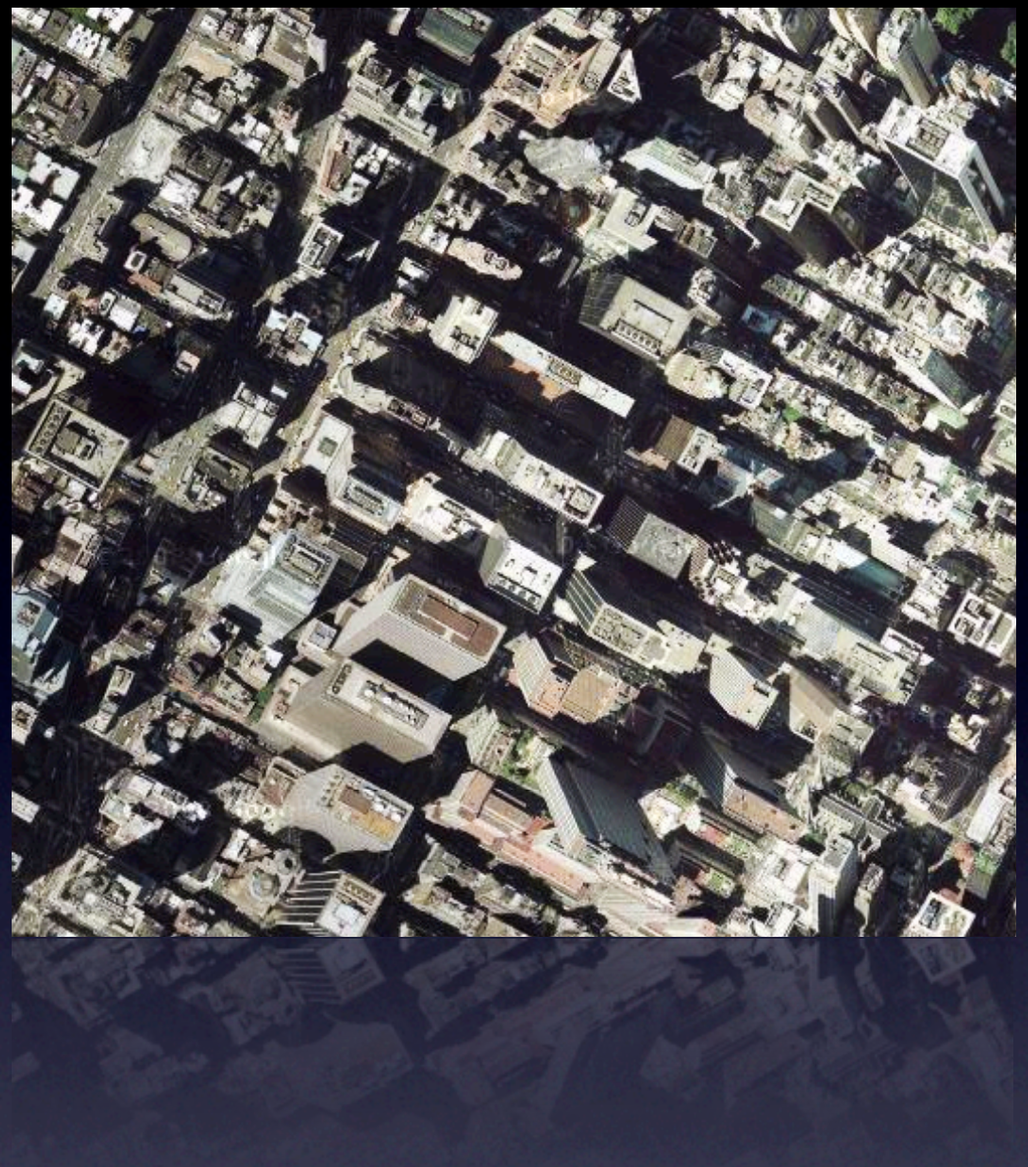

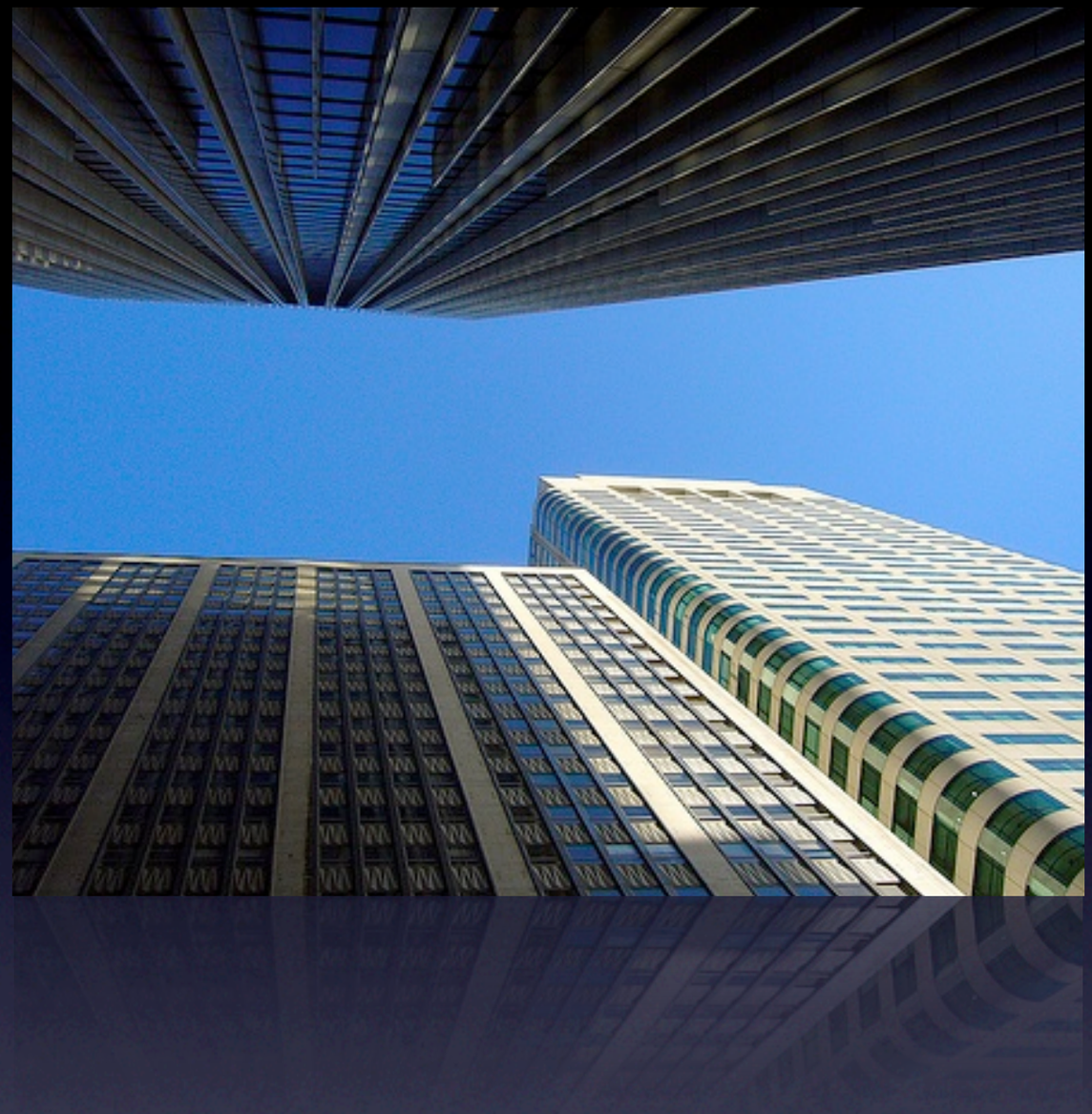

RF Propagation Environment Awareness

For Smart Mobile Ad-Hoc Networks

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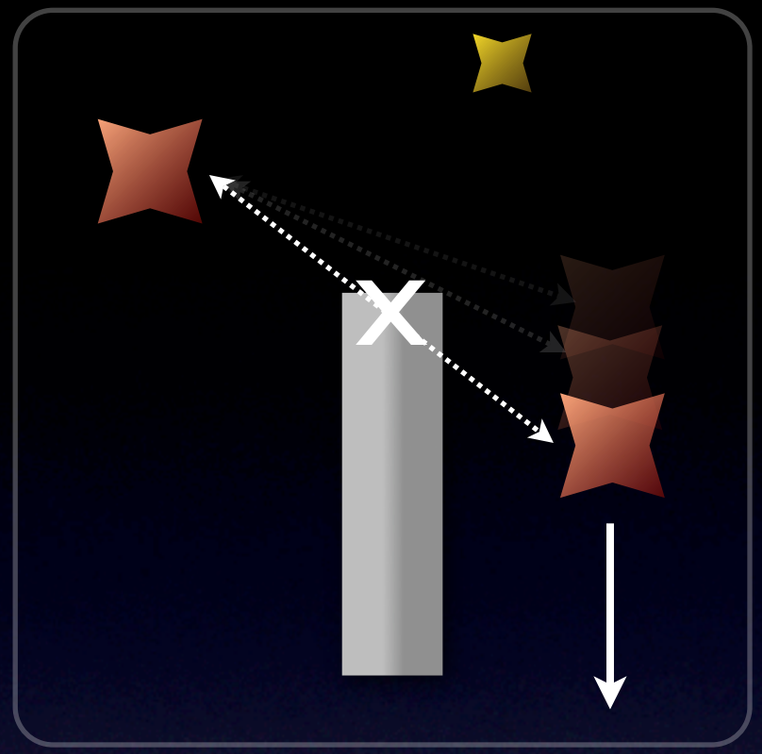
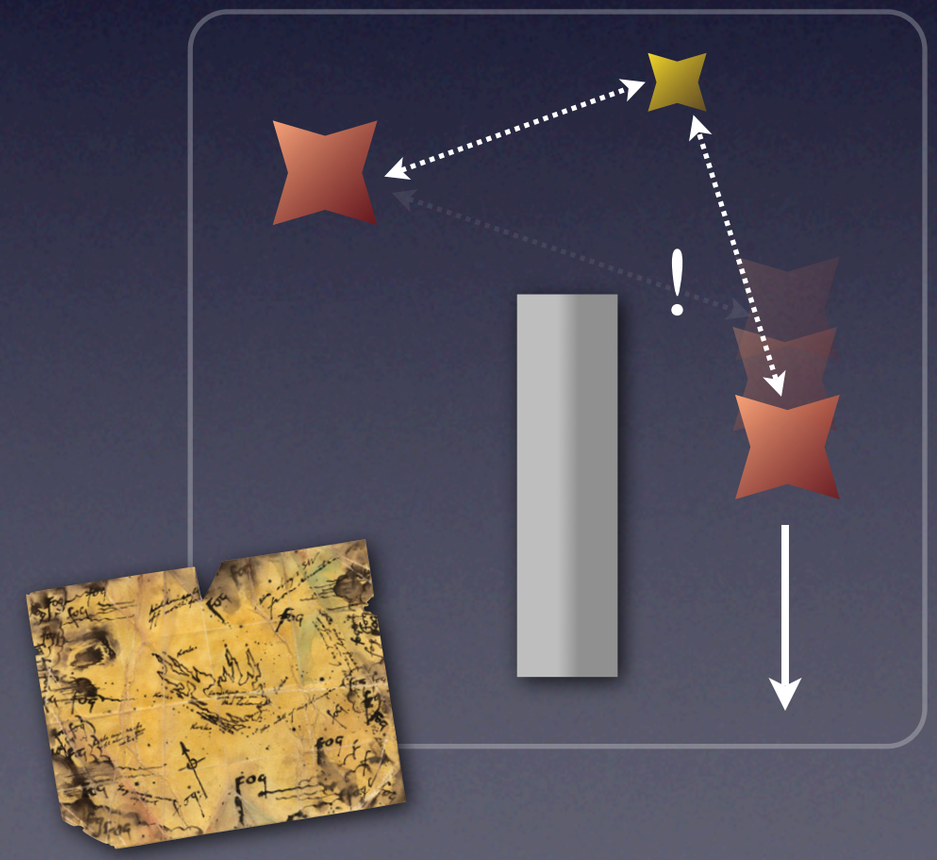
Dr. Carlo Kopp, MIEEE, SMAIAA, PEng

MONASH University

Goal: Optimisation of network operation in urban and suburban environments



RF Propagation Environment Awareness (RPEA) stores and exploits local *propagation geometry* information.



Overview

- Background: Network operation in urban environments, shadowing, MANET
- RF Propagation Environment Awareness (RPEA); Prediction
- Profiling the utility of RPEA

Urban Environments

Little line-of-sight connectivity available: *Shadowing* by objects

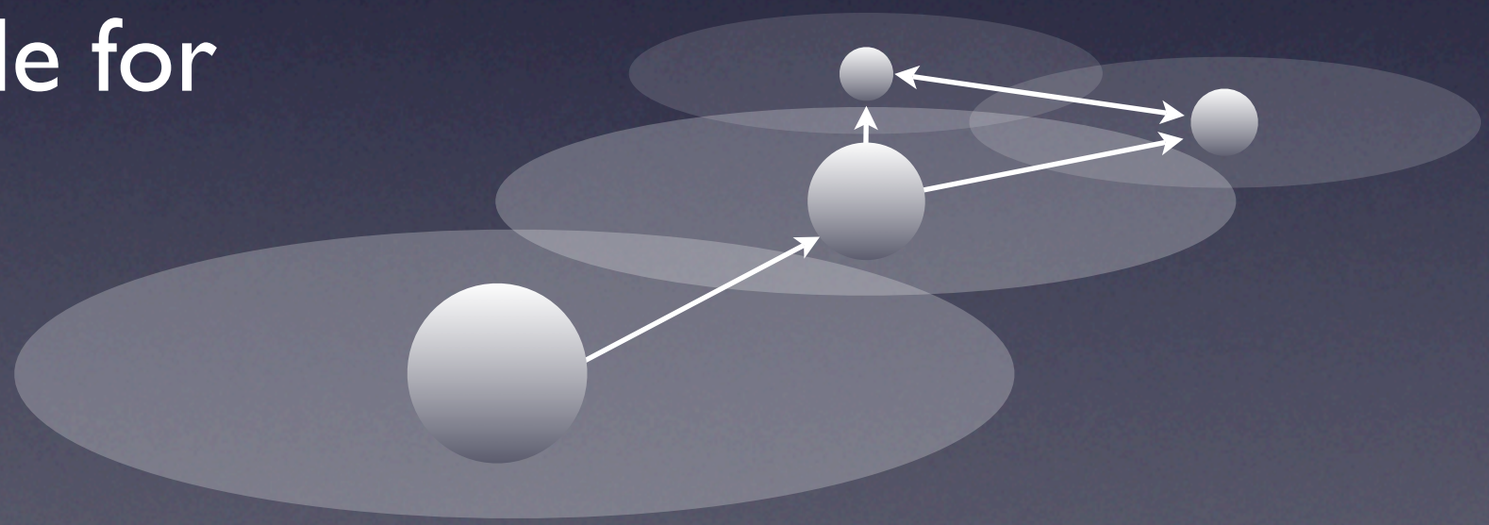
Traditional solutions involve airborne or satellite relay station overhead: *Expensive, possibly infeasible*

Urban Environments

Civilian solutions: Extra network infrastructure, taller masts, higher power/ gain equipment. *Expensive, typically infeasible for operational military environment*

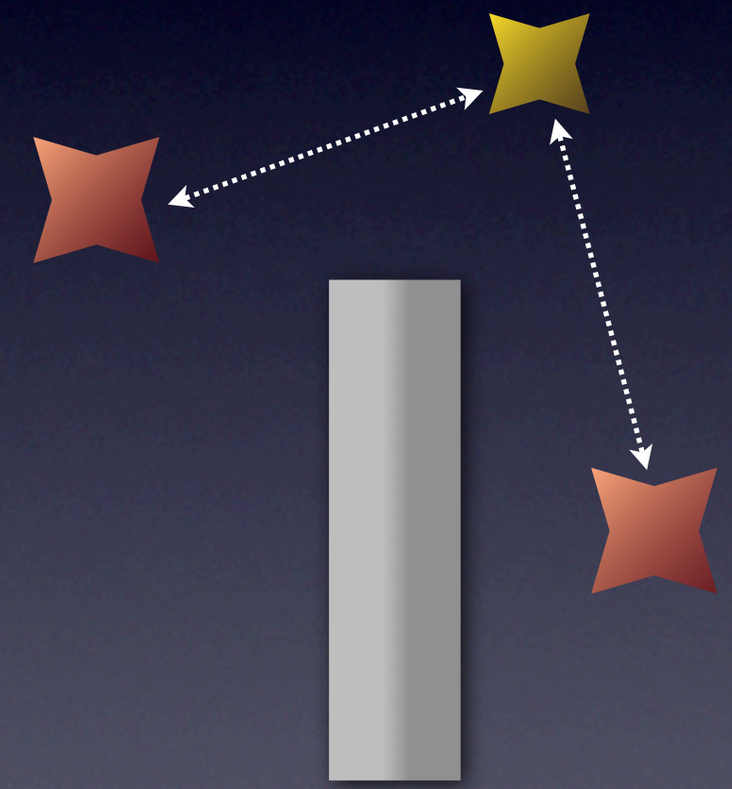
Ad-Hoc Networks/MANET

- Self-forming, self-healing
- Network participants (nodes) form infrastructure
- Mobile Ad-Hoc Networks (MANET) provide for movement



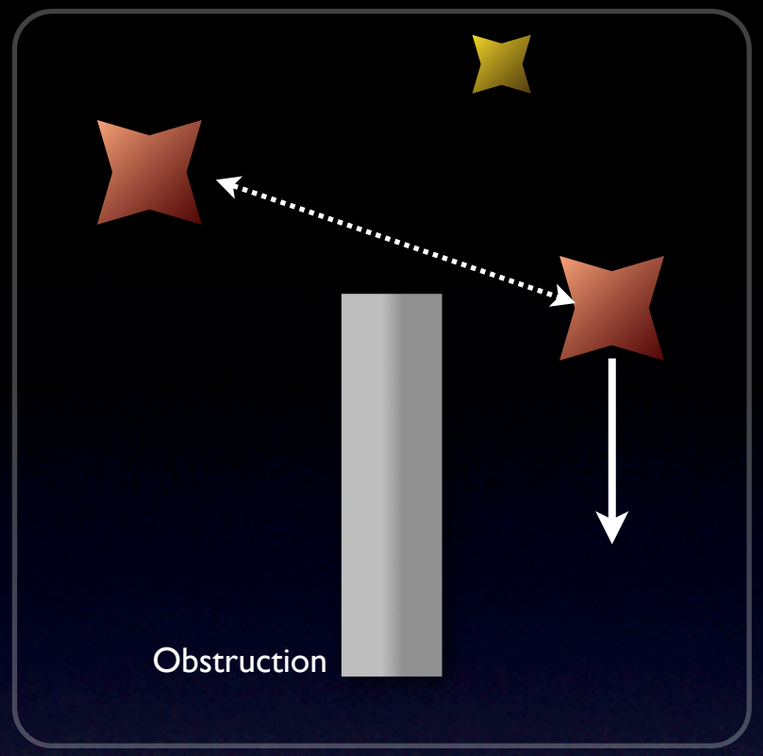
MANET in Urban Environments

Multi-hop links - line-of-sight unnecessary if alternate path available

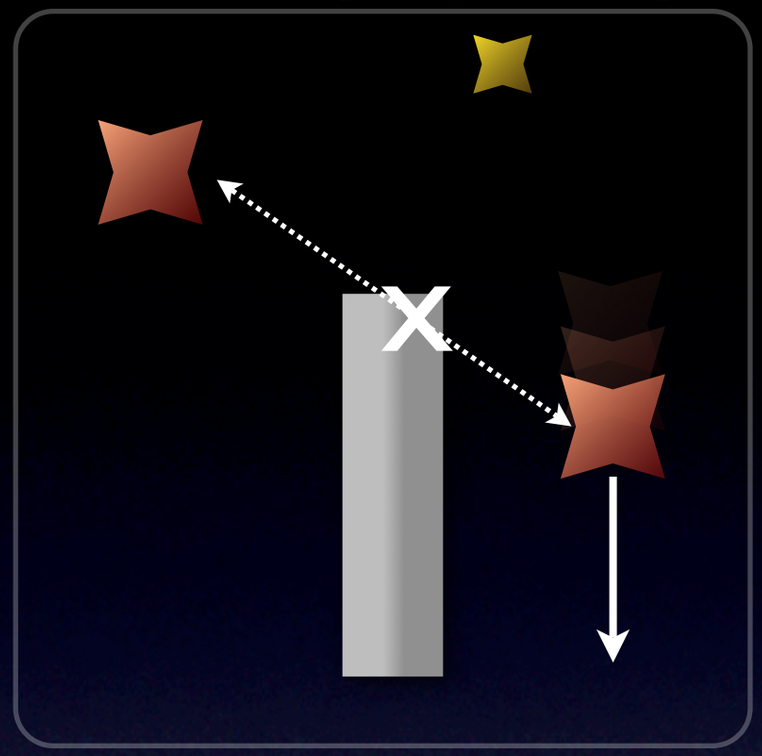


Movement causes **unpredictability** - drop-outs, while connection repaired with alternate path; Quality of Service difficult to provide

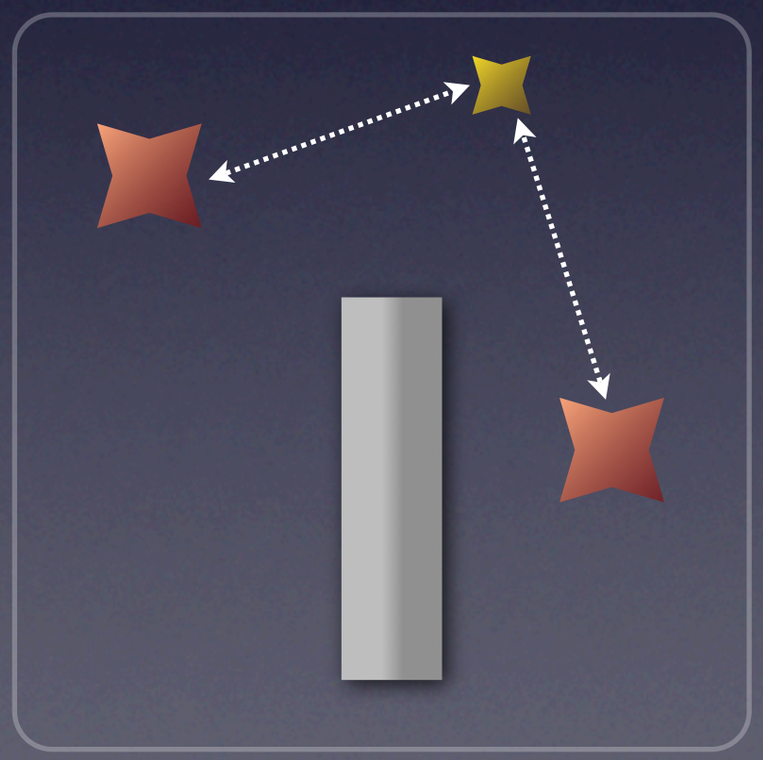
Communication



Shadowing impairs signal



Delay while searching



New route established

RPEA

Goal: Optimise network performance

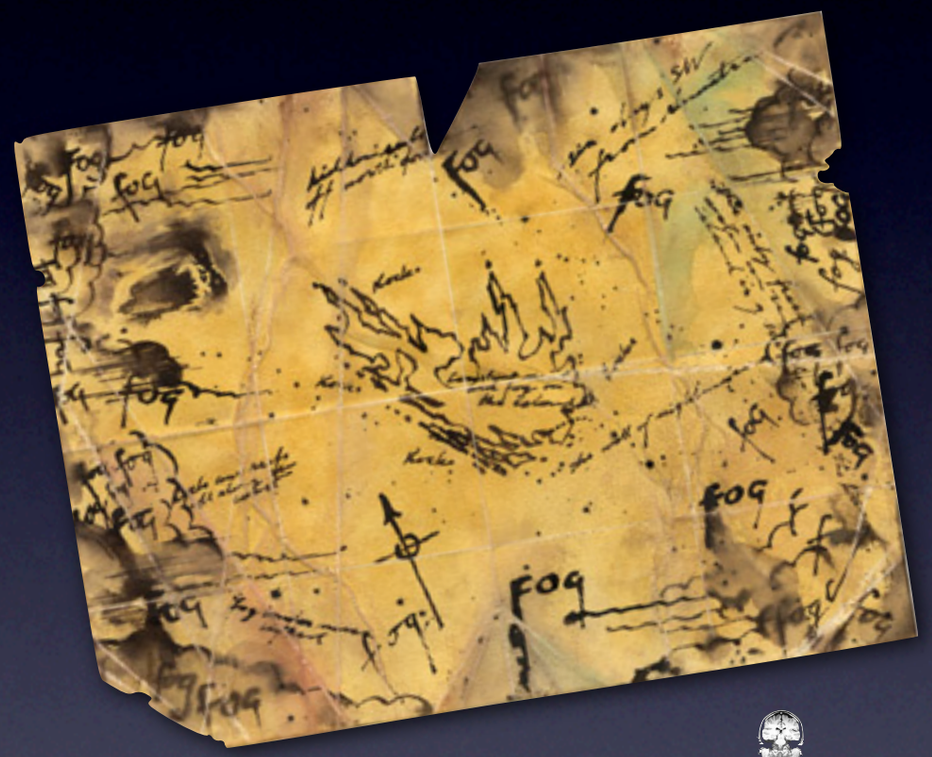
Avoid drop-out delays

Estimate link lifetime & reliability (QoS)

Better route selection and discovery

RPEA

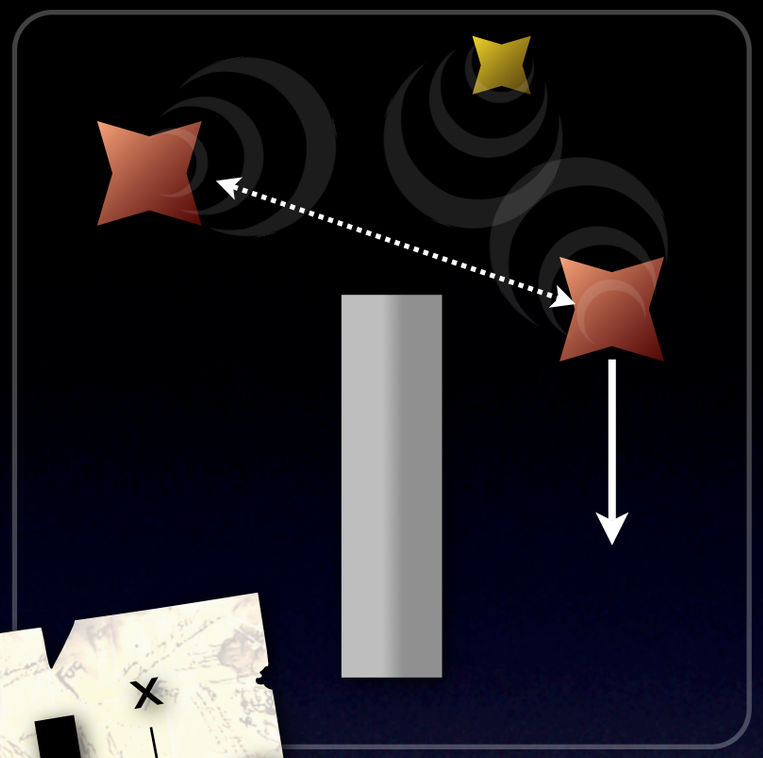
Build map of RF propagation environment by observing shadowing



RF propagation environment map
+ location information (GPS)
+ movement tracking/prediction

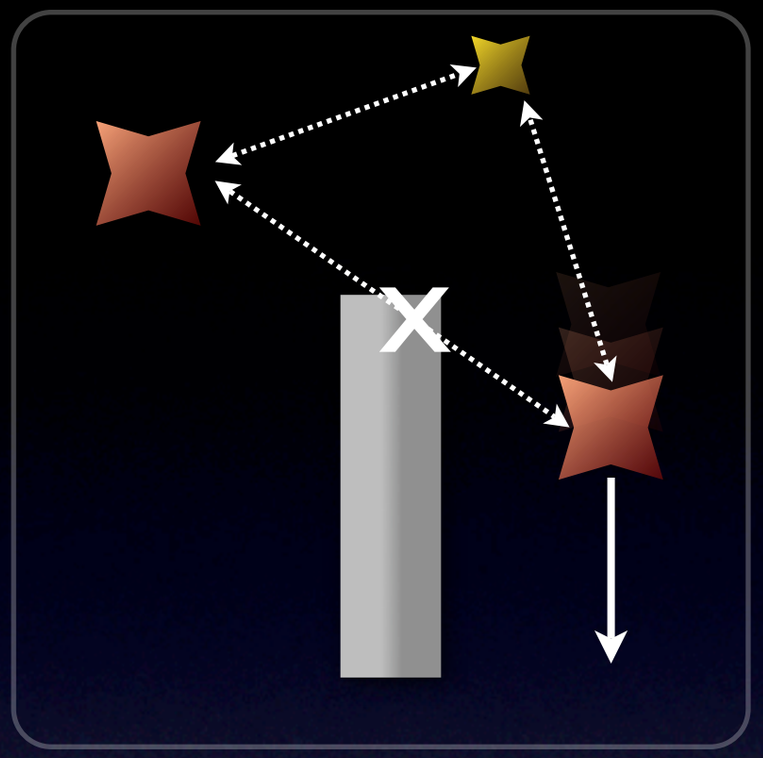
= *network state prediction*

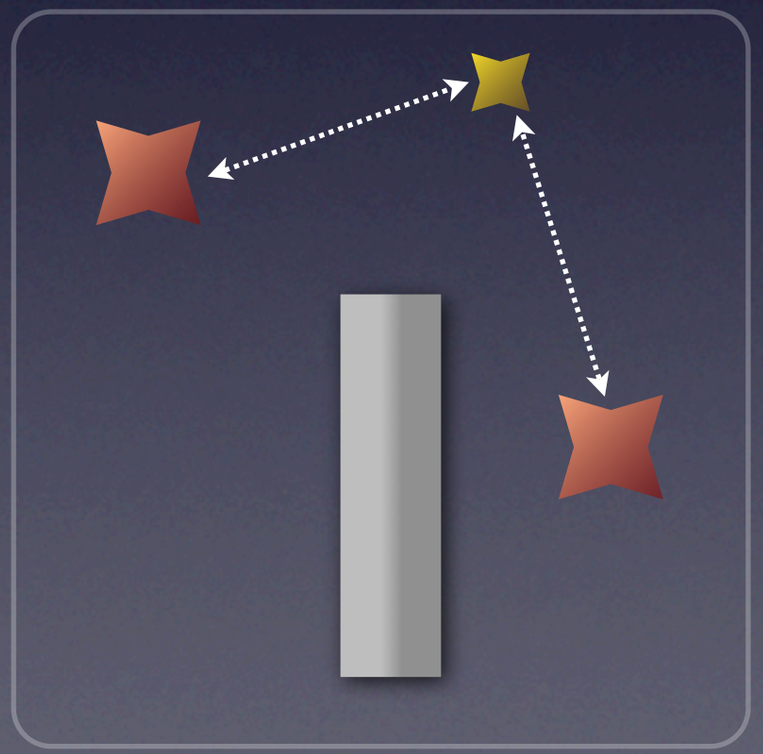
Communication



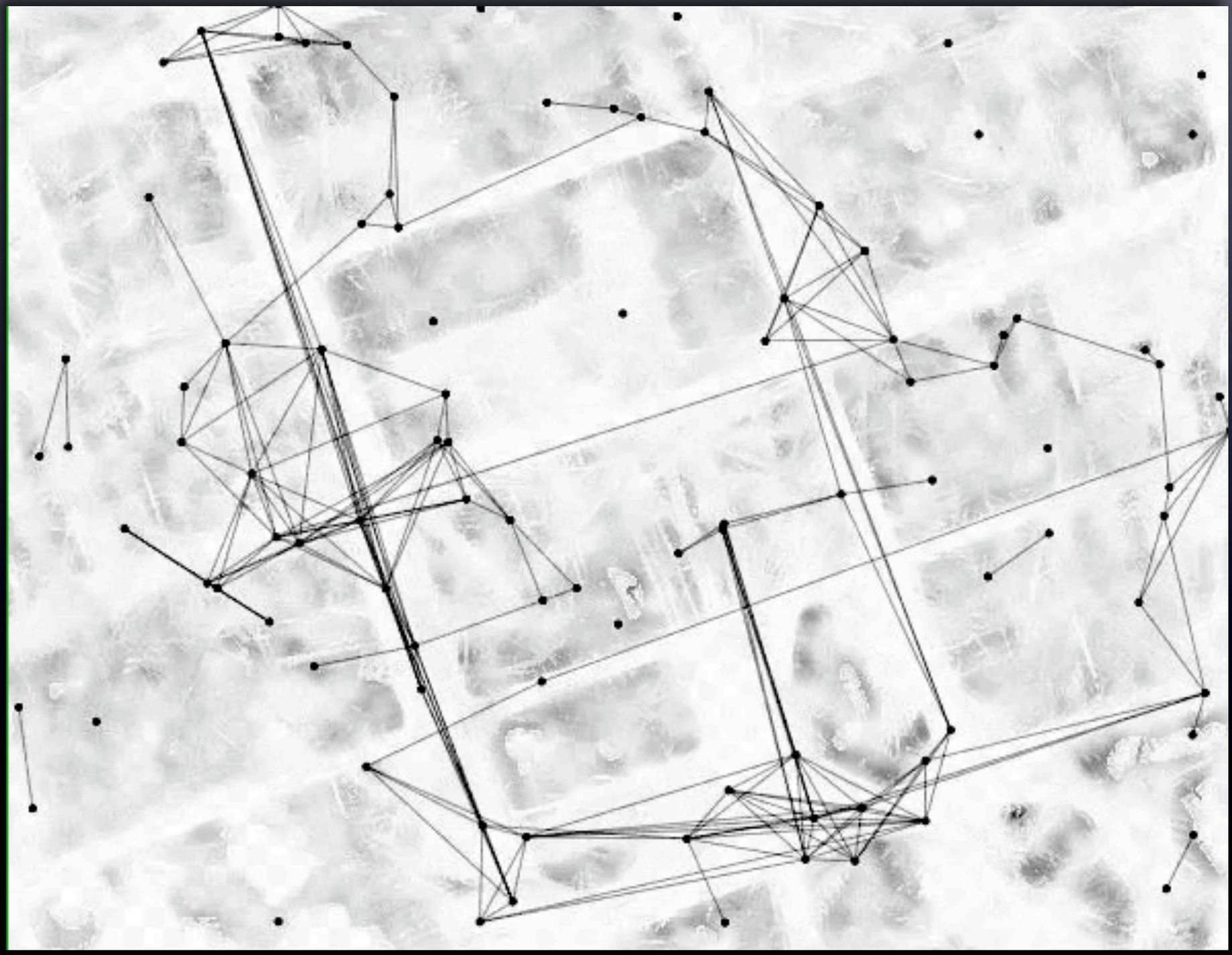
Map + location + motion indicates impending drop-out

Communication + search





Seamless switch to new path



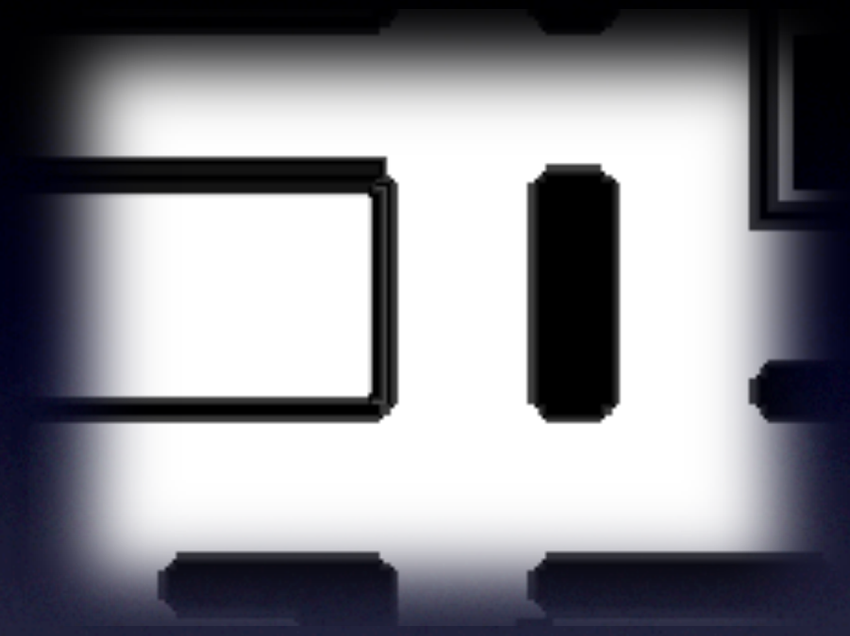
Assessing Utility of RPEA

RPEA Requirements:

- Build a map under normal operating conditions
- Predict feasibility of signal between two points
- Sufficiently accurate prediction to make reasonable decisions (> 50% correct)

Comparison

RPEA

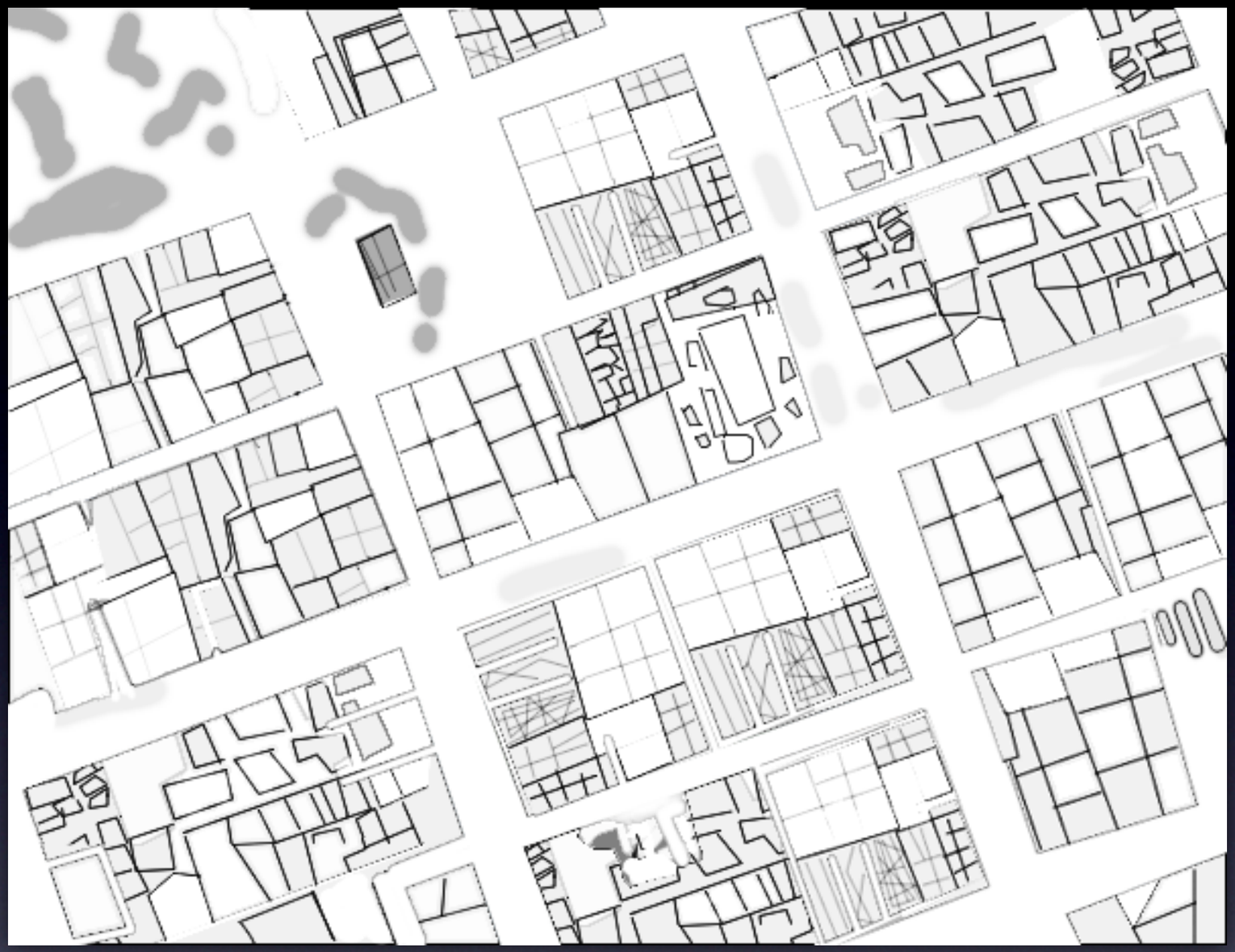


Friis free space path loss

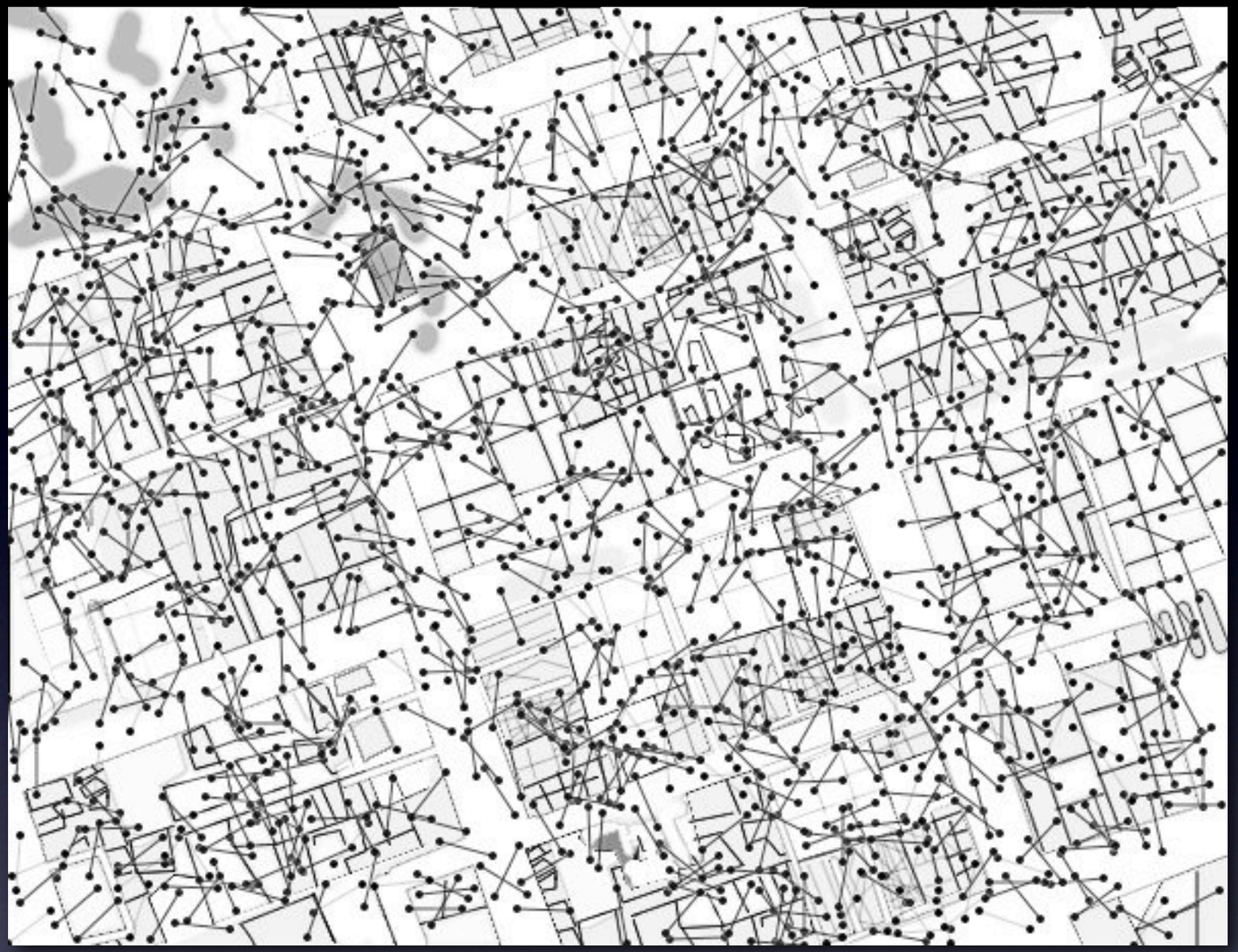
Log-normal shadowing

Simulation

Compare *prediction accuracy* of RPEA against Friis free-space and Log-normal shadowing models



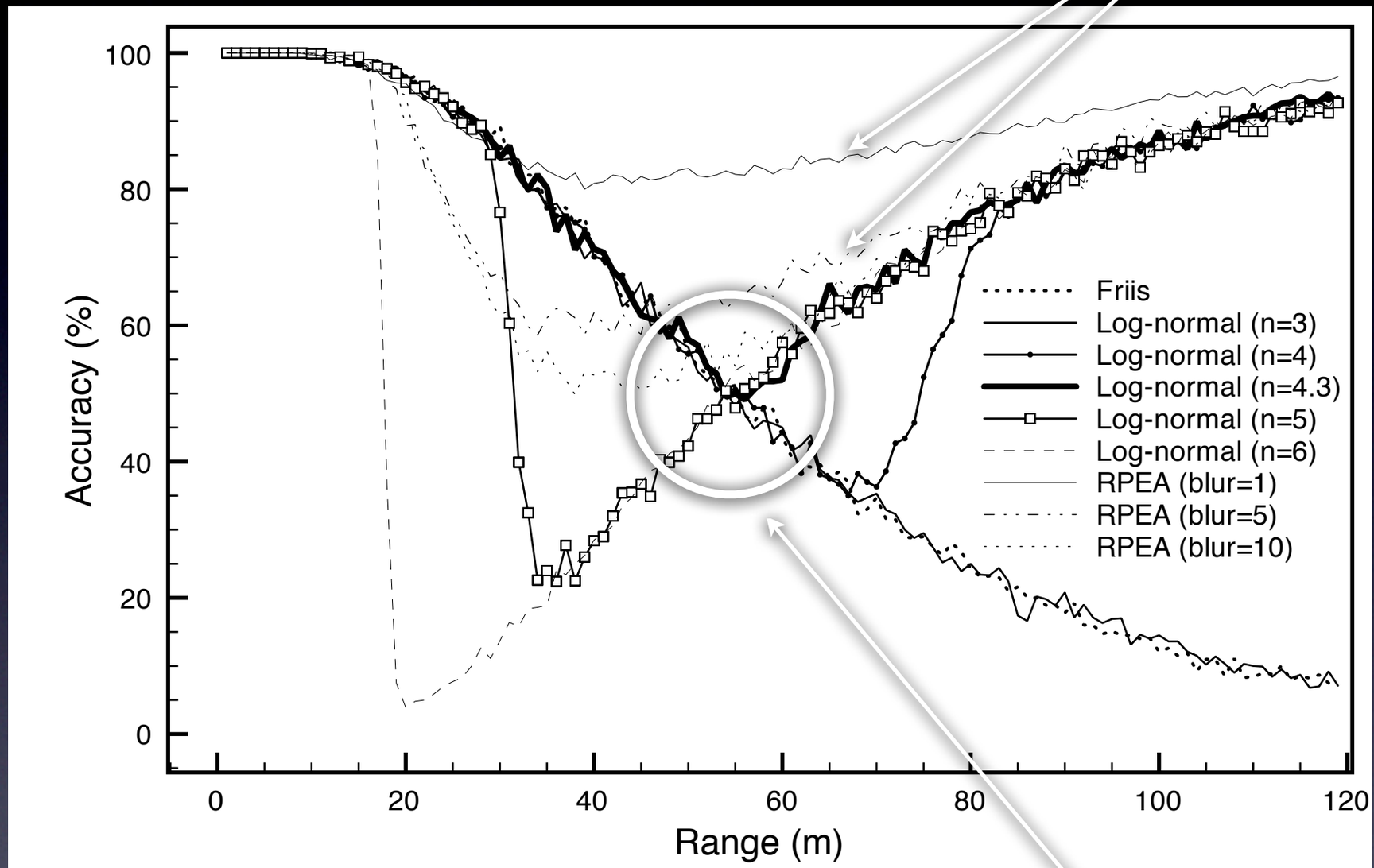
- Virtual urban environment
- Compare simulated signal presence against prediction of each model



- Perform comparisons at a variety of different ranges between communicating nodes

Comparison against conventional models

RPEA

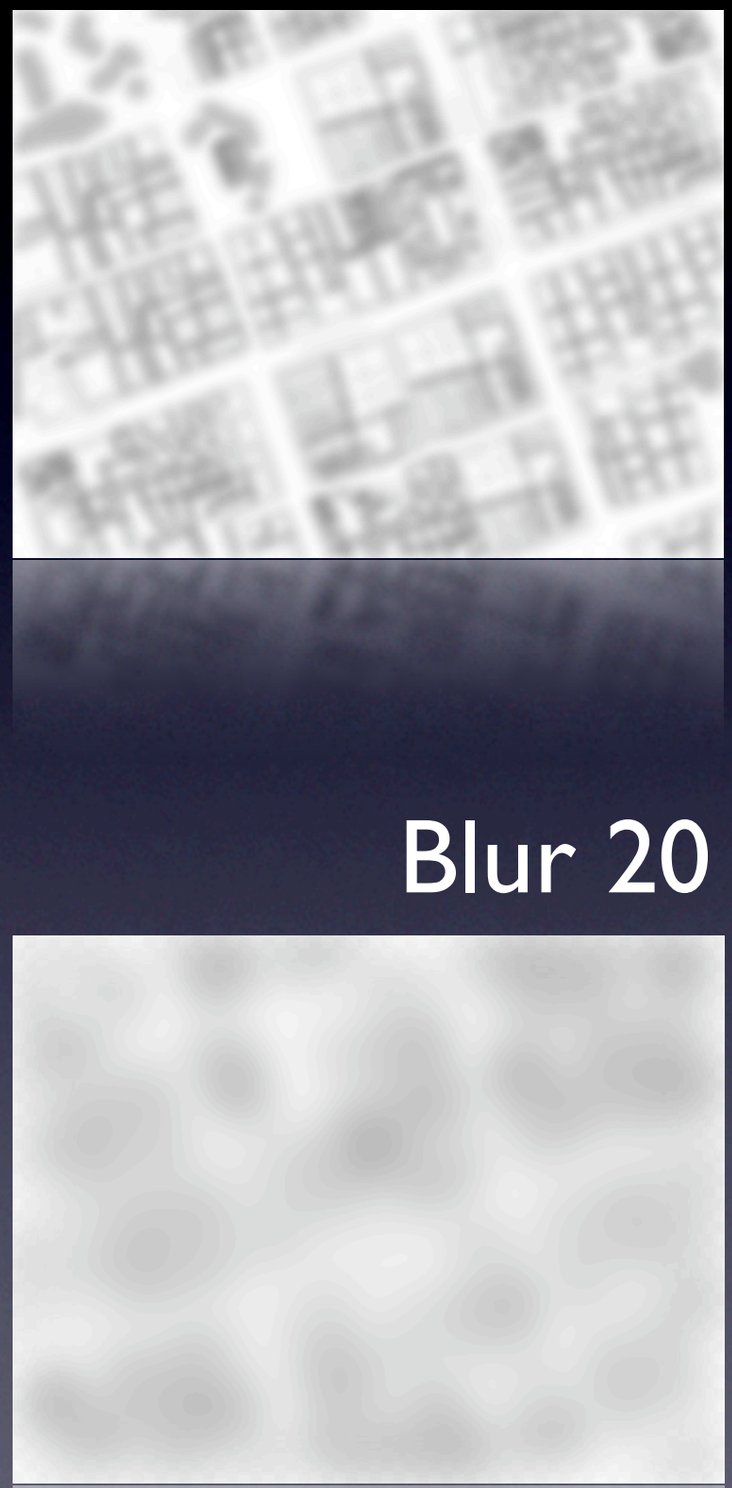


Conventional best case:
Log-normal (n=4.3)
50% accuracy

Fidelity

Blur 2

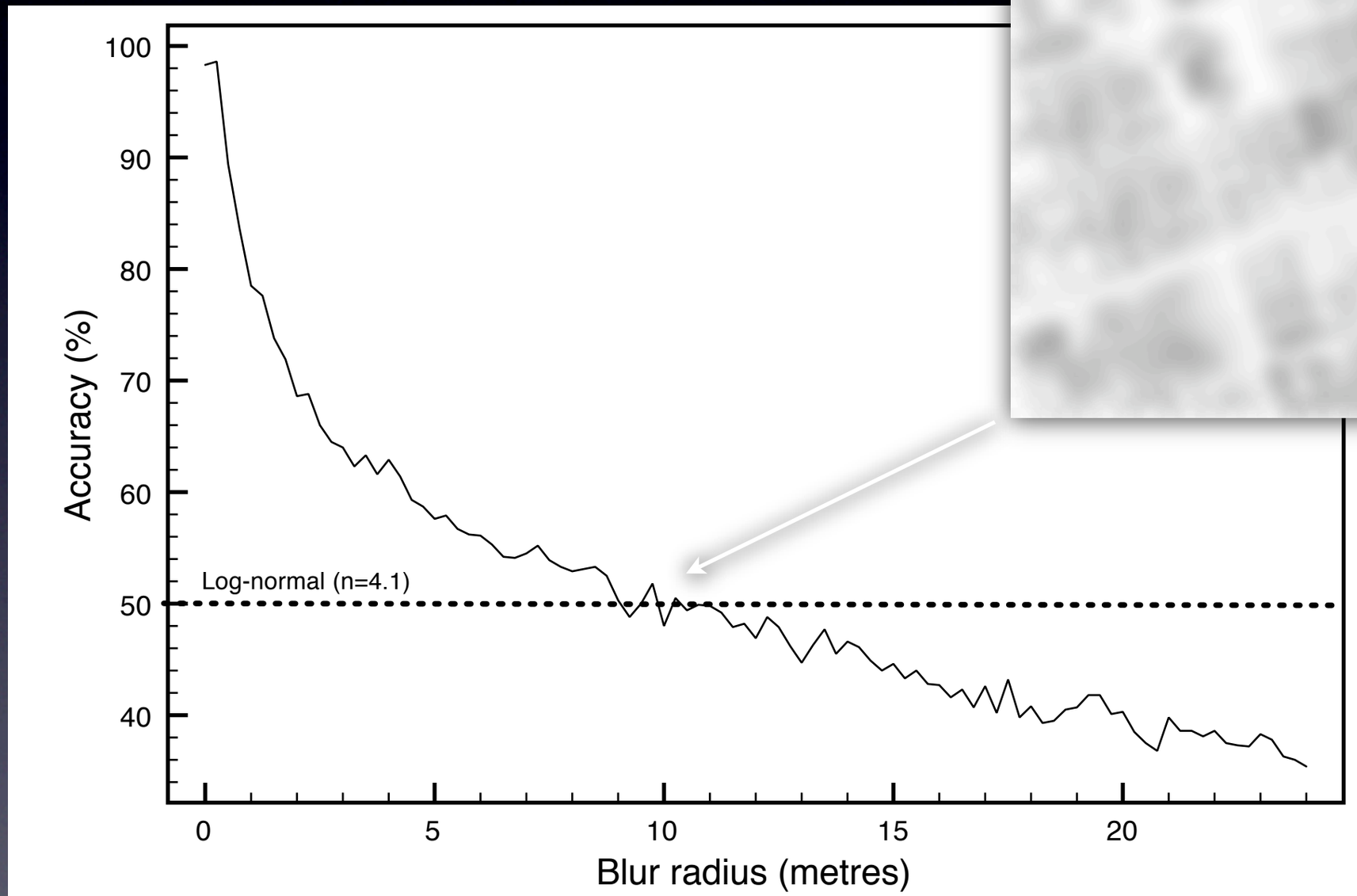
Blur 5



Blur 10

Blur 20

RPEA outperforms conventional models even with low fidelity



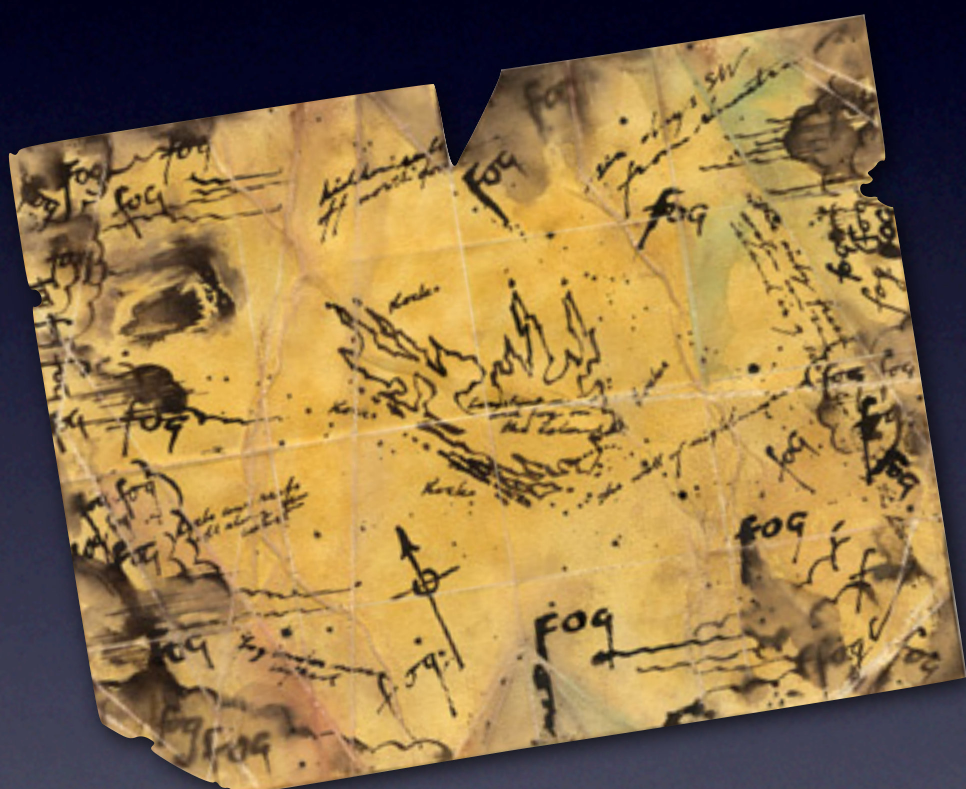
Results of Simulation

- Conventional models: 50% accuracy only
  - *Impossible to predict at distances similar to scale of objects in the environment*

- RPEA model surpasses 50% accuracy
- ...Even with low map fidelity

Future Research

- Develop + profile RPEA mapping algorithm
- RPEA network management algorithms
- Time-dependence of RF propagation (eg. weather, interference, movement of large objects)
- Provisions for incorporating reflection and refraction effects



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www.csse.monash.edu.au/research/san/

Map image www.danielreeve.co.nz
MRI images radiologyinfo.ca, greenemedicalimaging.com
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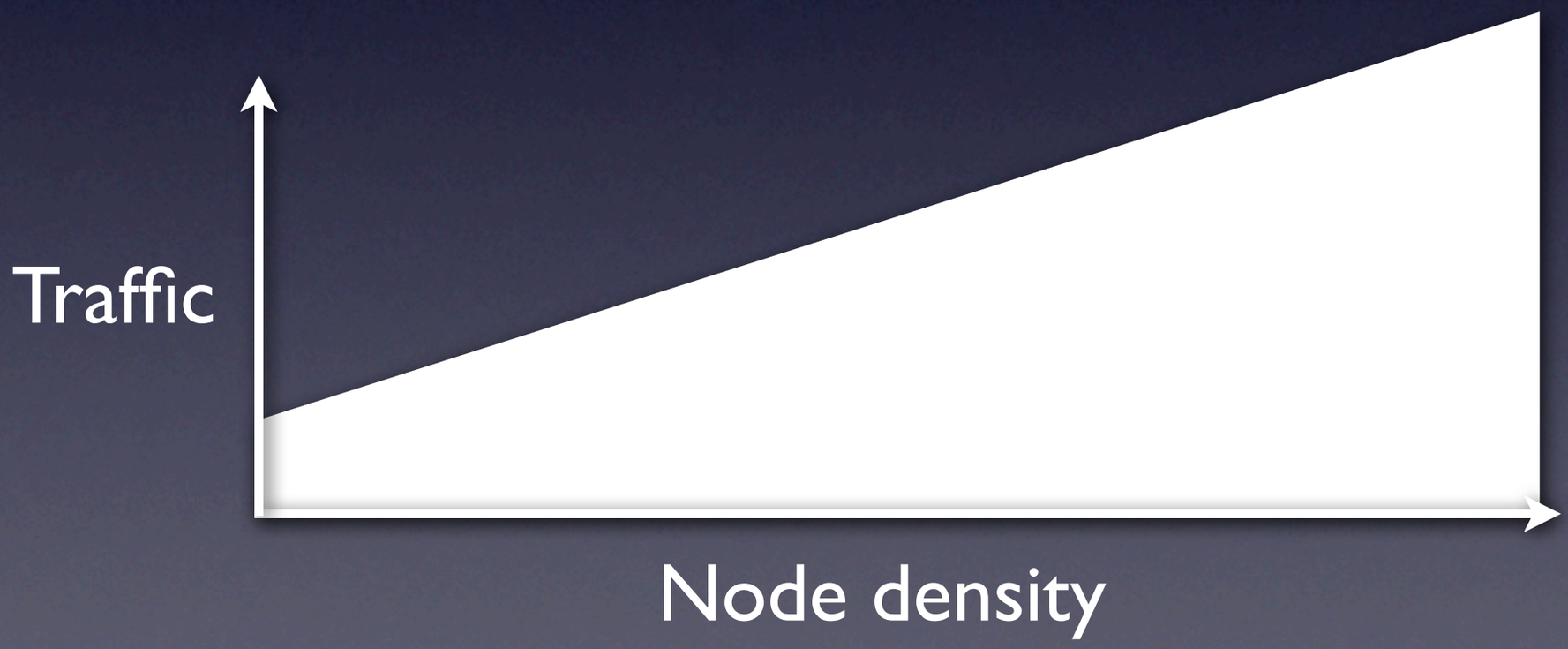
Broadcasting

Traditional MANET

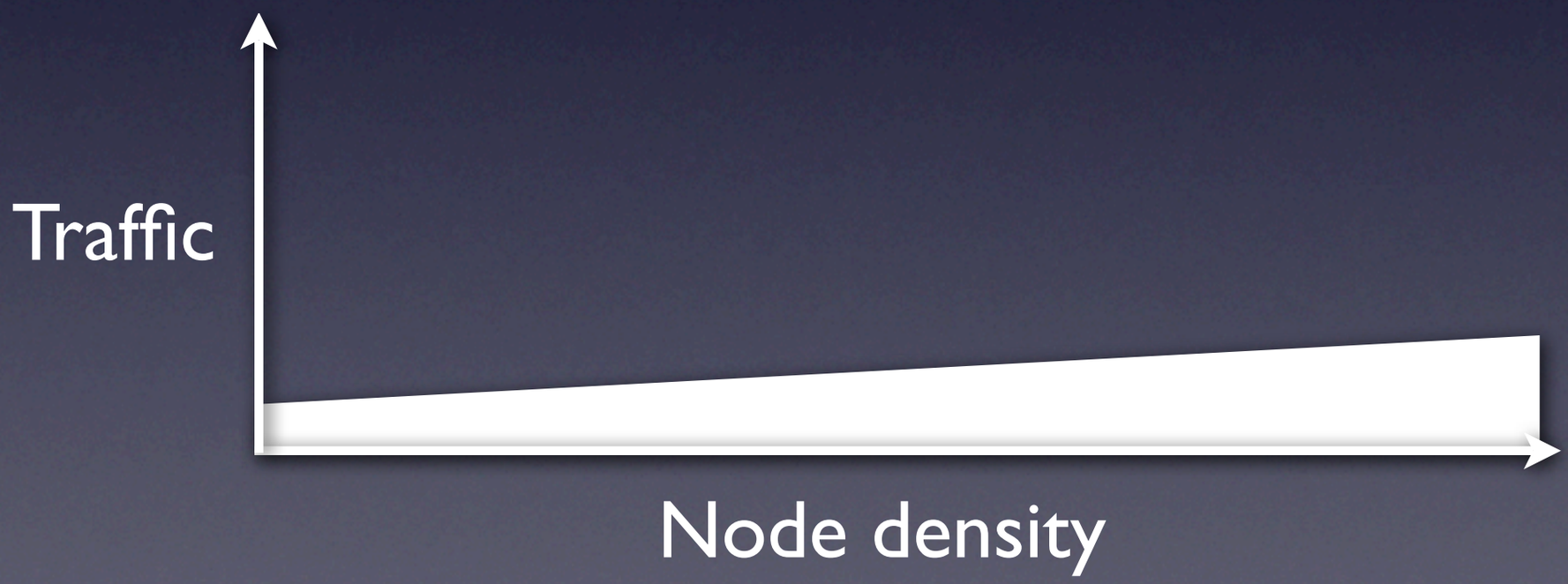
- Must broadcast presence frequently to establish redundant paths



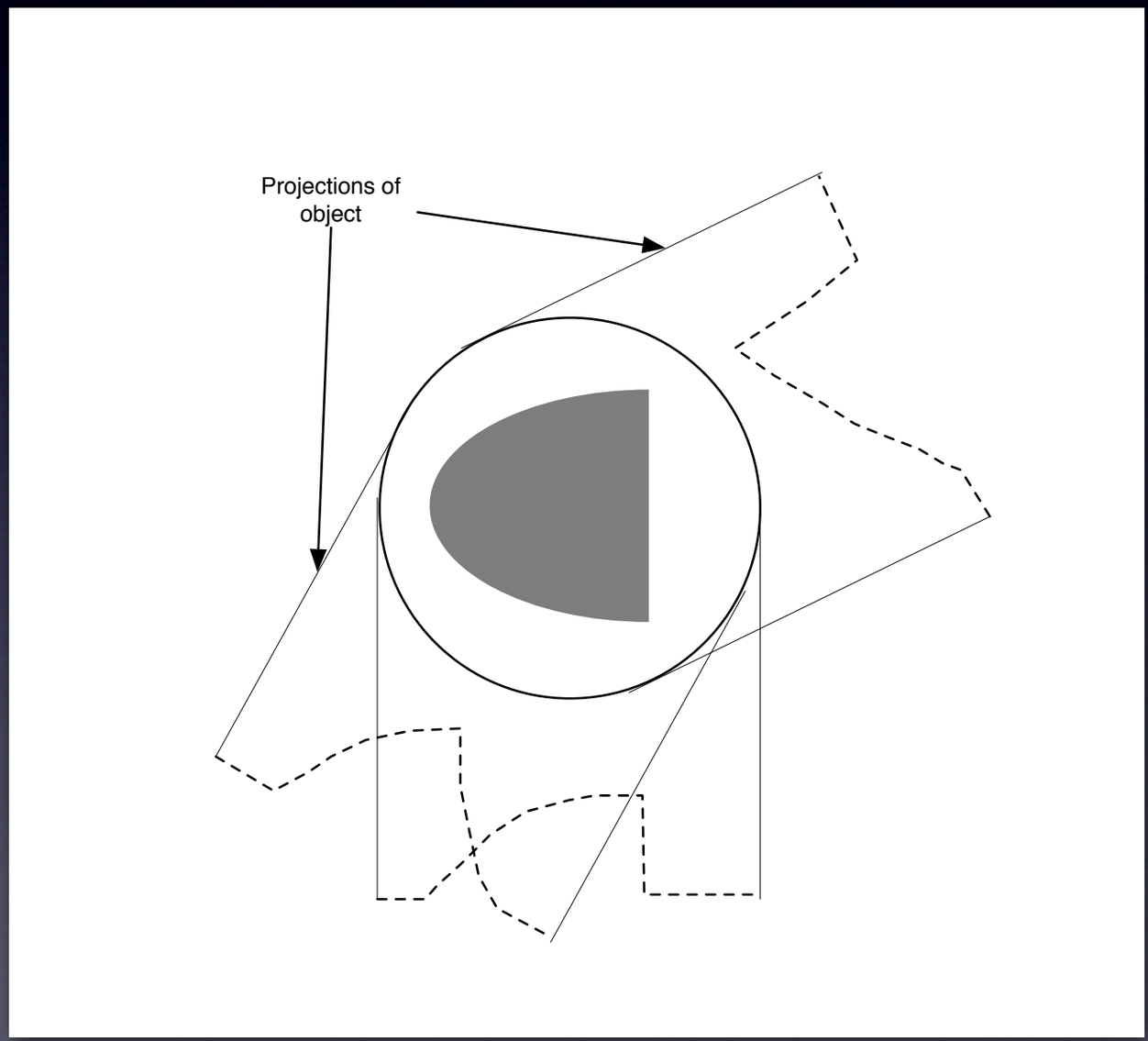
Broadcasting

RPEA Network

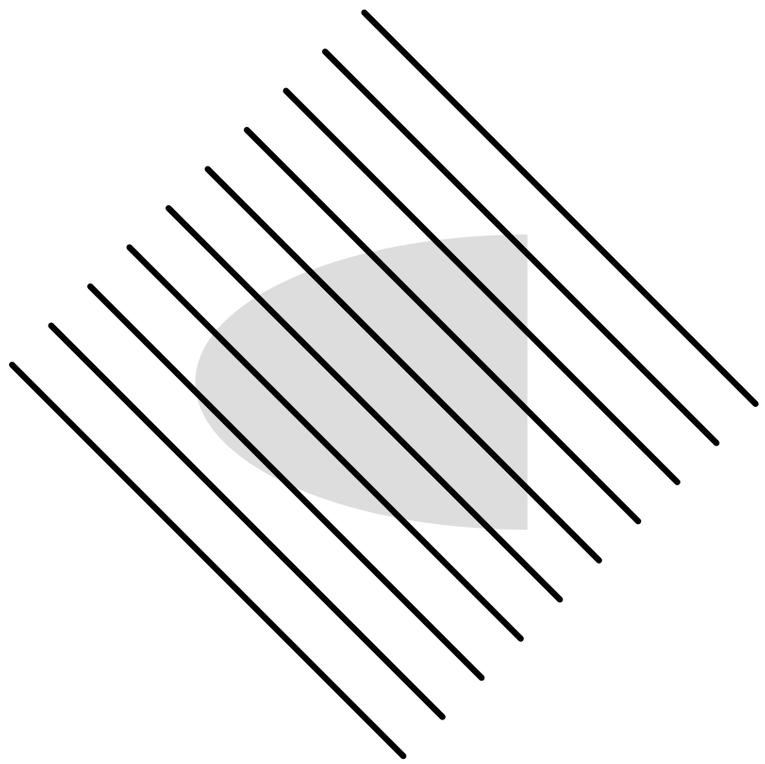
- Location information embedded in packet headers, minimal overhead
- Distributed map updates infrequent



Imaging by Projections



Traditional Imaging



RPEA Imaging