Seeing the bigger picture: context-aware regulations

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DySpAN 2012 Bellevue, Washington, USA

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Policy Track
Session 1

Conclusions

Conclusions

Databases

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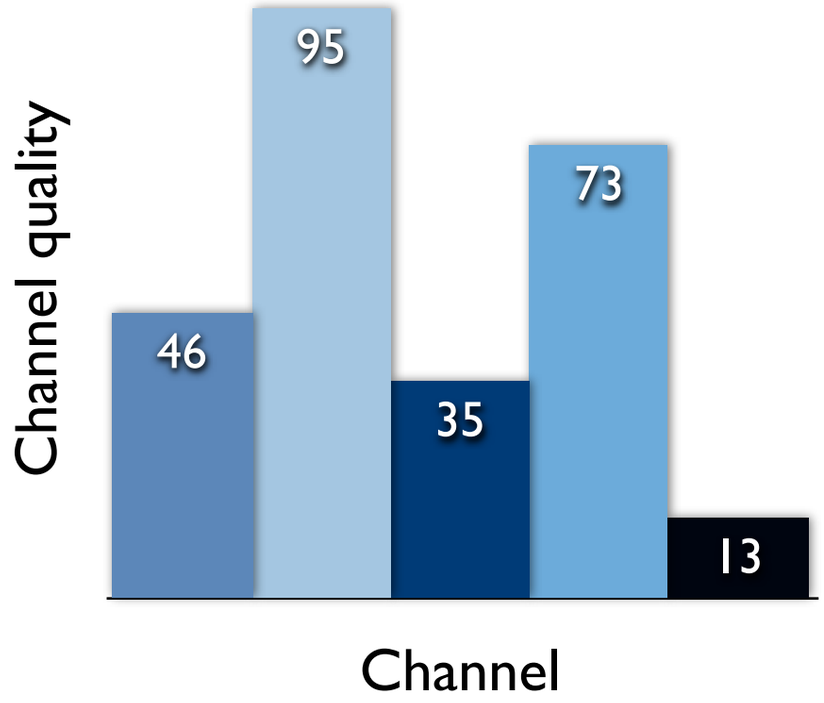
Databases



Context awareness

Databases

Whitespace device

Whitespace database

Databases

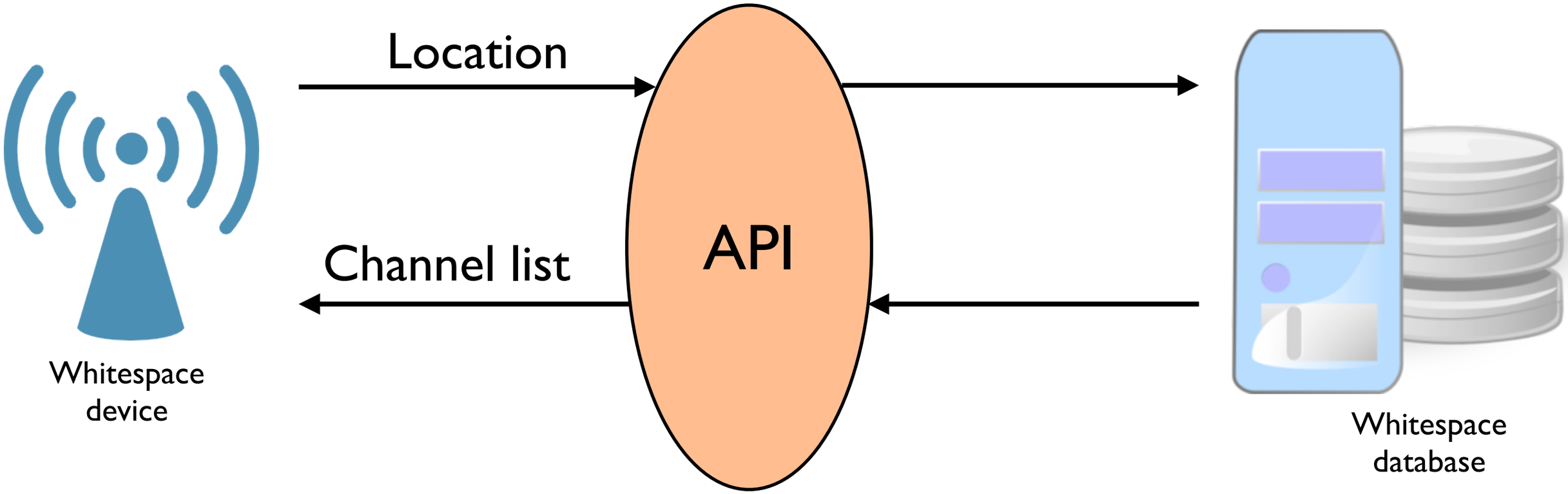
Whitespace device

Location

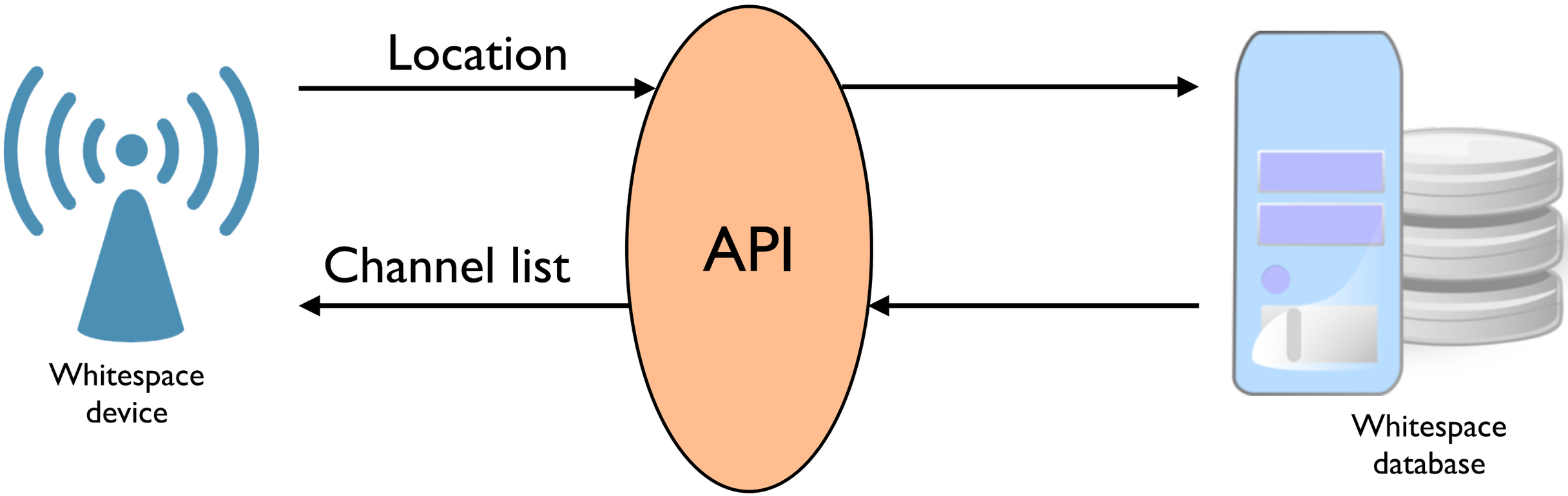
Channel list

Whitespace database

Databases


Location
Channel list
API
Whitespace device
Whitespace database

Databases



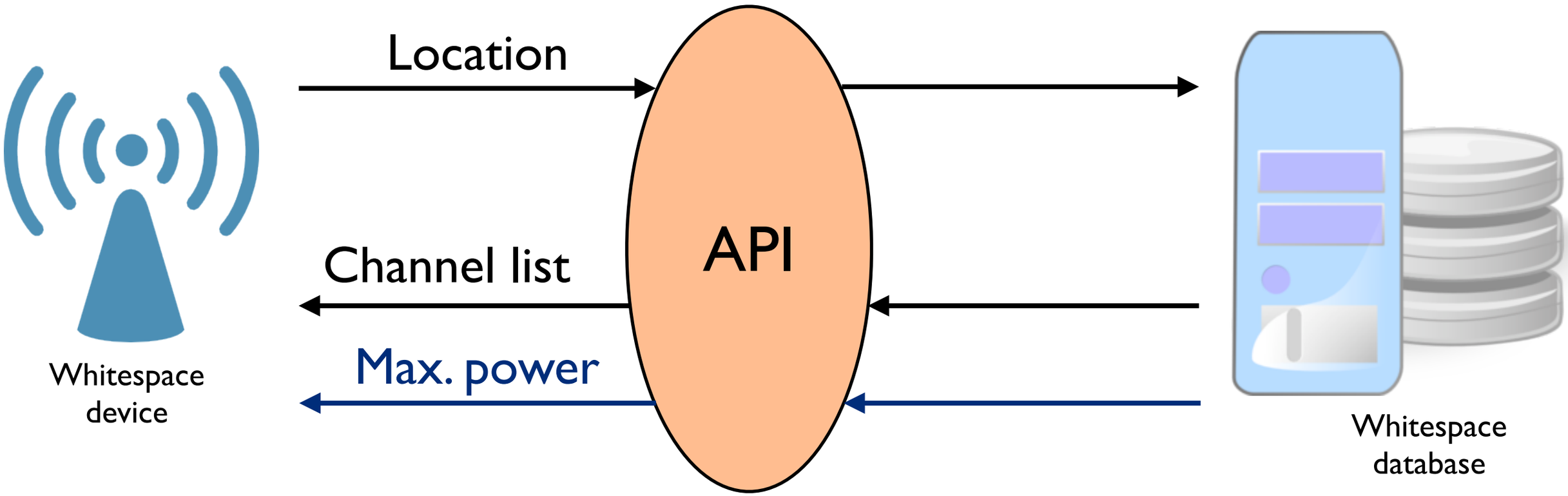
New devices

Must be fixed

Compatibility,
international harmonization

Can change

Databases



New devices

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Compatibility,
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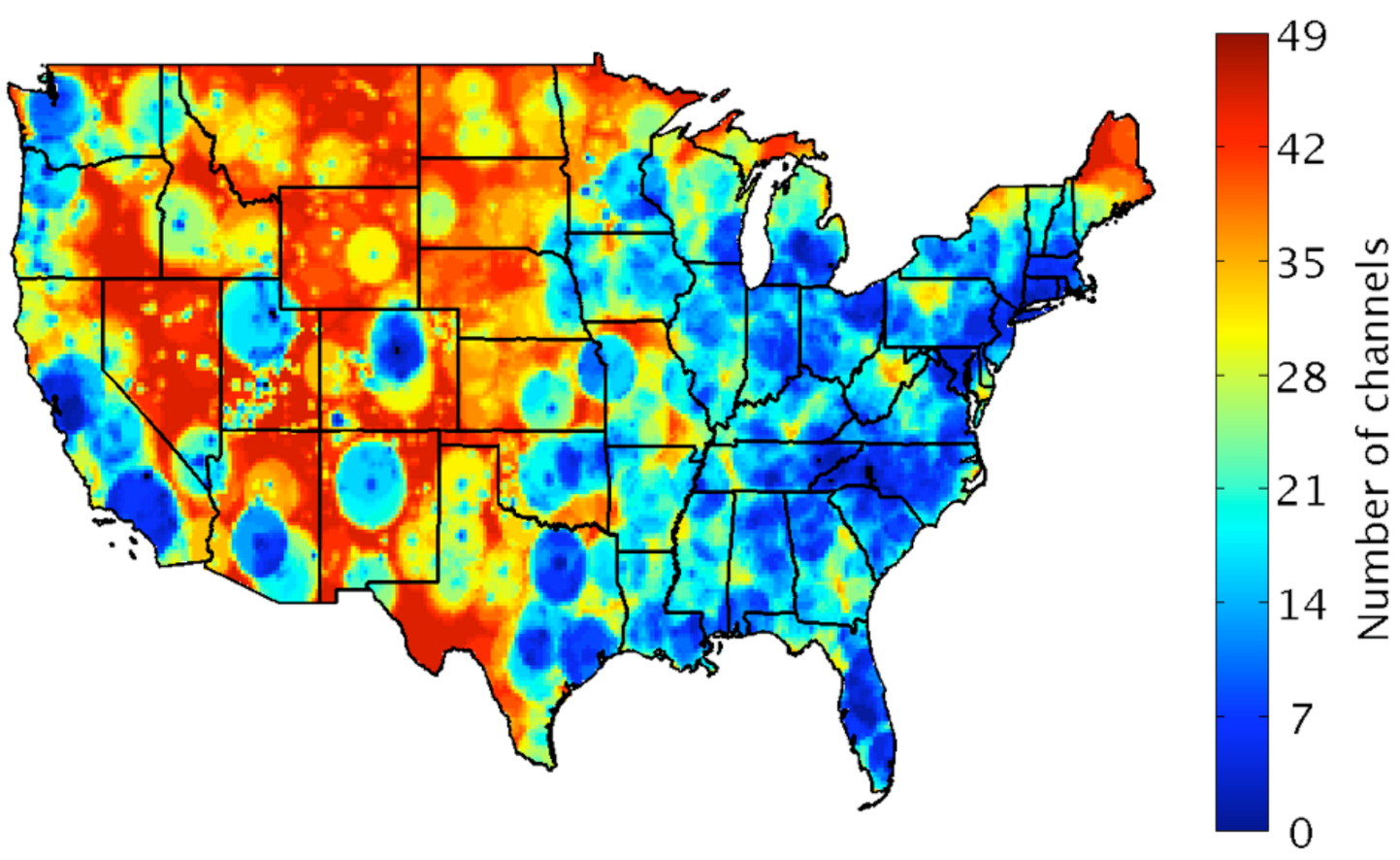
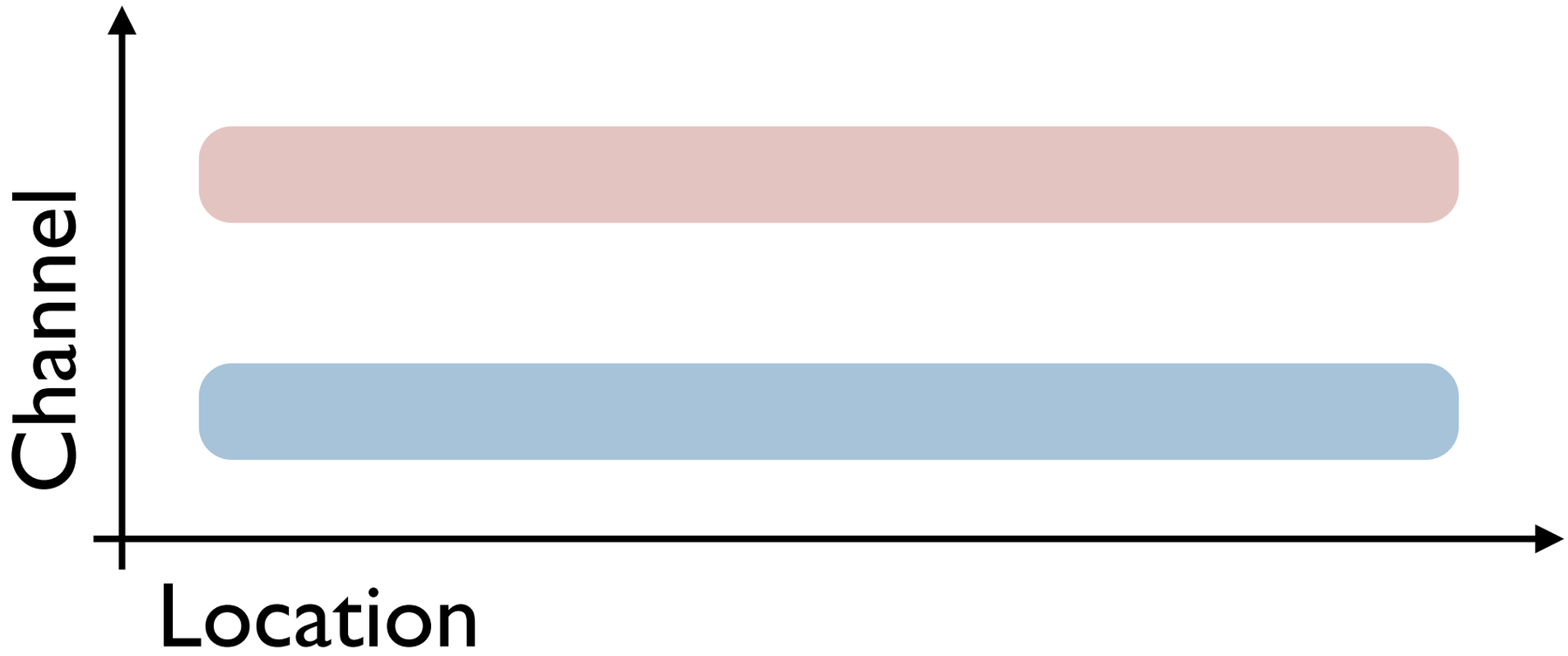
A free marketer's dream

- Optimal power allocation is nontrivial
- Use trading to gain efficiency (Coase theorem)



Thought experiment: how would Coasian bargaining play out?



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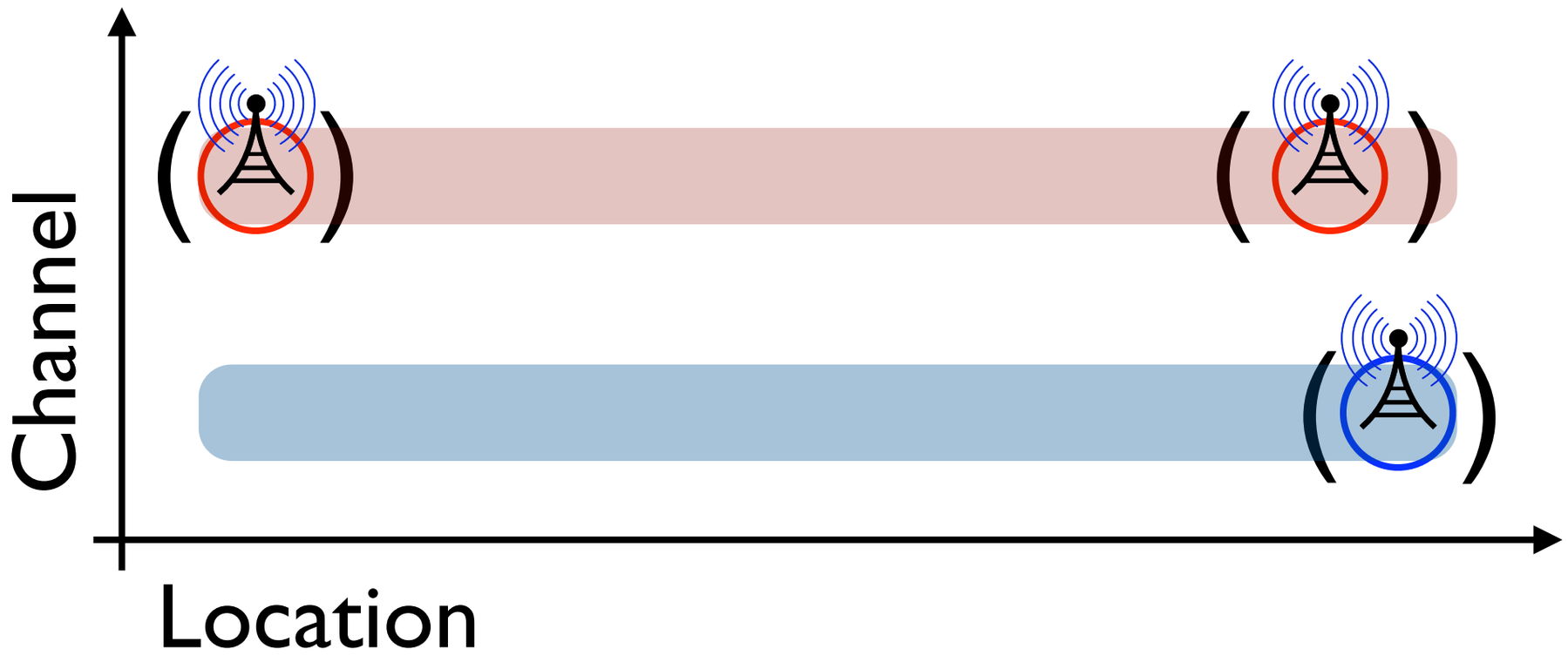

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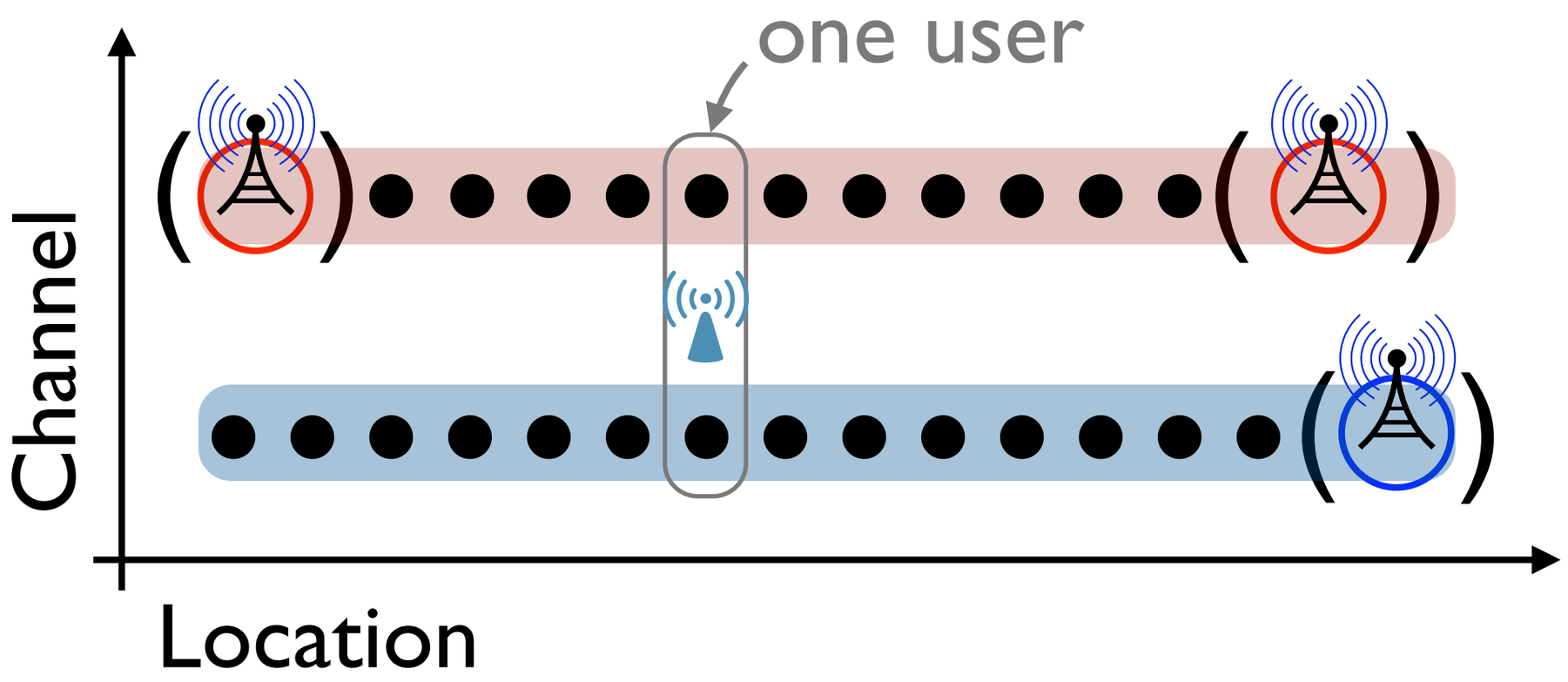

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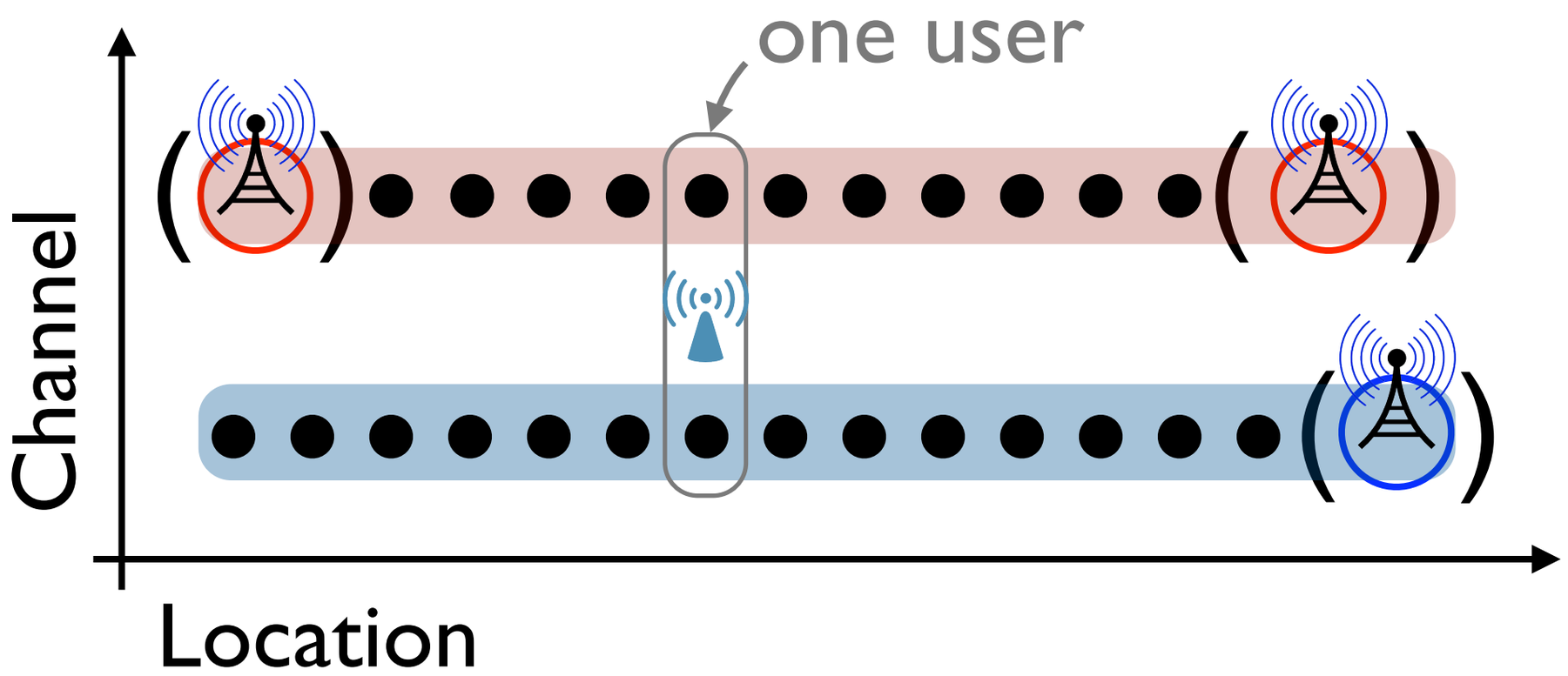

Currency?

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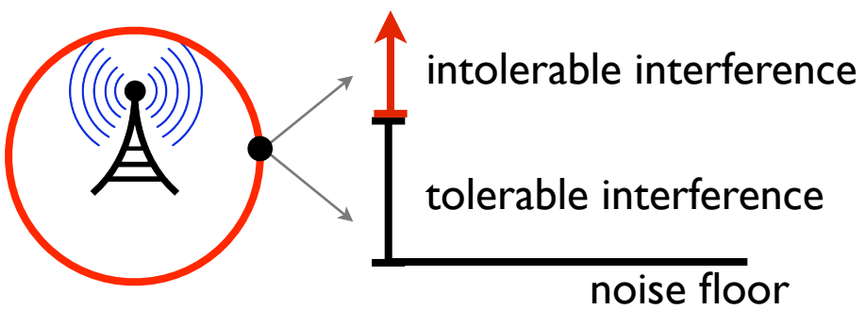

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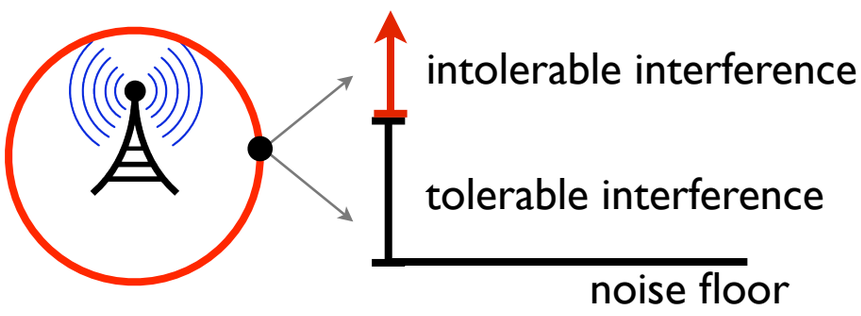

Fixed “budget” 

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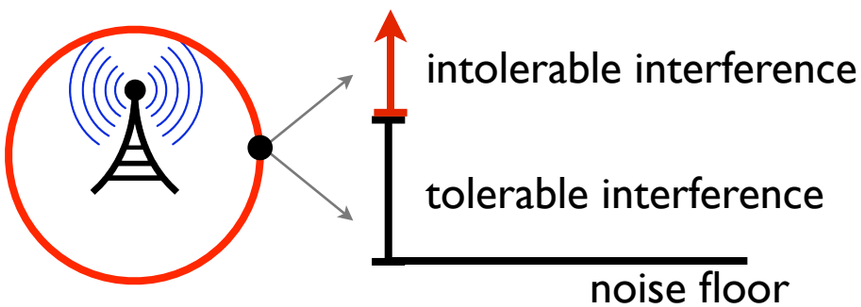

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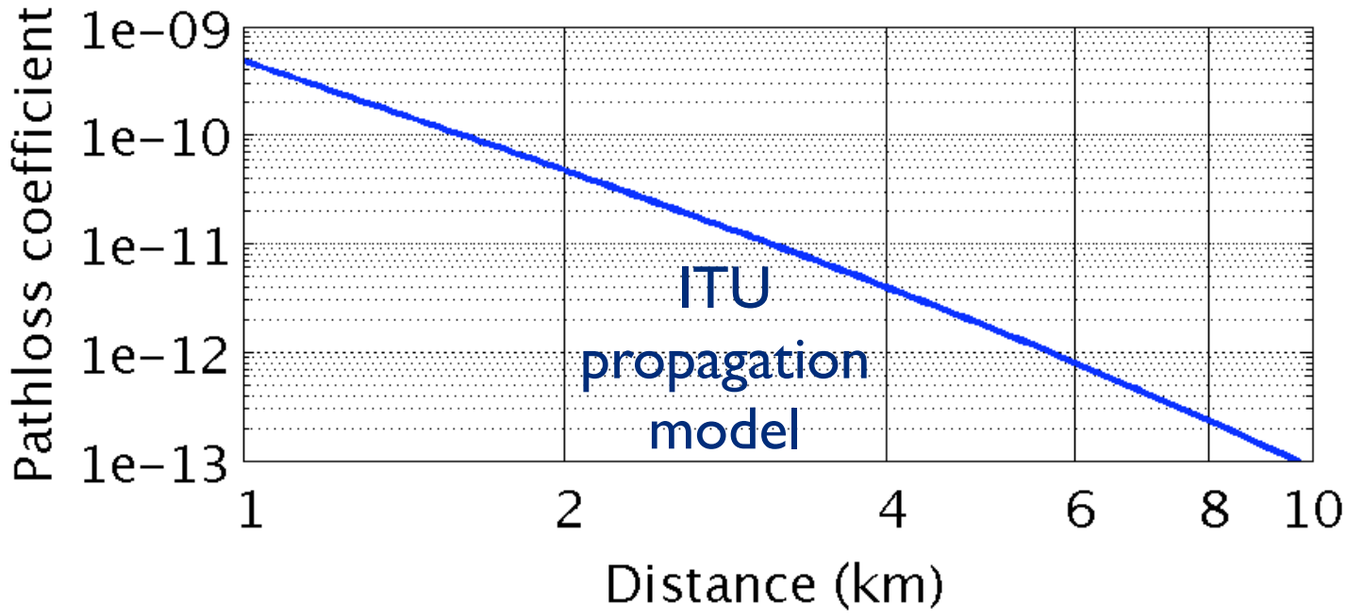

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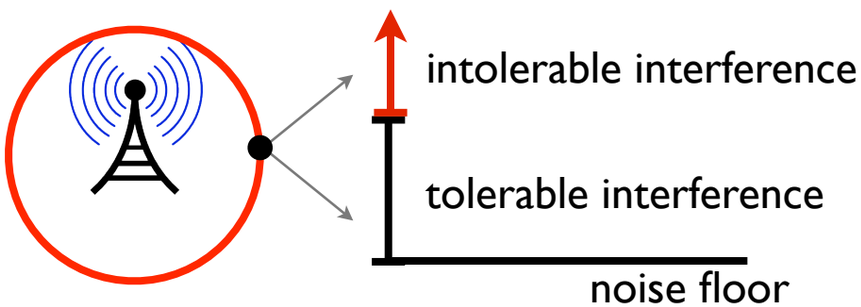

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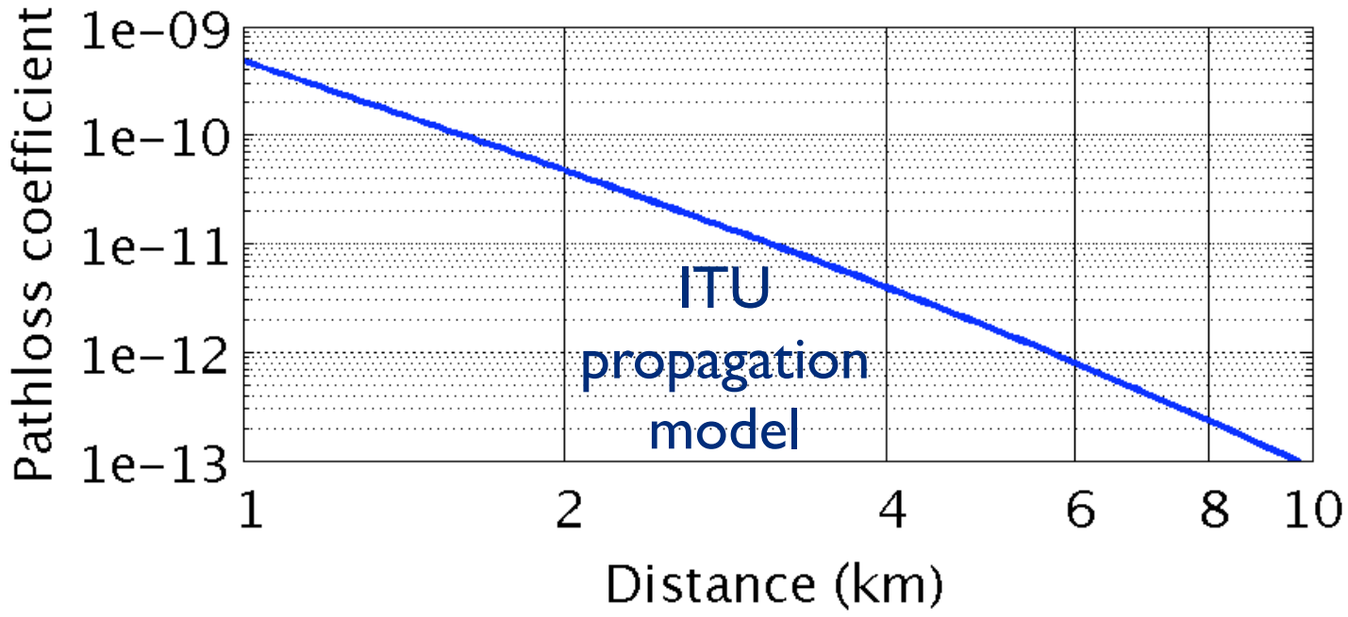

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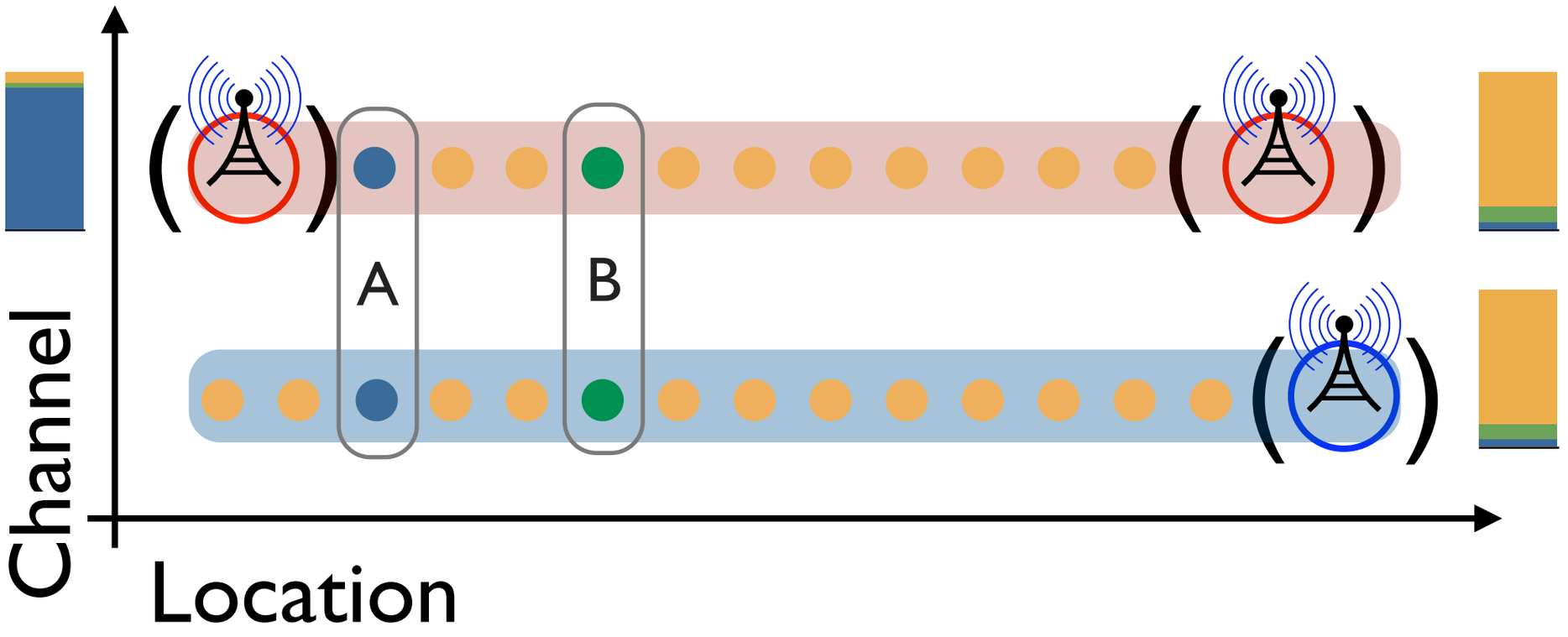

size of ● ⇔ transmit power

Total power used

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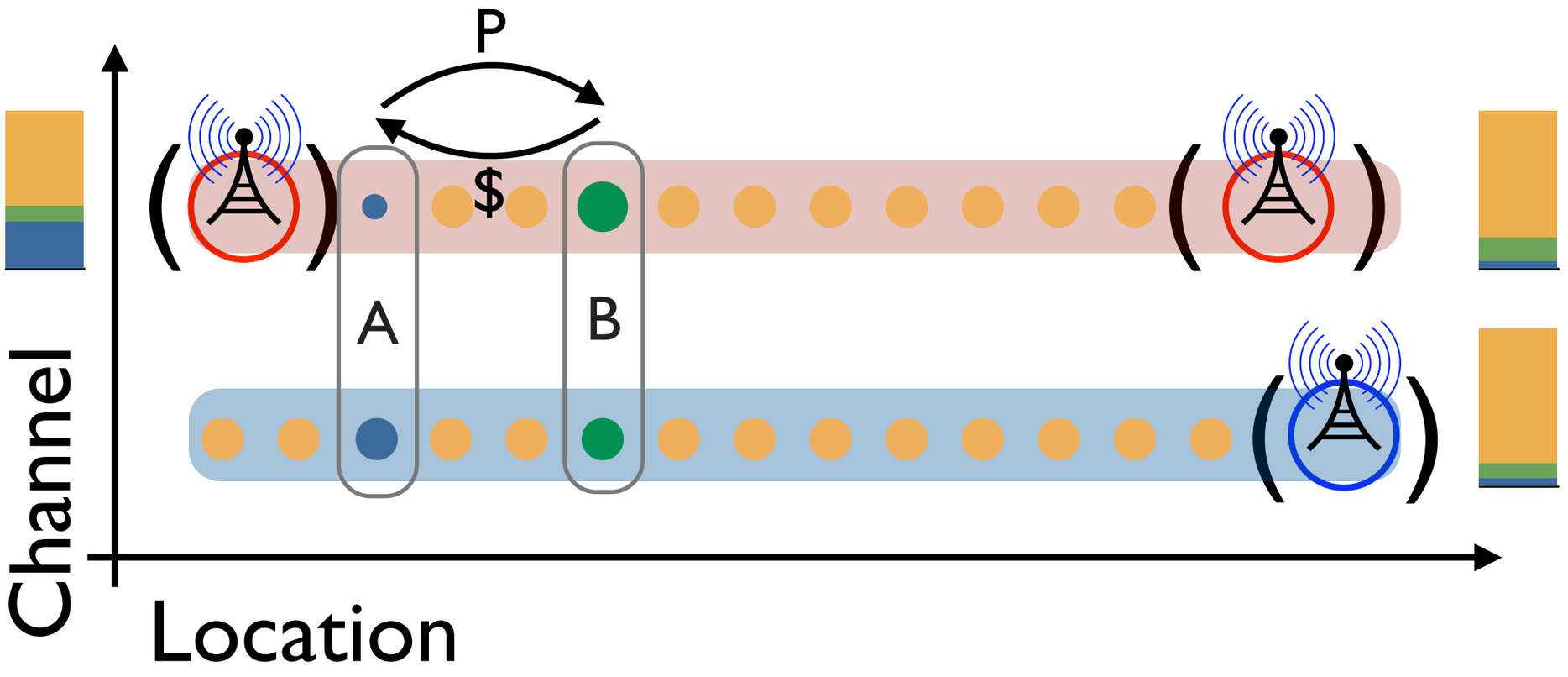

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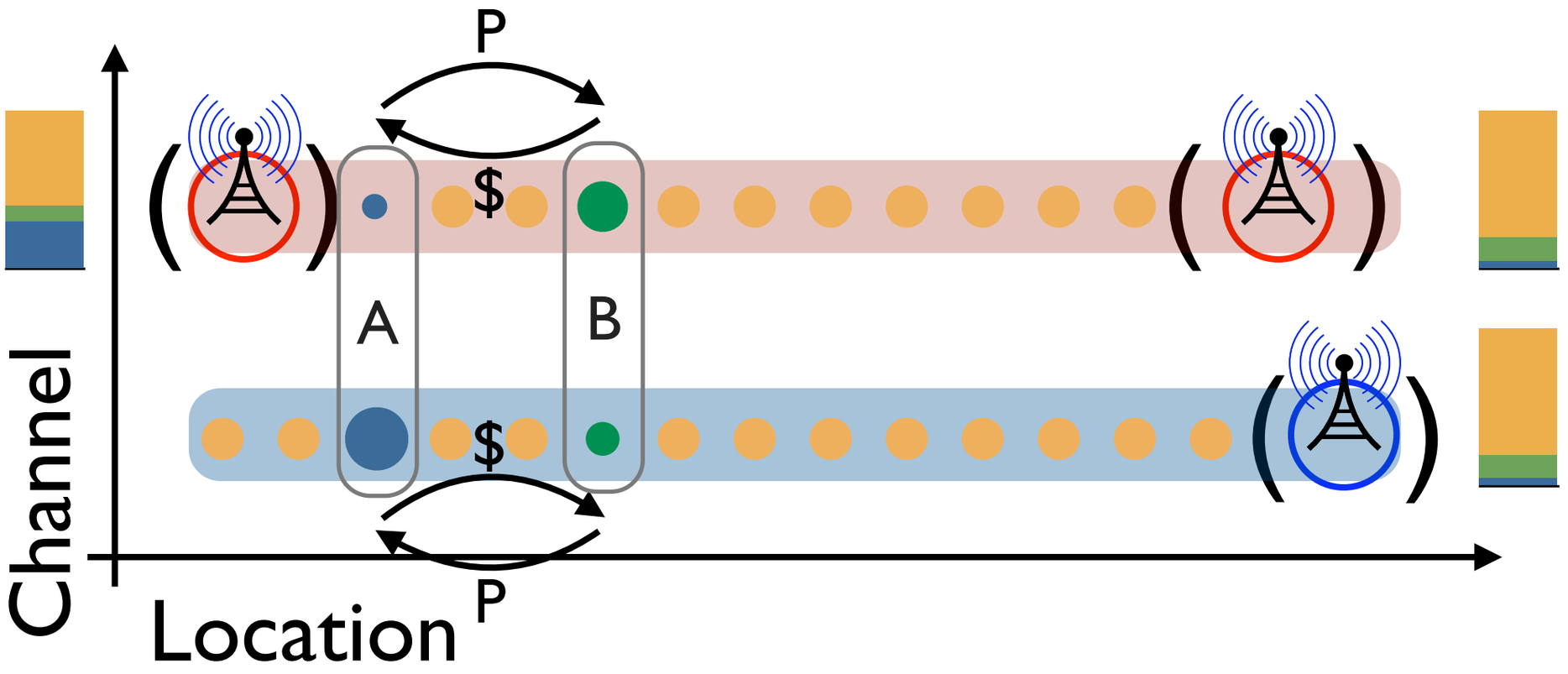

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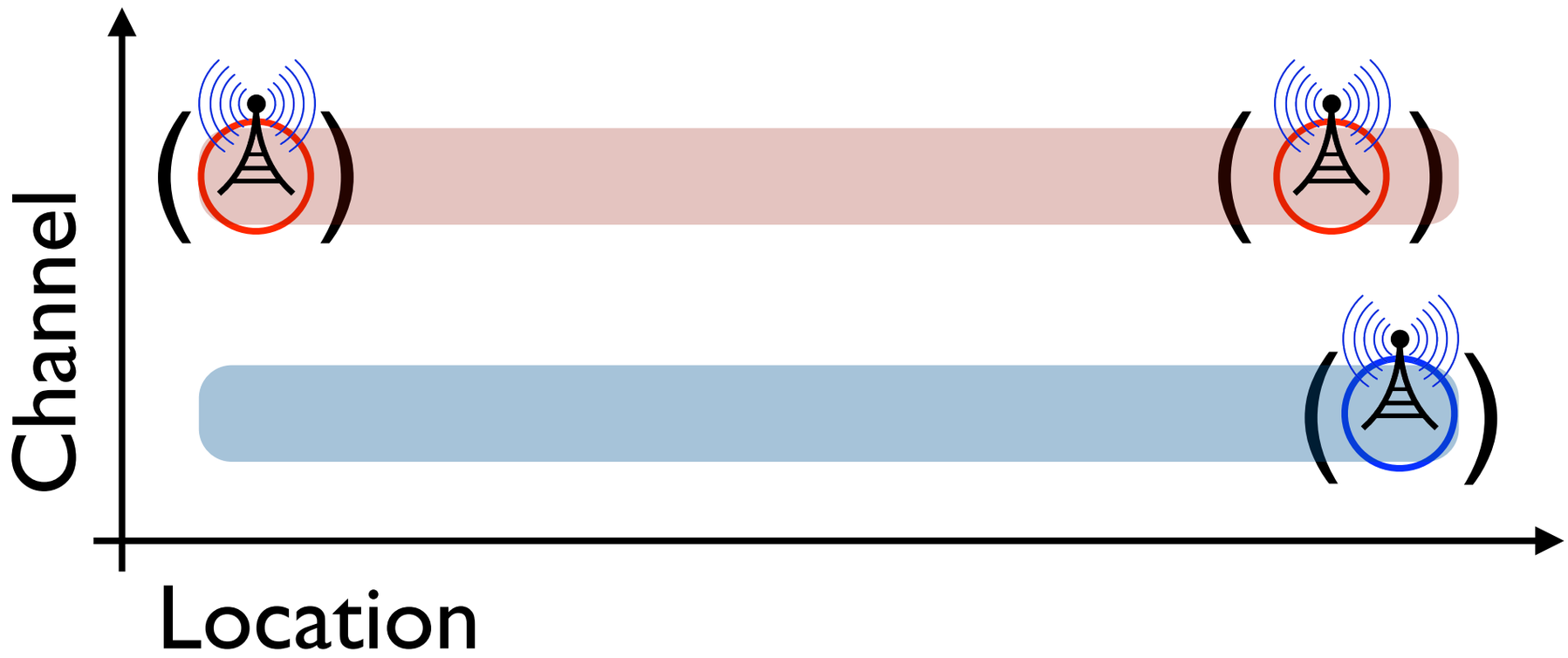

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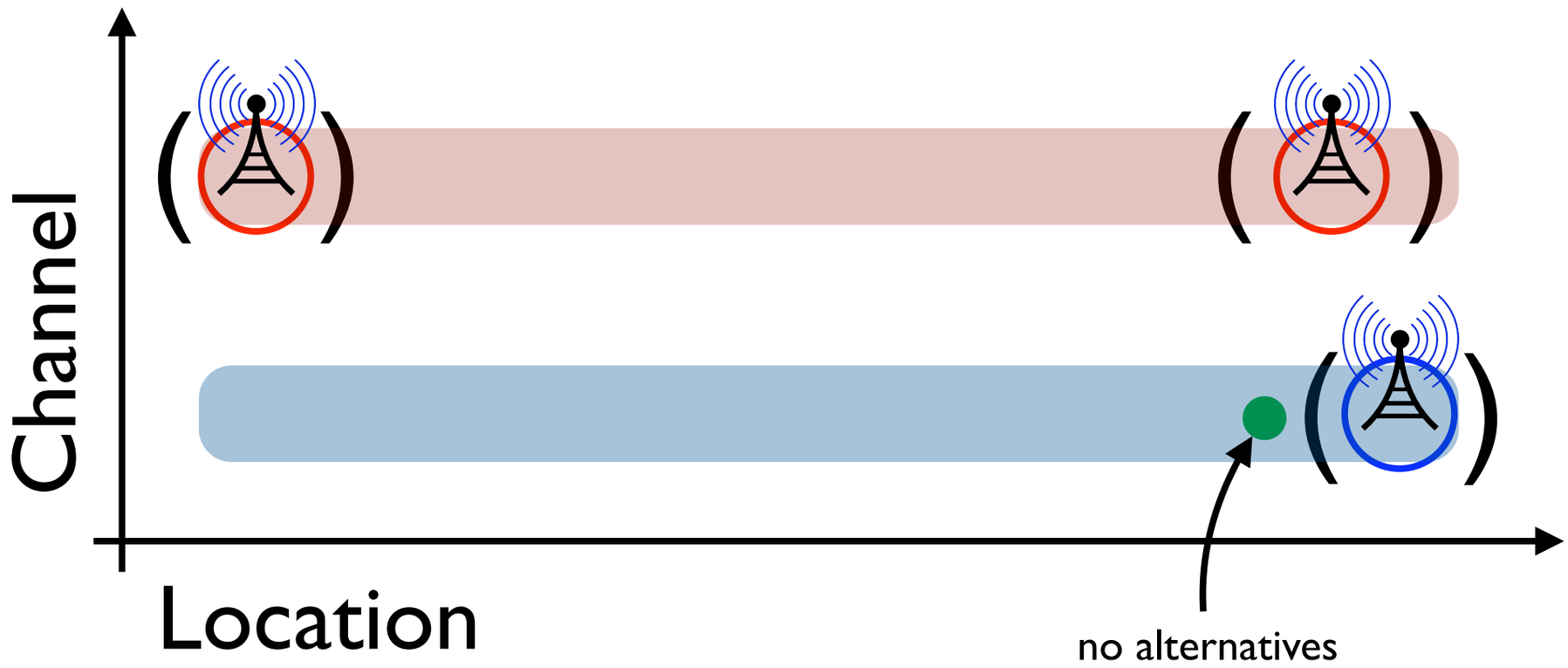

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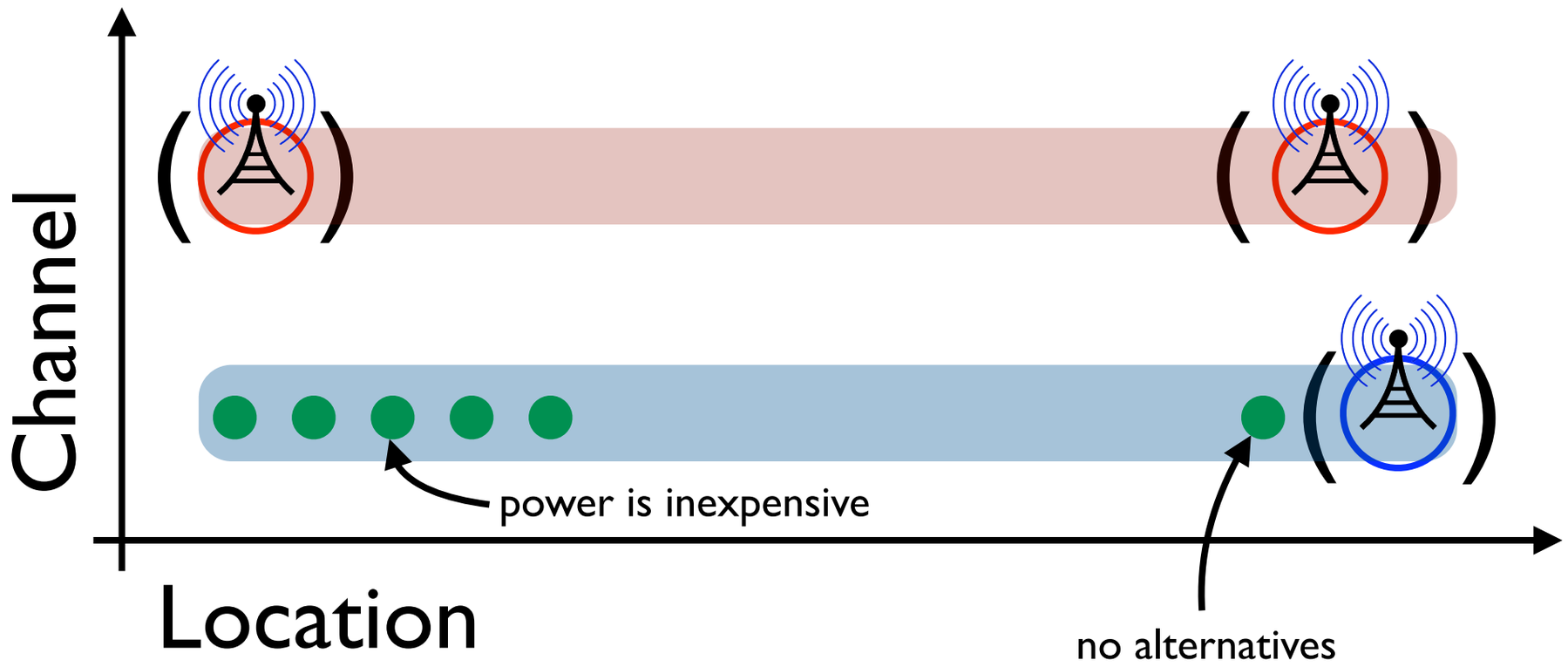

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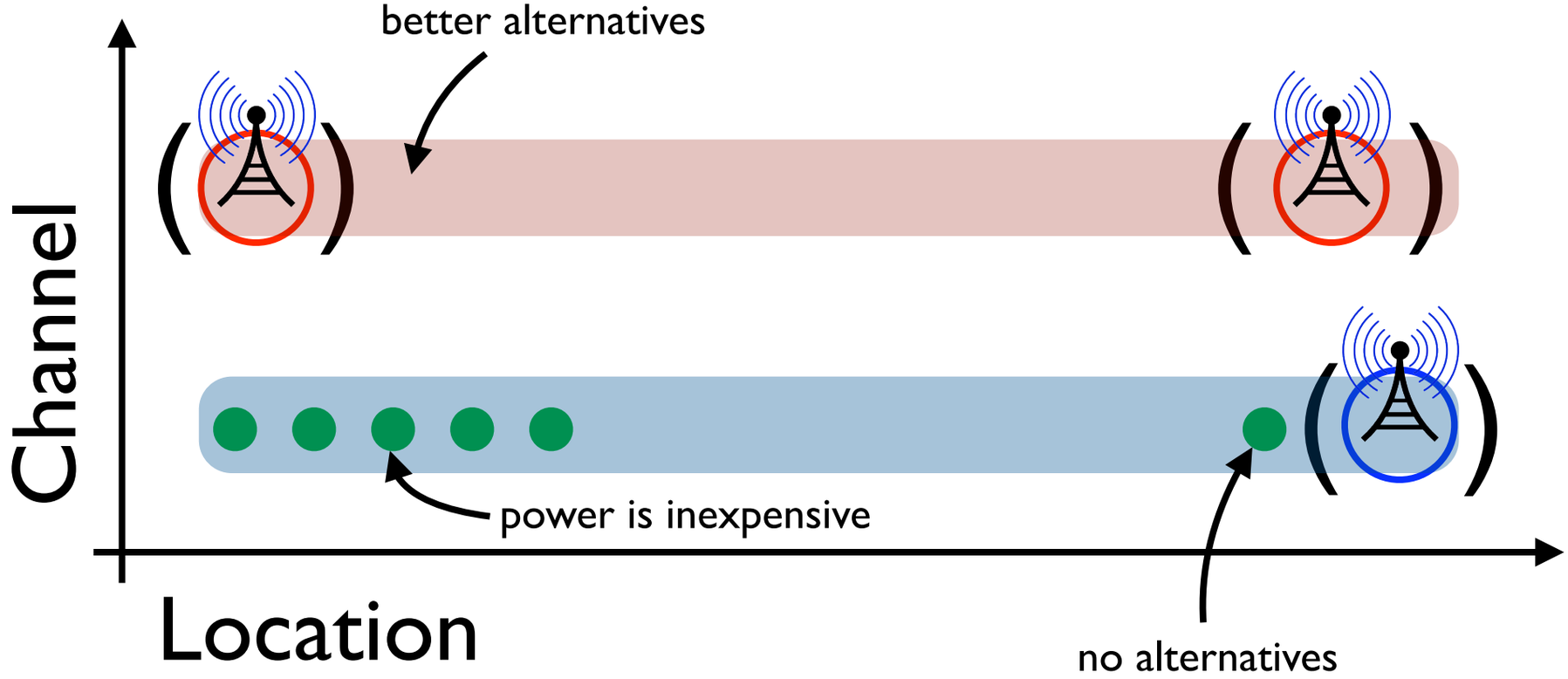

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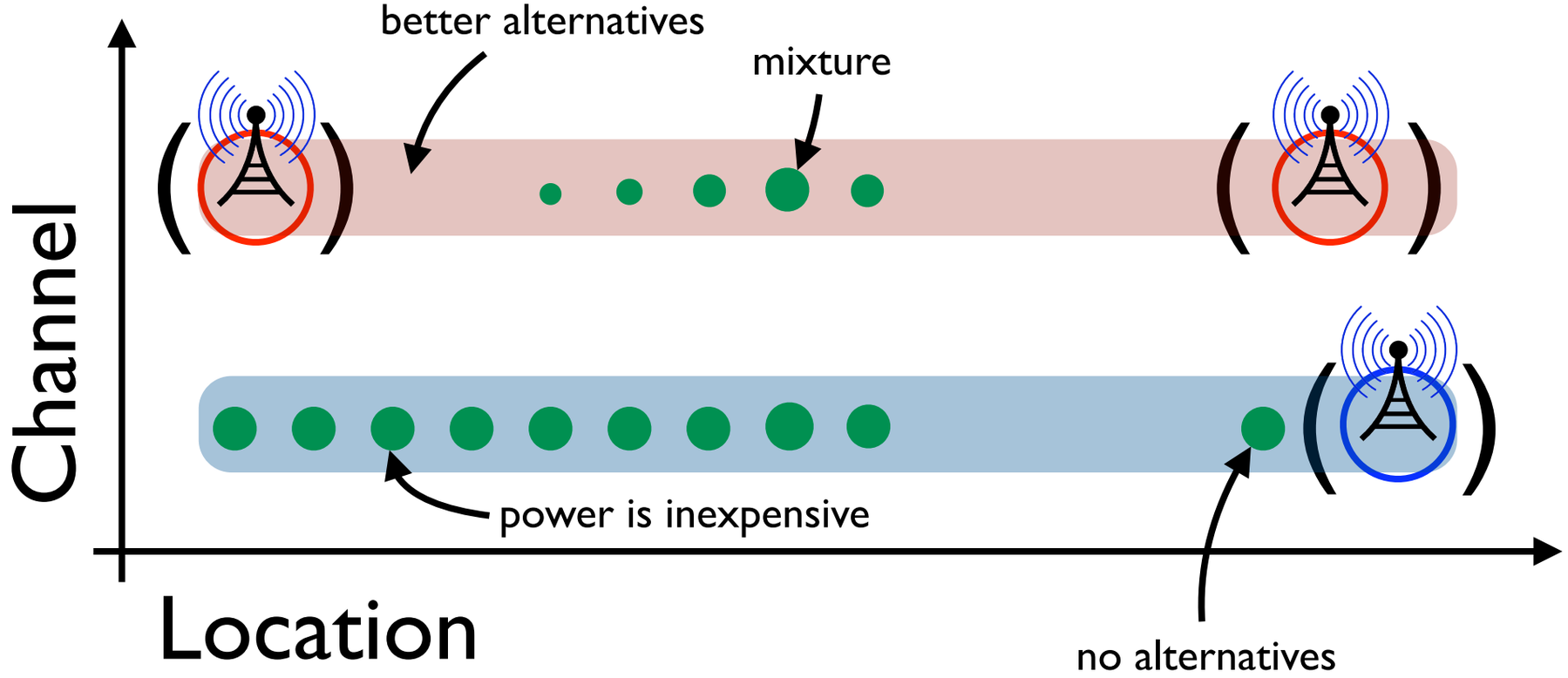

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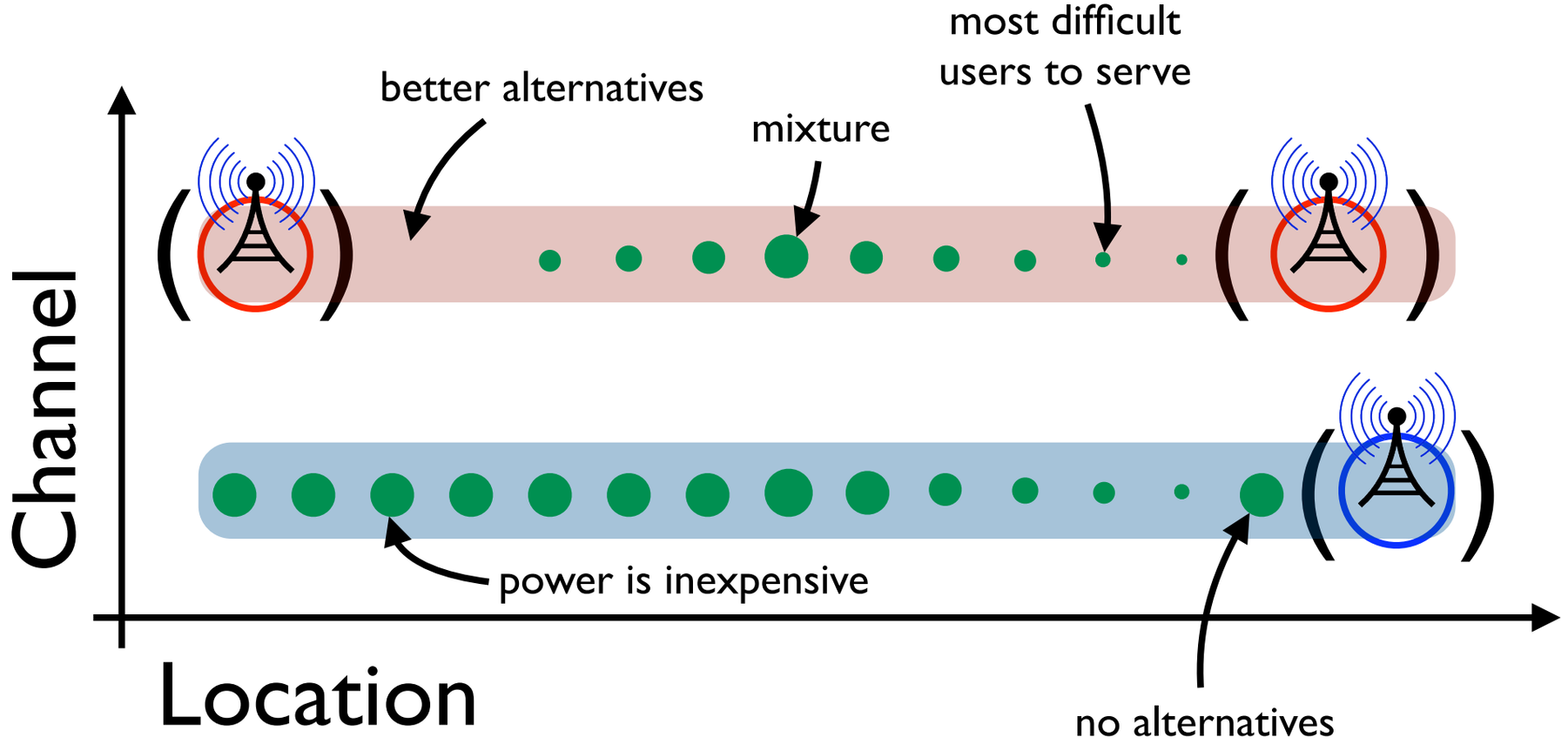

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Practical problems with trading

Many participants

TRANSACTION COSTS

Constraints on devices

Alternative to trading: databases++

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- Databases have near-global knowledge

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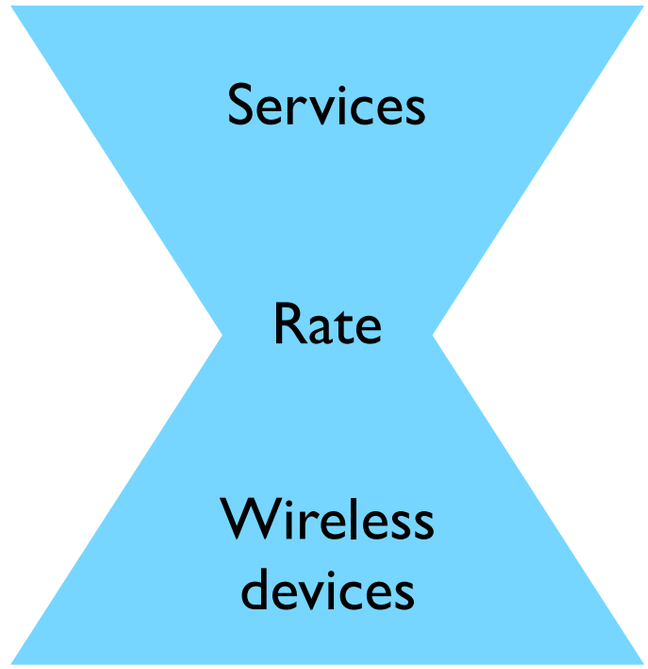
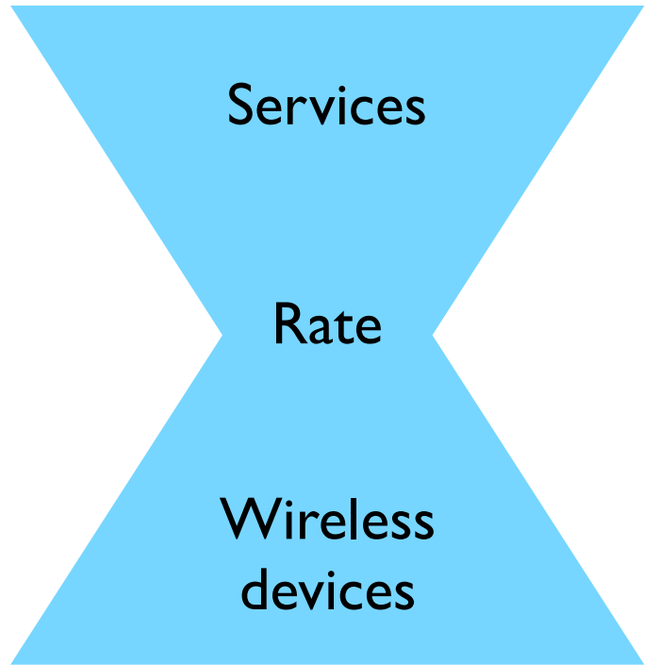
- WSDs have simple desires: data rate



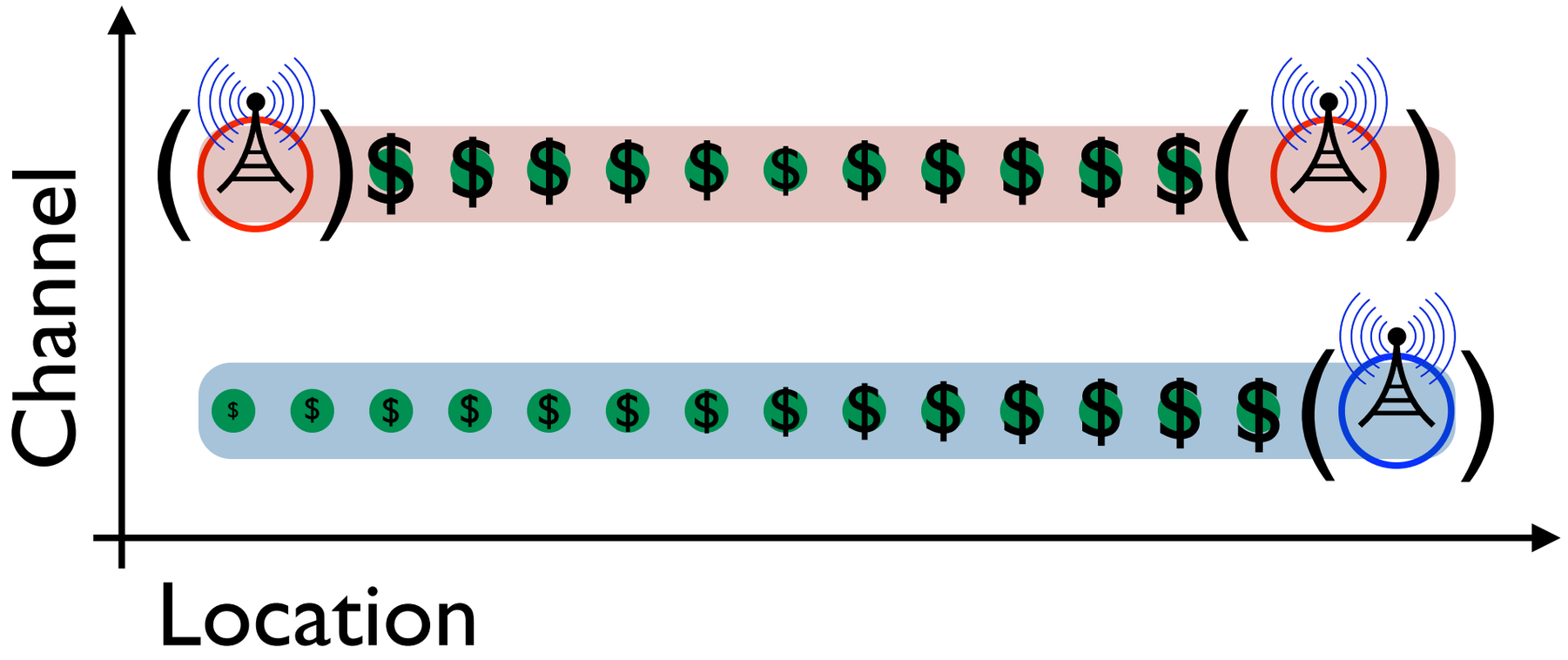
Alternative to trading: databases++

- Databases have near-global knowledge
- WSDs have simple desires: data rate
- Goal: offer good *default*
  - Approximate trading solution via optimization of the greater good



What is the greater good?

maximize total power used



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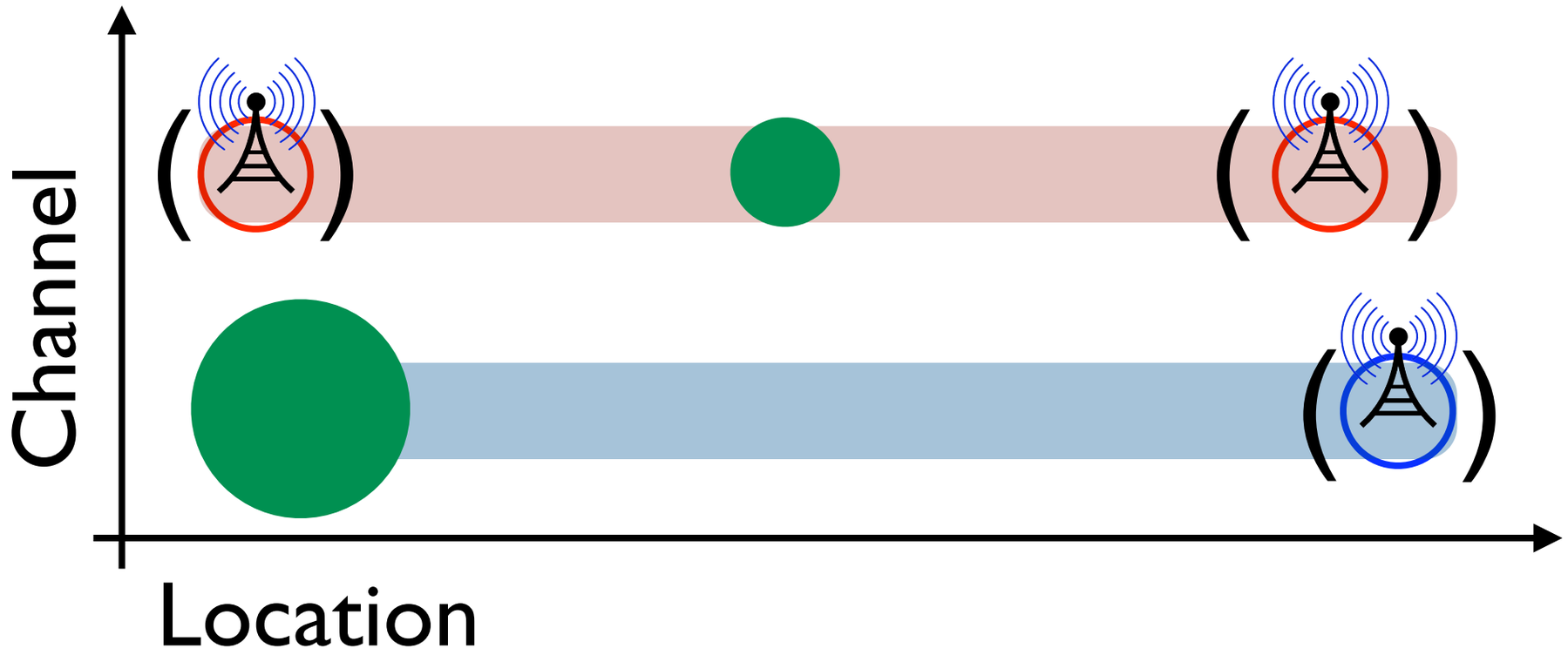

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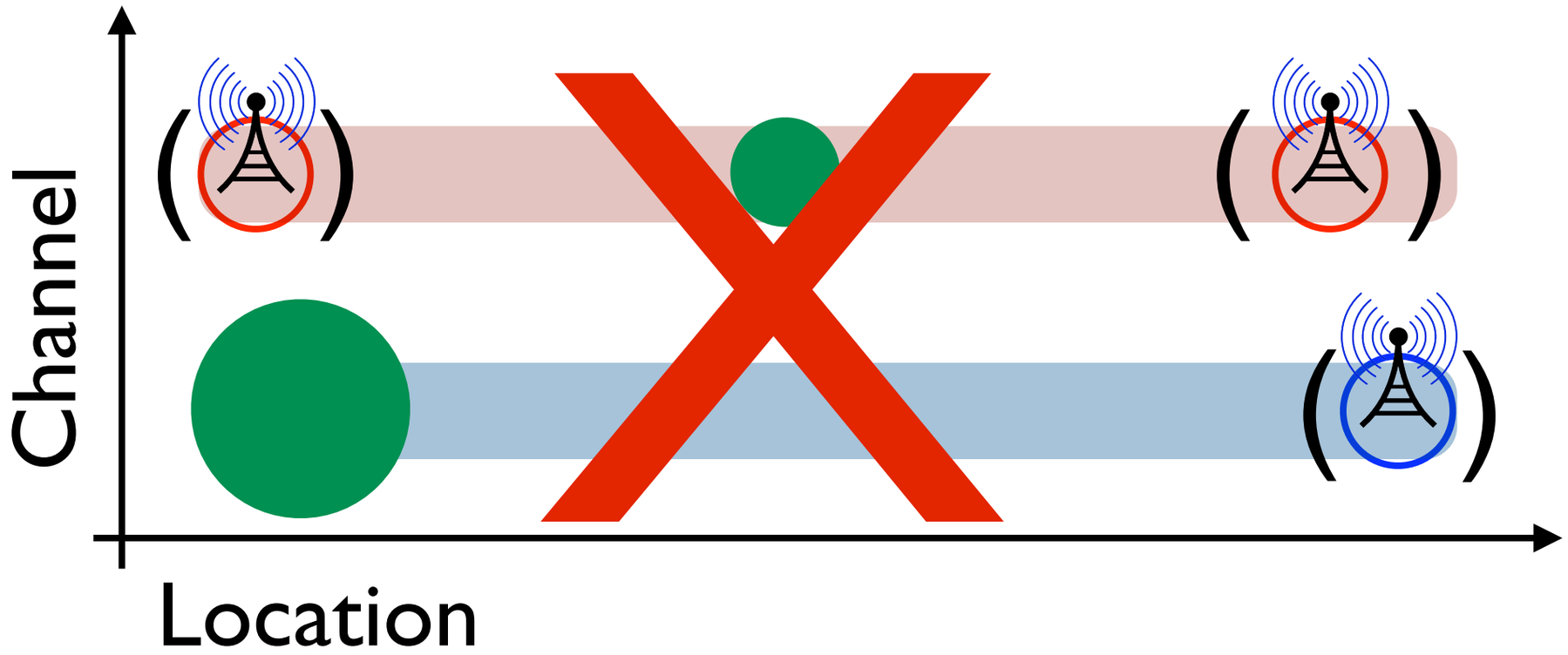

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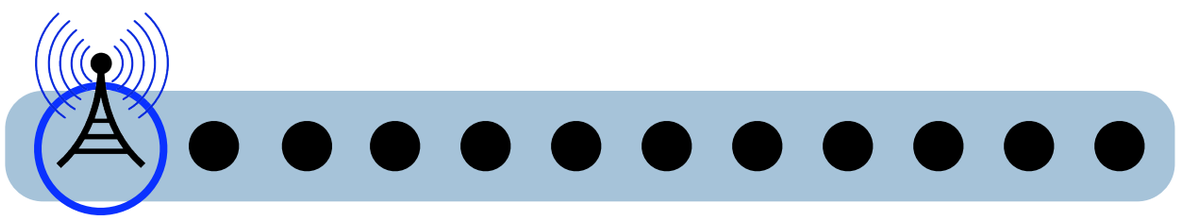
What is the greater good?

maximize average data rate



What is the greater good?

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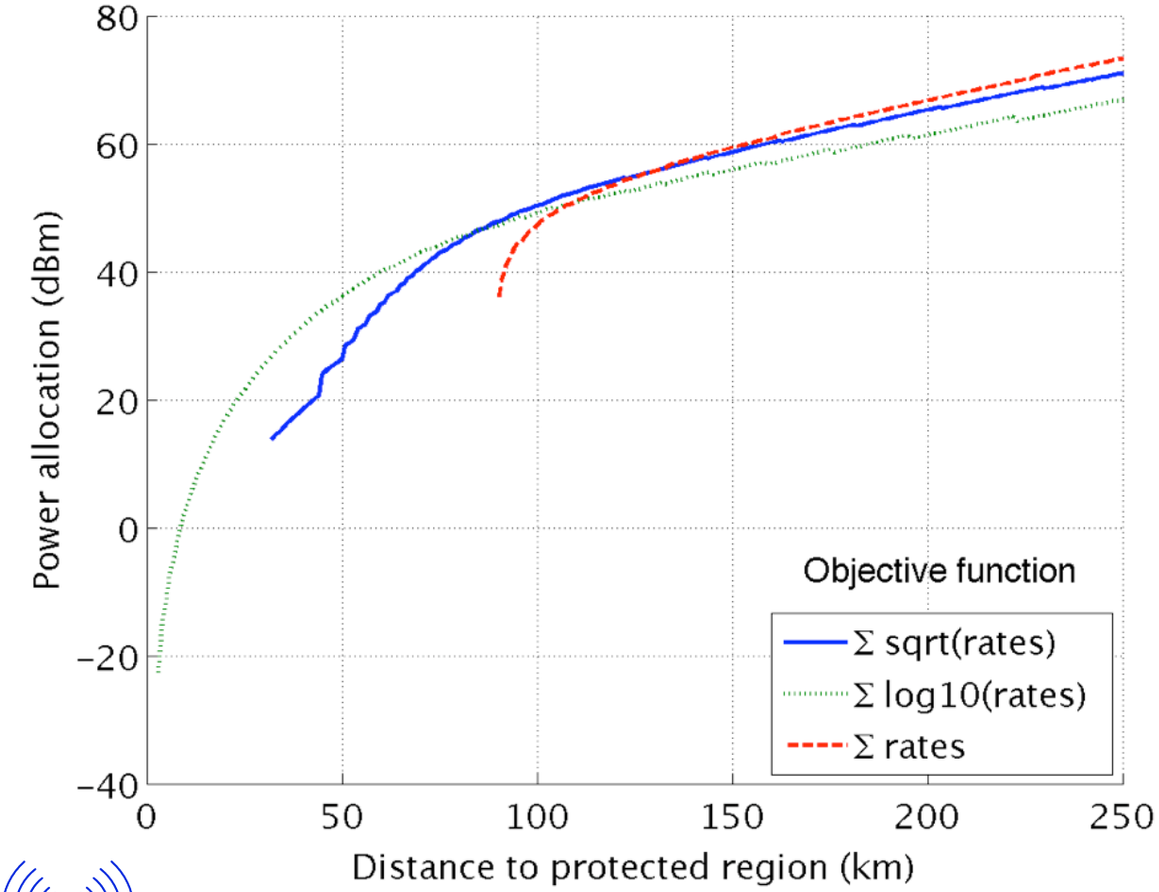
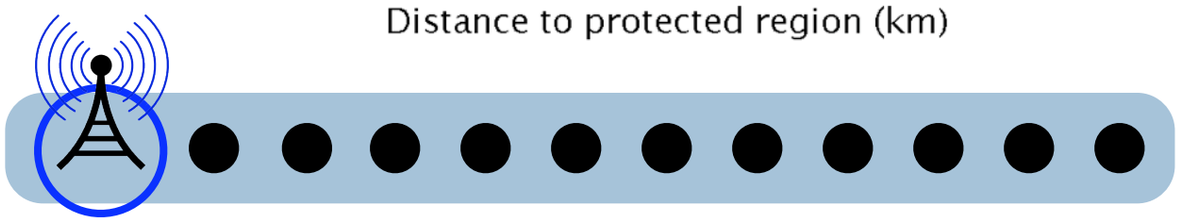
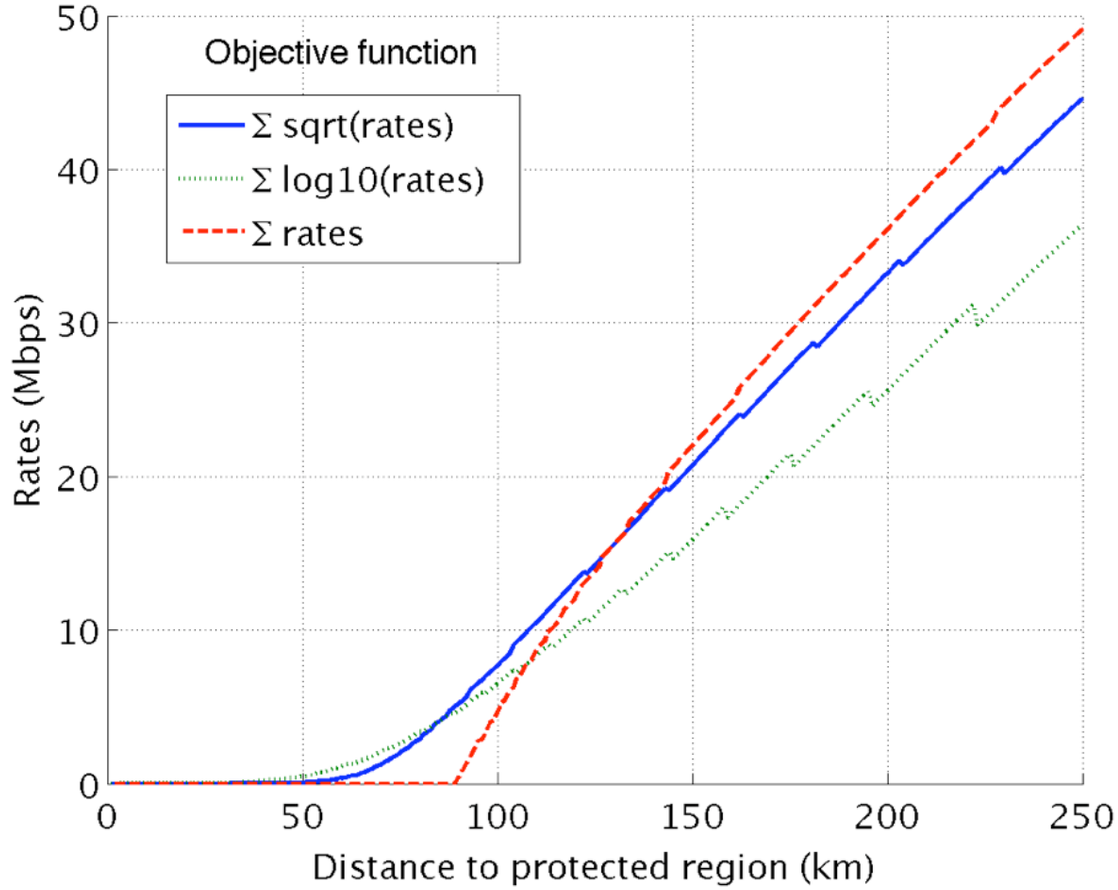
Power allocation





Data rate allocation



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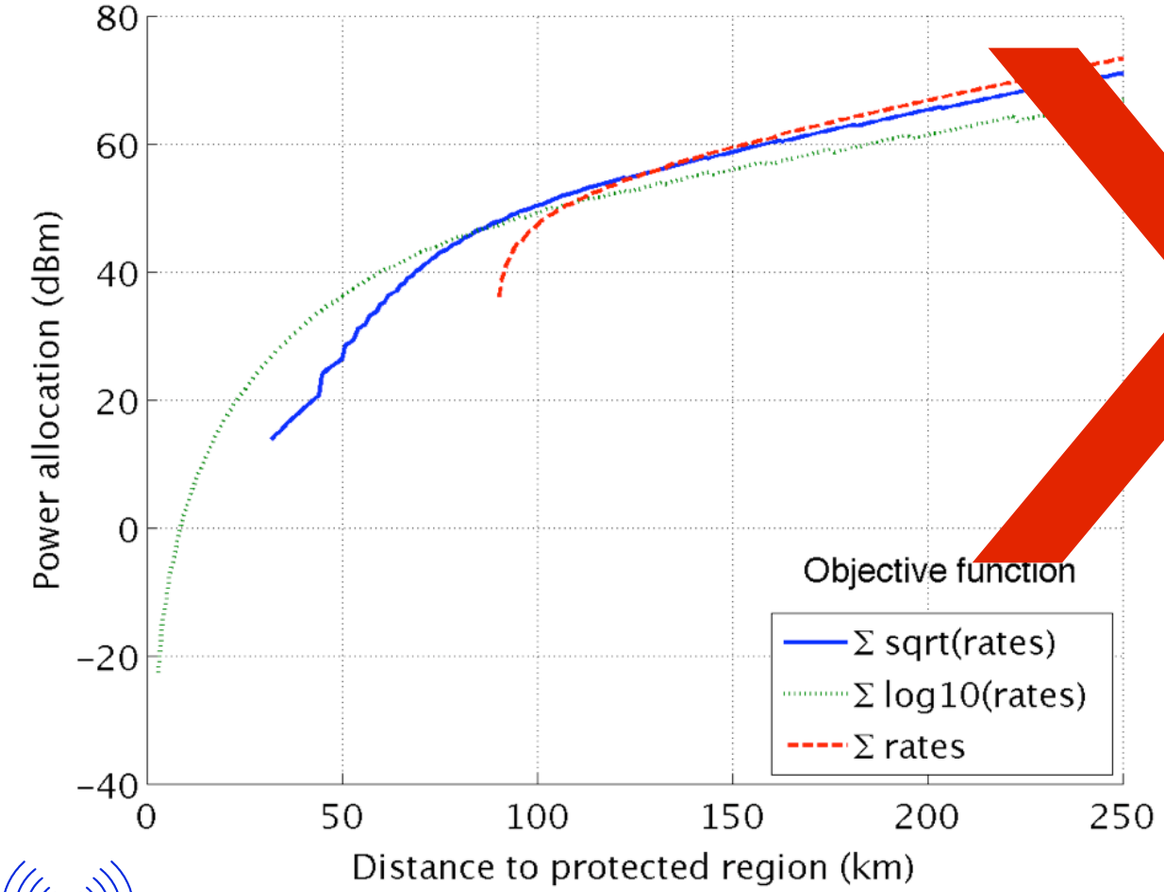

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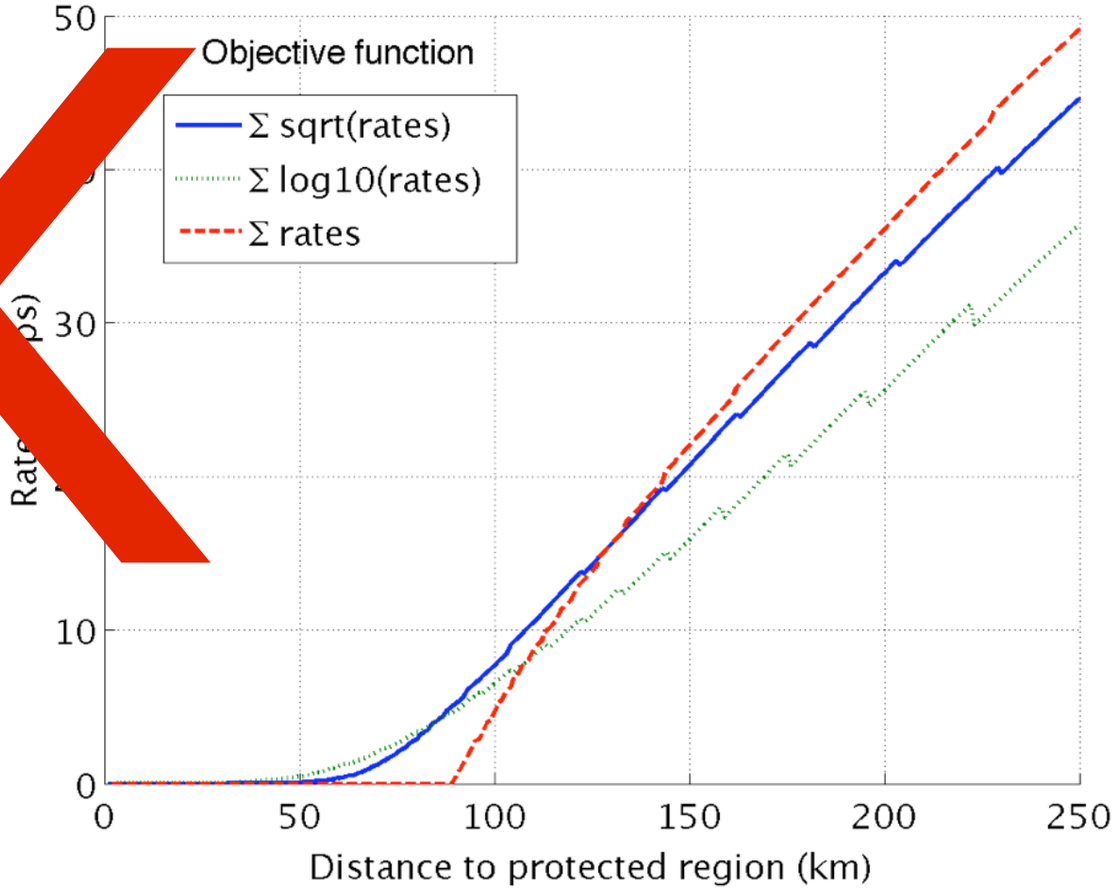

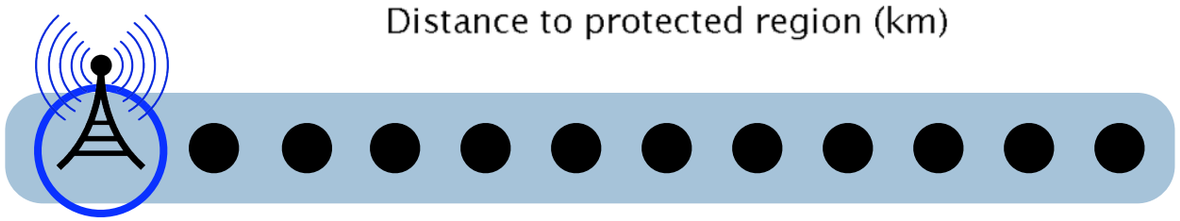

50+ km of wasted whitespace

What is the greater good?

maximize average data rate

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Homogeneous spectrum **Whitespace spectrum**

What is the greater good?

maximize average data rate

Homogeneous spectrum

- System-wide (sum) power constraint

Whitespace spectrum

- Weighted-sum power constraint (primary interference margin): *power cost depends on location*

What is the greater good?

maximize average data rate

Homogeneous spectrum

- System-wide (sum) power constraint
- Only self-interference

Whitespace spectrum

- Weighted-sum power constraint (primary interference margin): *power cost depends on location*
- Self-interference + noise from nearby TV towers: *power utility depends on location*

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maximize minimum data rate

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- Properties of the optimal solution:

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What is the greater good?

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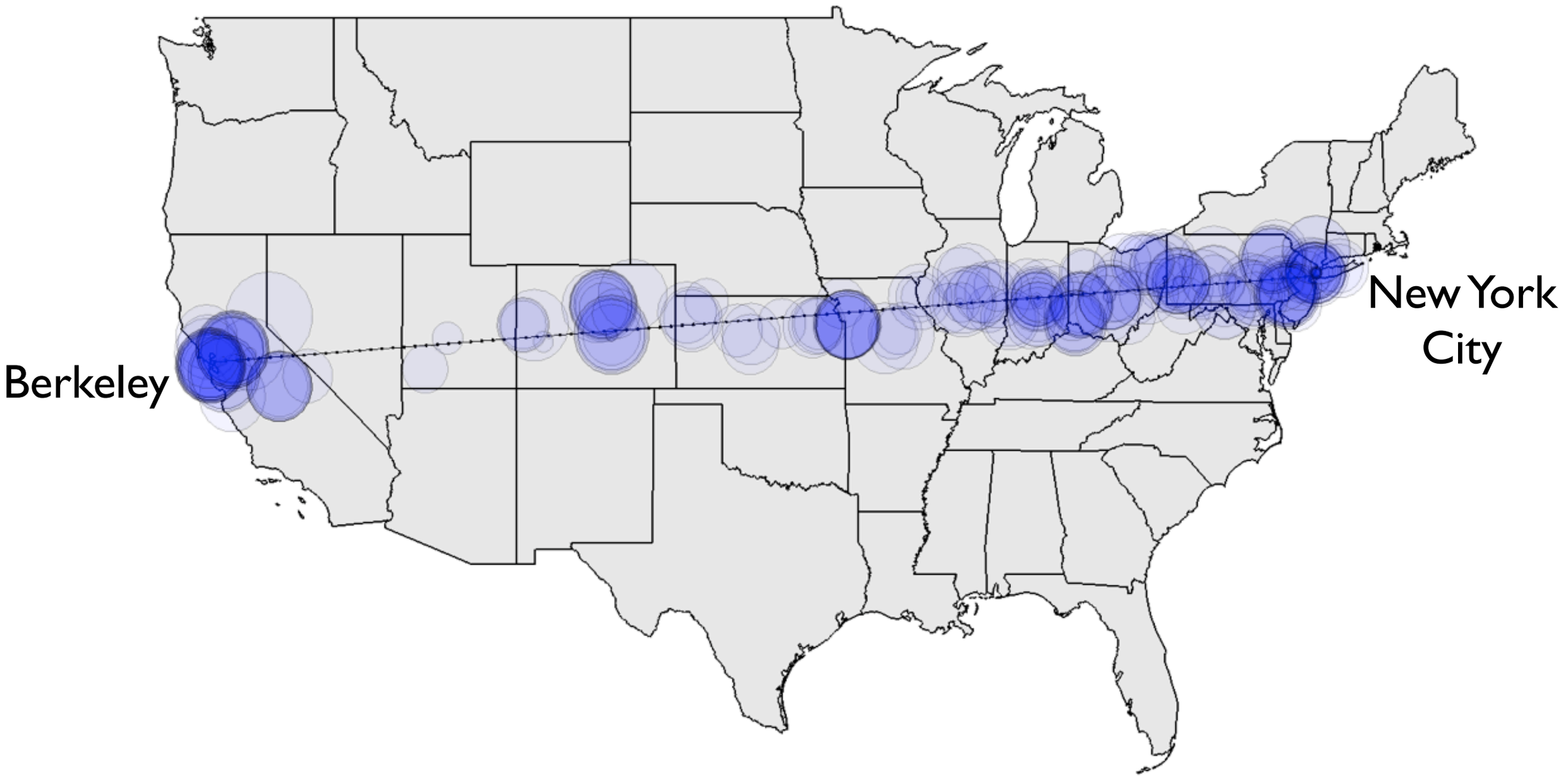
- Properties of the optimal solution:
  - Not a hard guarantee: can ignore locations which are unreachable
  - Guarantee power to even “expensive” locations
  - Use “inexpensive” power first

One-dimensional test in the United States



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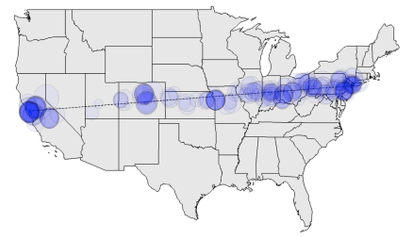
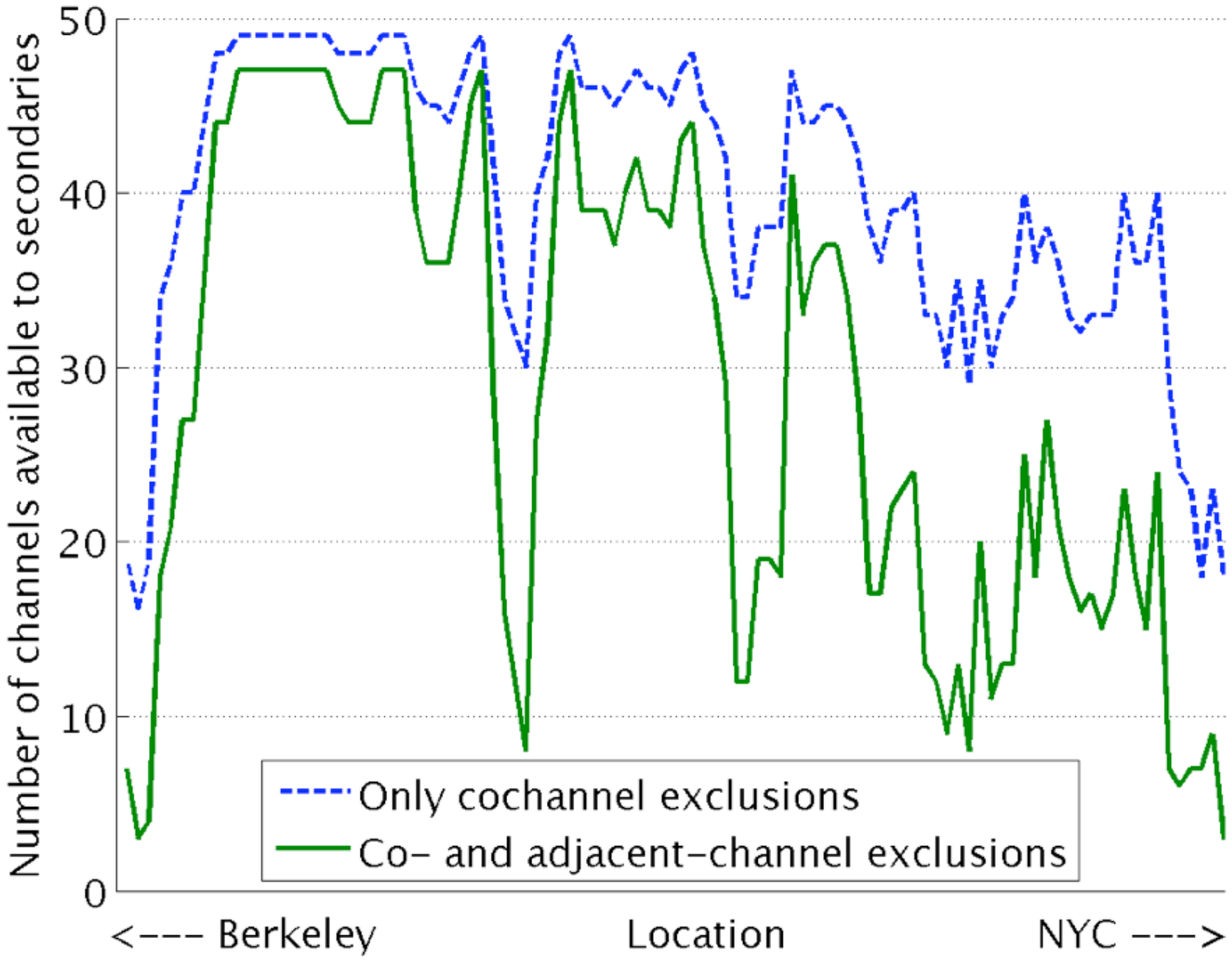
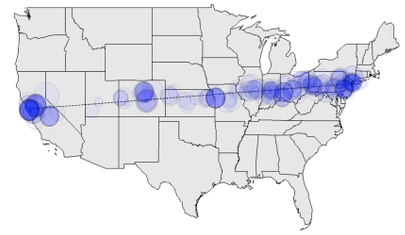


spectral variation



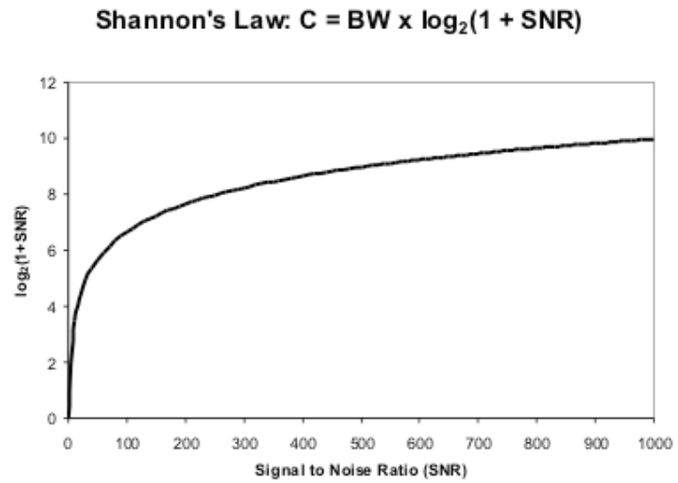
One-dimensional test in the *objective function*



total number of whitespace channels

data rate at location *l* on channel *c*

$$\max_{\text{powers}} \min_{l} \sum_{c=1}^{N_c} R_{l,c}(\text{power}(l))$$



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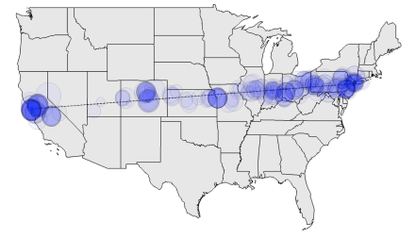


total number of whitespace channels

data rate at location *l* on channel *c*

$$\max_{\text{powers}} \min_{l} \sum_{c=1}^{N_c} R_{l,c}(\text{power}(l))$$

subject to:

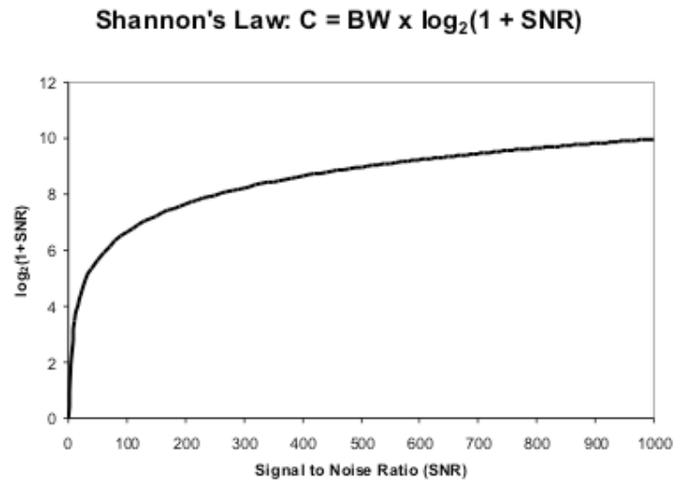
$$\sum_{l} w_1(l) \cdot \text{power}(l) \leq T$$

$$\sum_{l} w_2(l) \cdot \text{power}(l) \leq T$$

$$\vdots$$

$$\sum_{l} w_n(l) \cdot \text{power}(l) \leq T$$

aggregate interference constraints for each primary



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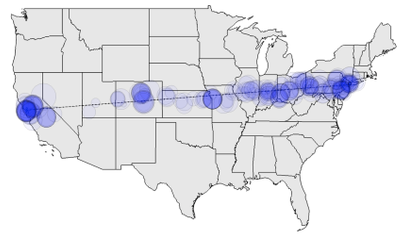
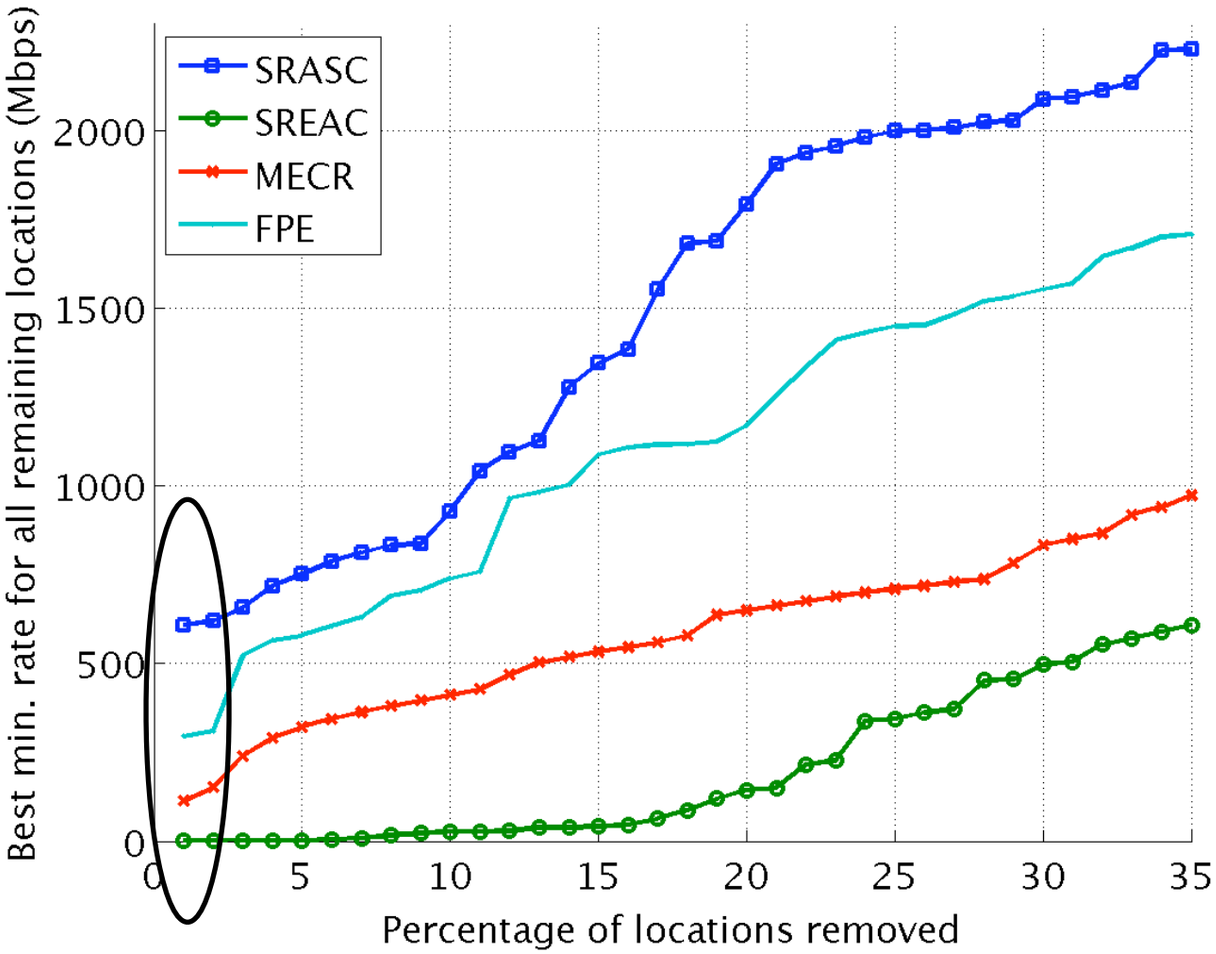
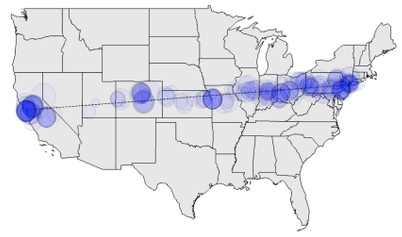


remove worst locations



	Freq. aware	Freq. unaware
Spatially aware	SRASC	MECR SREAC
Spatially unaware	FPMEQ (not pictured)	FPE

One-dimensional test in the



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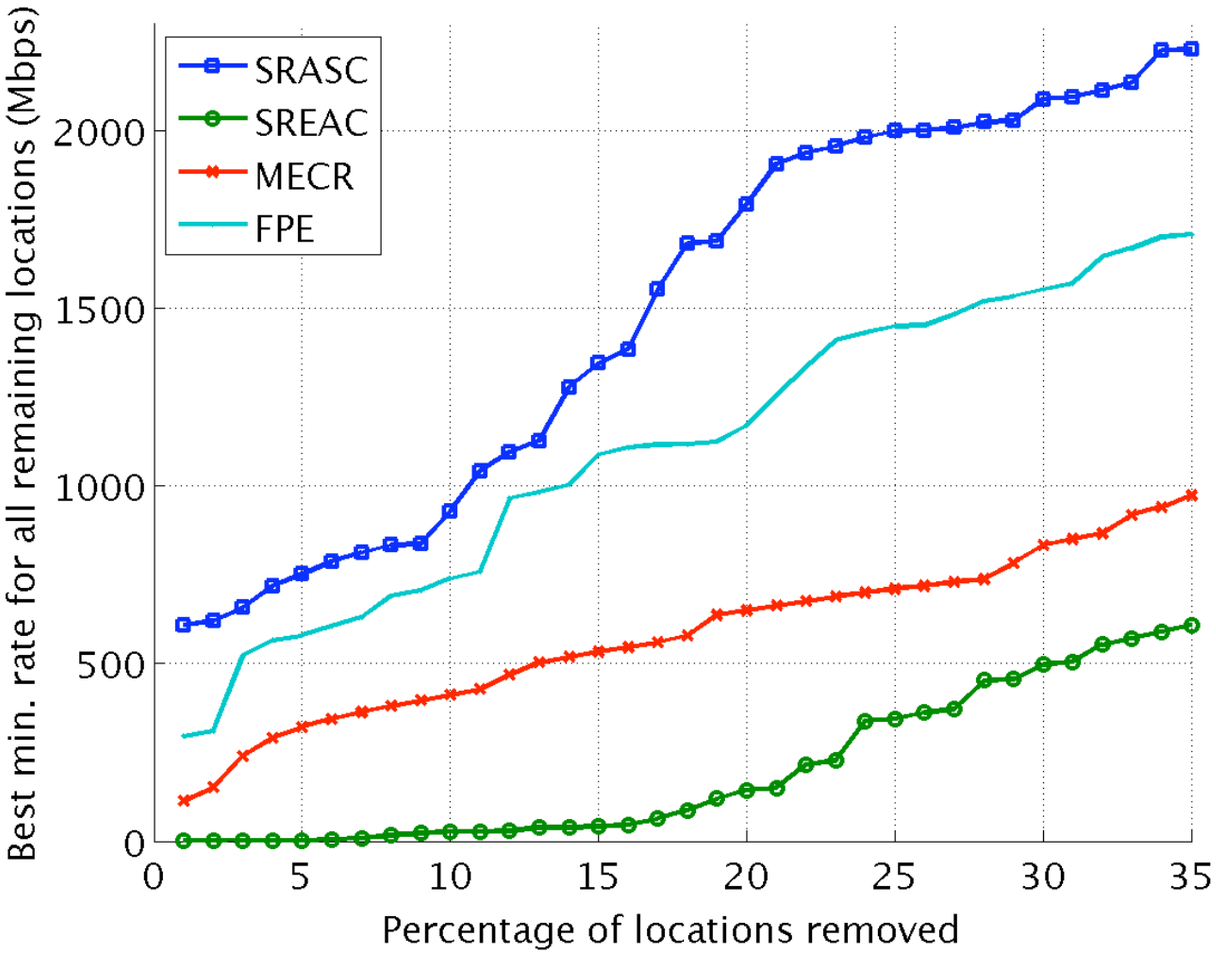

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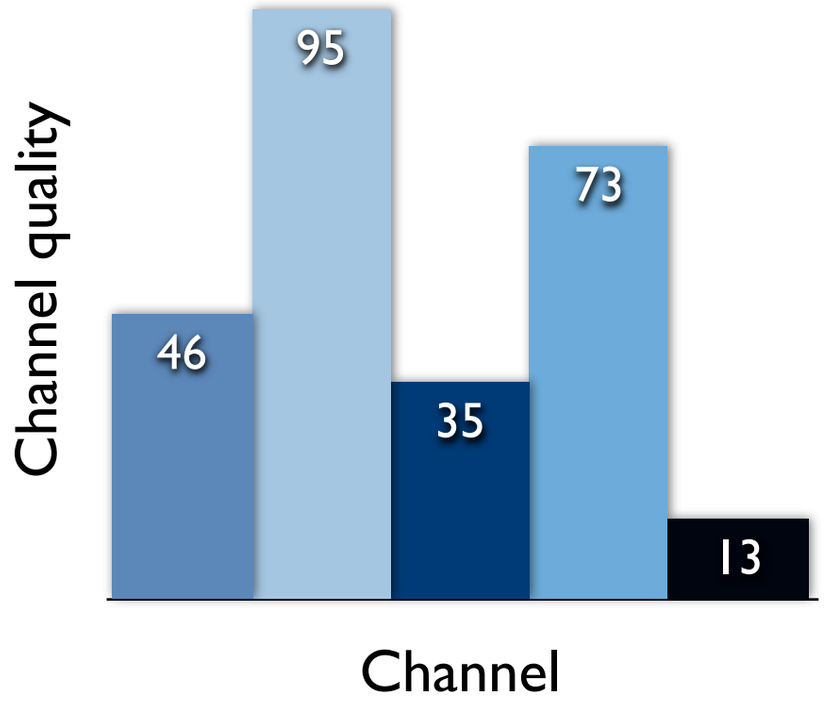
Conclusions



Databases + API

- Spectrum-as-a-service
- Real-time spectrum markets

Context awareness

- Evaluated in real-time
- Offer good defaults