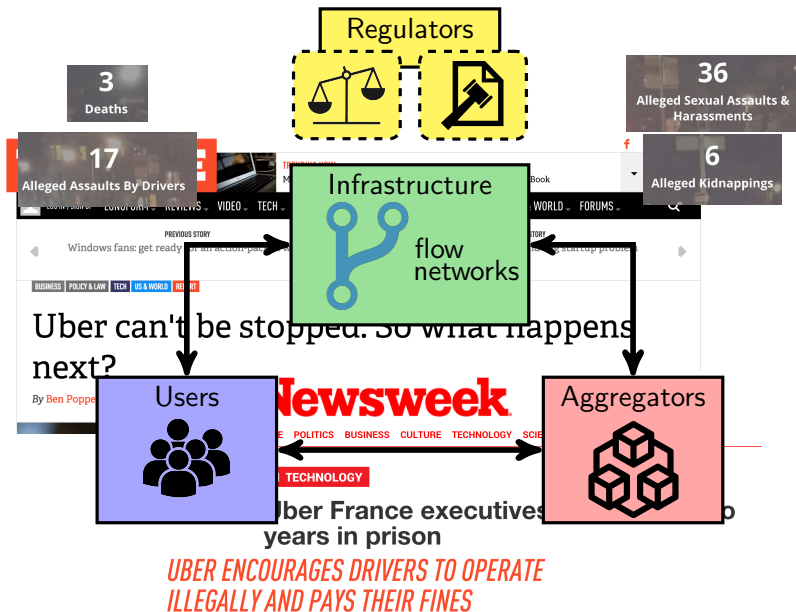
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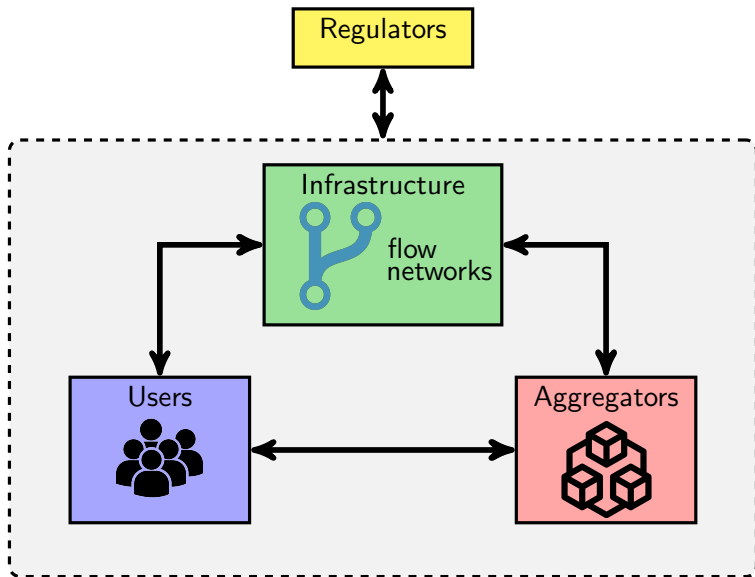
Old School Regulation



Breakin' the Law, Breakin' the Law,...



Technologically-Aware Regulation and Policies



Infrastructure Evolution

The shared economy requires service providers to evolve in order to provide **improved services** that are **competitive in the new marketplace**.



- Companies emerging that capitalize on access to streaming data.
- Forces existing infrastructure systems to modify their operational model in order to survive.

Not Just Existing Infrastructure: New infrastructure systems are emerging! (e.g. UAVs+UTM monitoring road, water, power networks)

Smart Cities: Service Models, Vulnerabilities, and Resilience

Goal: To see new research and discuss open questions about smart urban infrastructure.



http://www.eecs.berkeley.edu/~roydong/2015_cdc_ws.html