UCSD Center Piece Project -status report

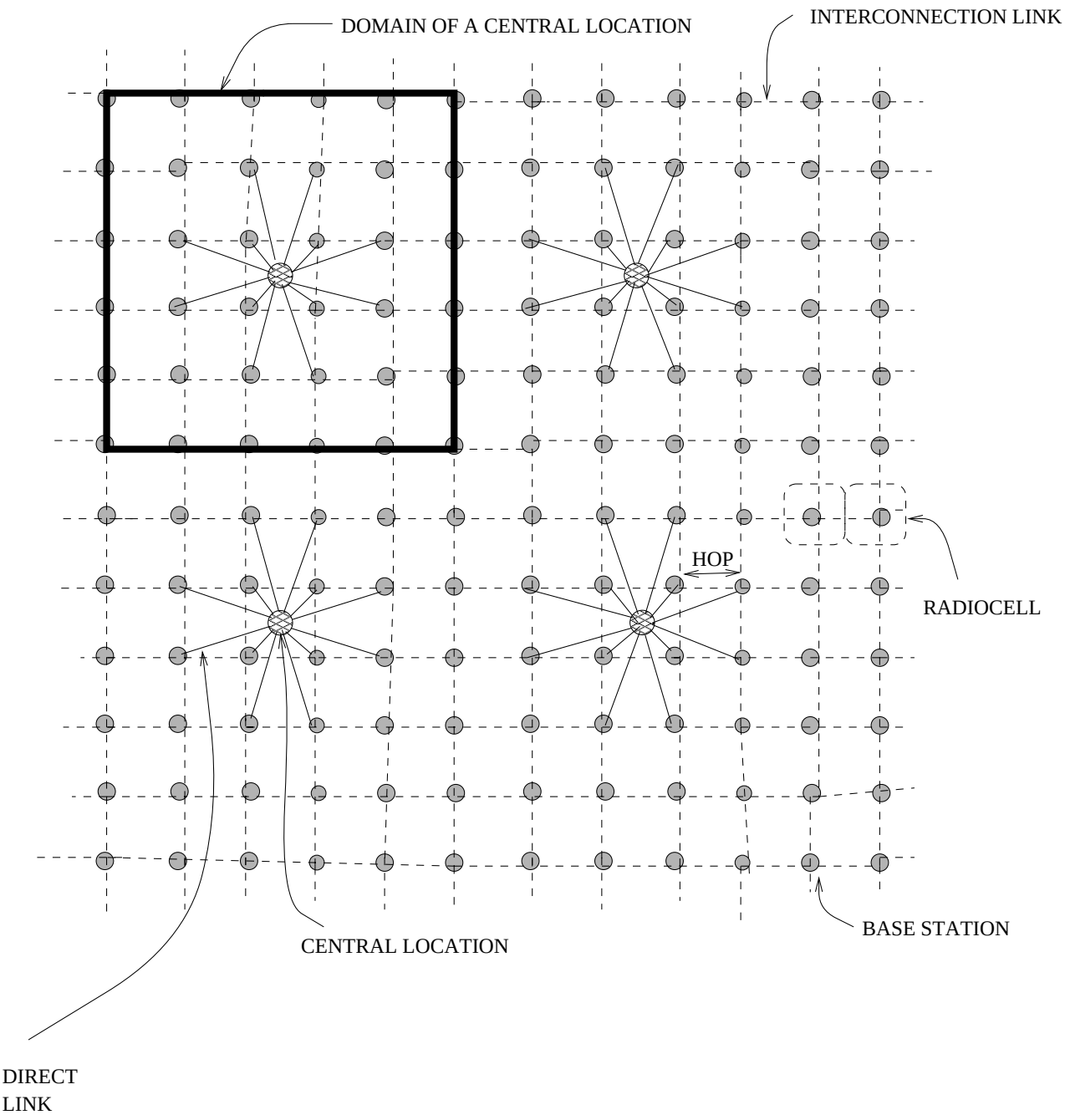
rrao@ucsd.edu

Overview

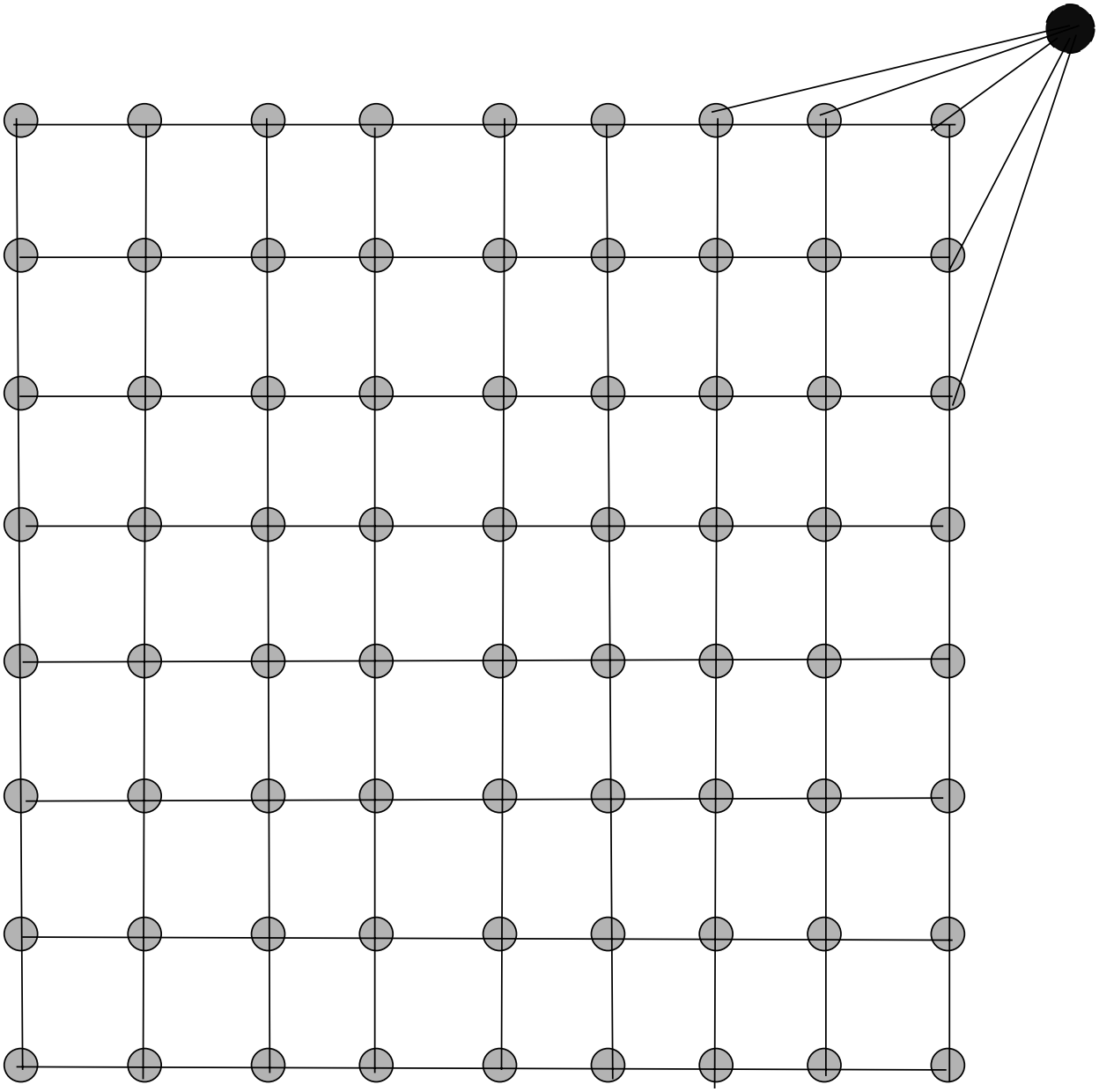
- Physical Layer architecture and status
- Network layer architecture and status
- Experimental setup

Scenario

- three-tiered structure
- Wireless Local Loop applications
- picocell concept: wireless nodes serving small areas
- picocell nodes are connected through a mesh of free-space optical links (or some other wireless means)
- this mesh relays traffic towards geographically distributed Central Locations



Coverage of the service area through multiple Central Locations.



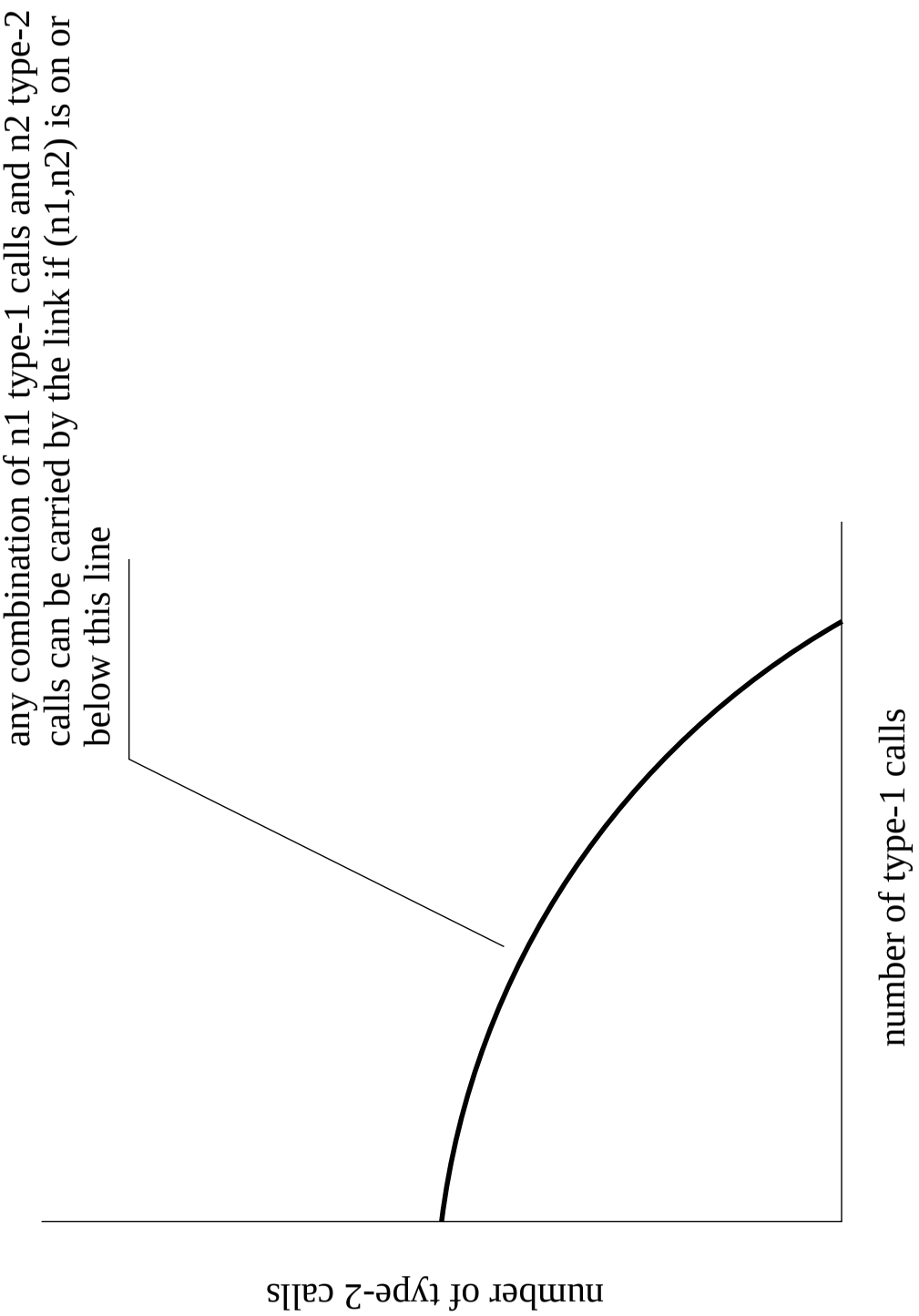
Connection of the grid structure to a Central Location (point of entry to pre-existing world-wide facilities).

Major networking issues

- QoS guarantees
- blocking:
  - ⋆ in the radio cell
  - ⋆ in the mesh
  - ⋆ on the direct links
- network capacity
- reliability/survivability
- mobility management

Capacity study

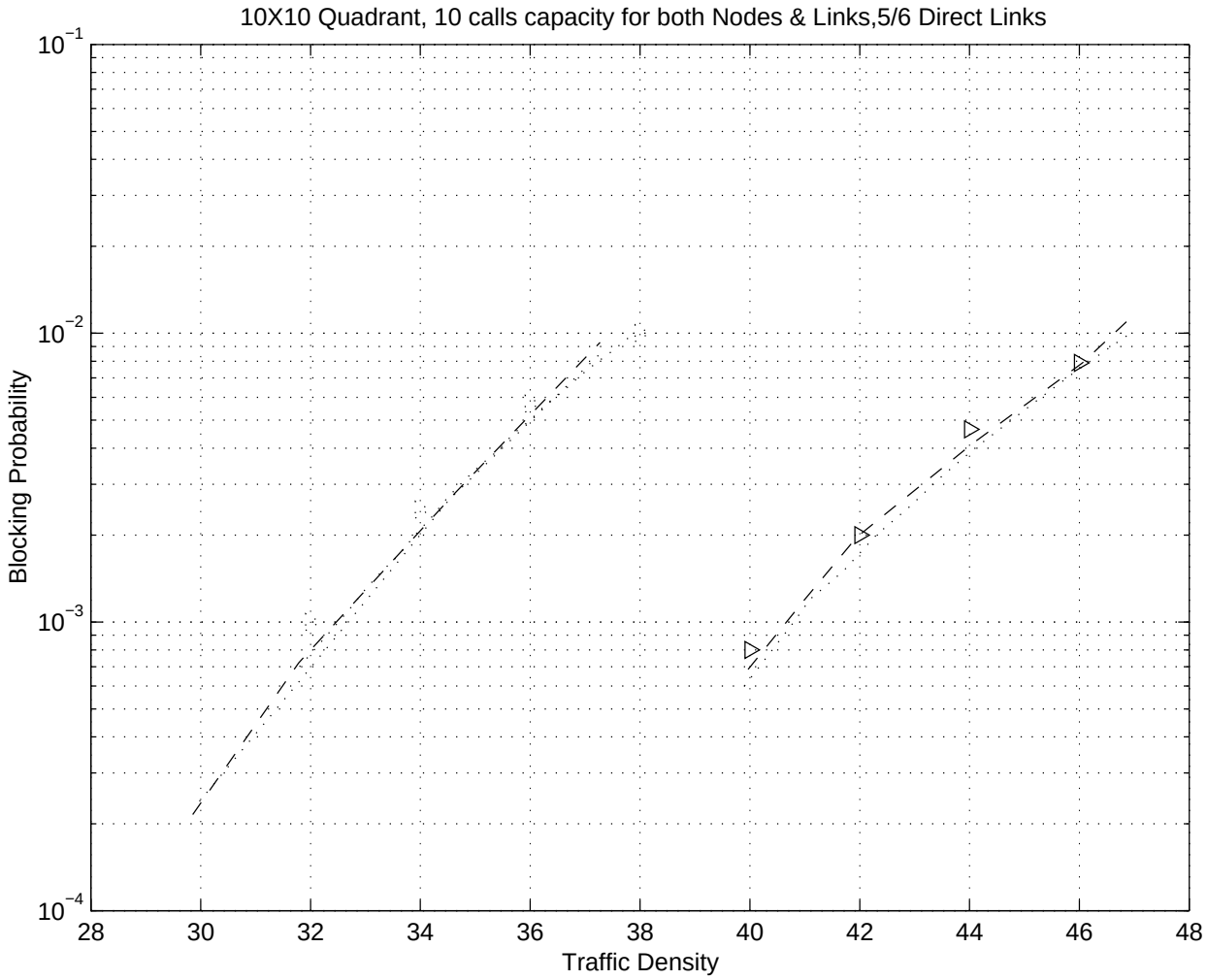
- goal: to evaluate the capacity of the network given the capacity of the links
- capacity: total amount of traffic which can always be routed to the CL without blocking regardless of the distribution throughout the network
- main result: if C is the capacity of the links and of the radio cells, the network capacity is $5C$
- extensions:
  - ⋆ link capacity K times the radio cell capacity ($4K^2 + K$?)
  - ⋆ multiple traffic classes (still 5 times?)



Example of capacity region for two classes of traffic.

More on the network capacity

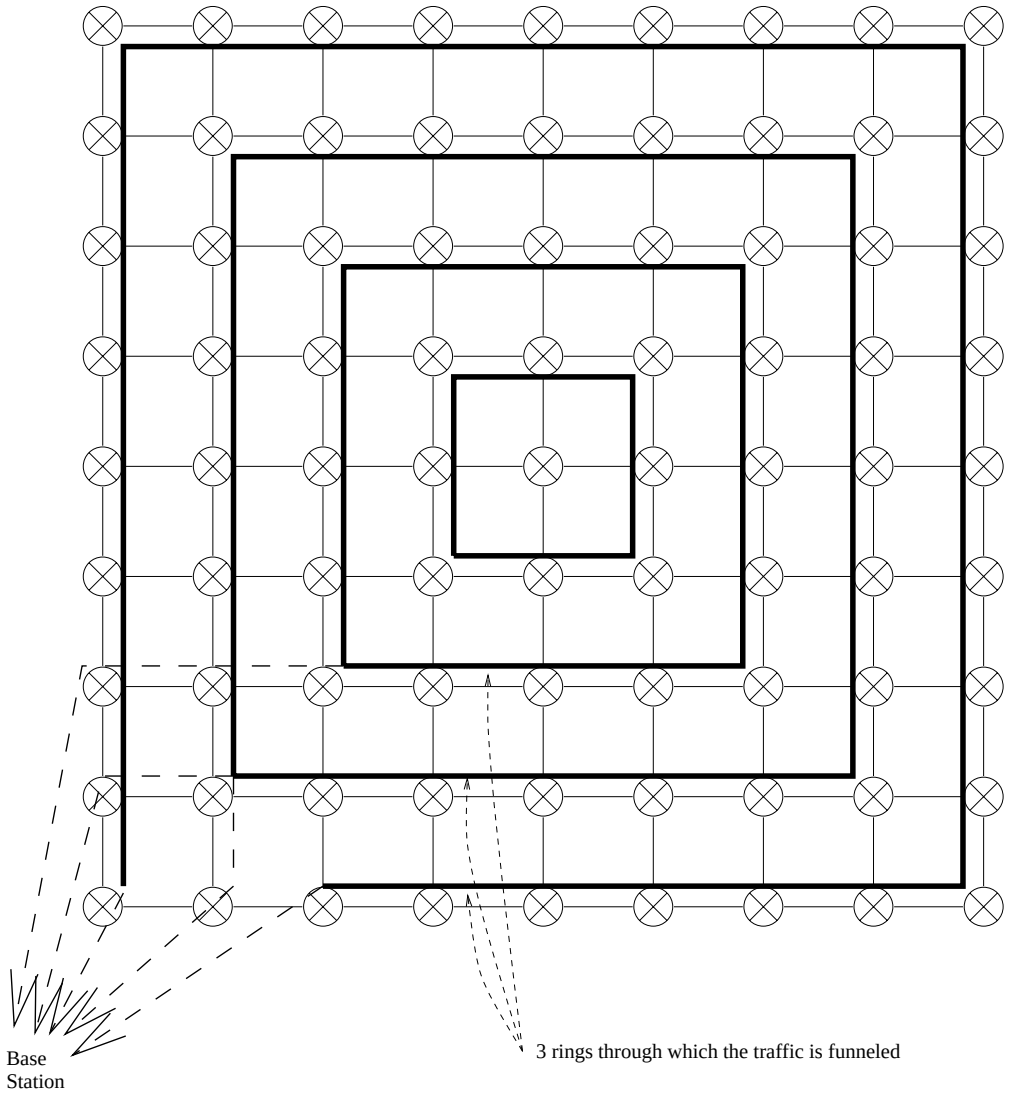
- the previous approach has the following problems:
  - ⋆ routing scheme may require rerouting
  - ⋆ no mobility considered
  - ⋆ the definition of capacity is somewhat too strict
- traffic study: instead of computing the capacity, we study the blocking probability versus the traffic load of the network
  - ⋆ this depends on the routing strategy
  - ⋆ optimal routing should be sought



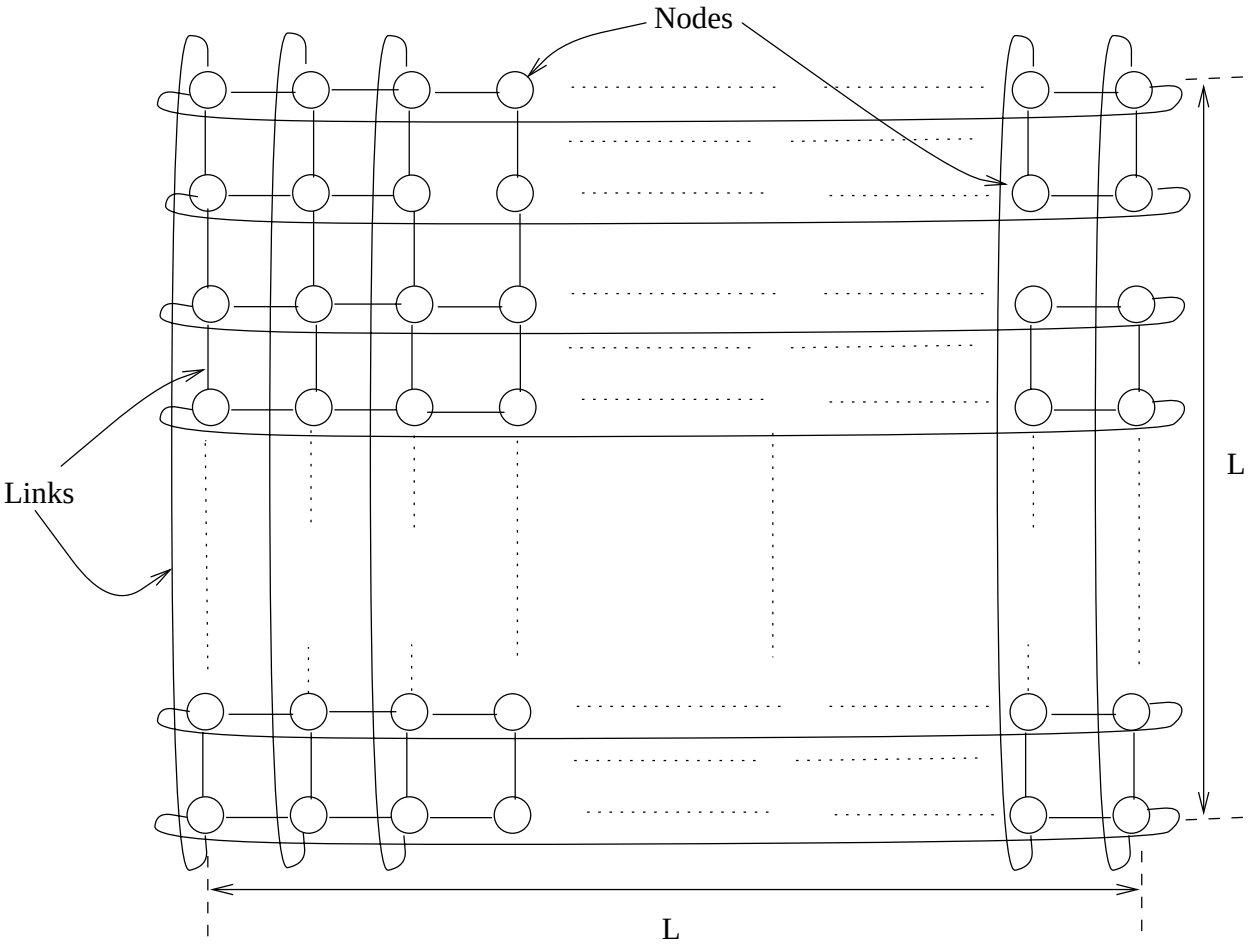
Example of blocking results.

Reliability study

- understand the impact of link/node failures
- find how much capacity should be kept unused to guarantee that failures can be tolerated
- first scenario: Uninet mesh
  - ⋆ traffic directed toward central location
  - ⋆ capacity limited to $4C$ for single-link failure
  - ⋆ double-link failures do not impact except for very special cases
  - ⋆ main conclusion: Uninet is fault-tolerant
- second scenario: perfect torus
  - ⋆ uniform traffic
  - ⋆ all single-link faults can be tolerated if link capacity is increased by $1.5/\sqrt{N}$ (N number of nodes)
  - ⋆ all double-link faults can be tolerated if link capacity is increased by $\alpha/\sqrt{N}$
  - ⋆ main conclusion: mesh structure provides great potential for fault-tolerance



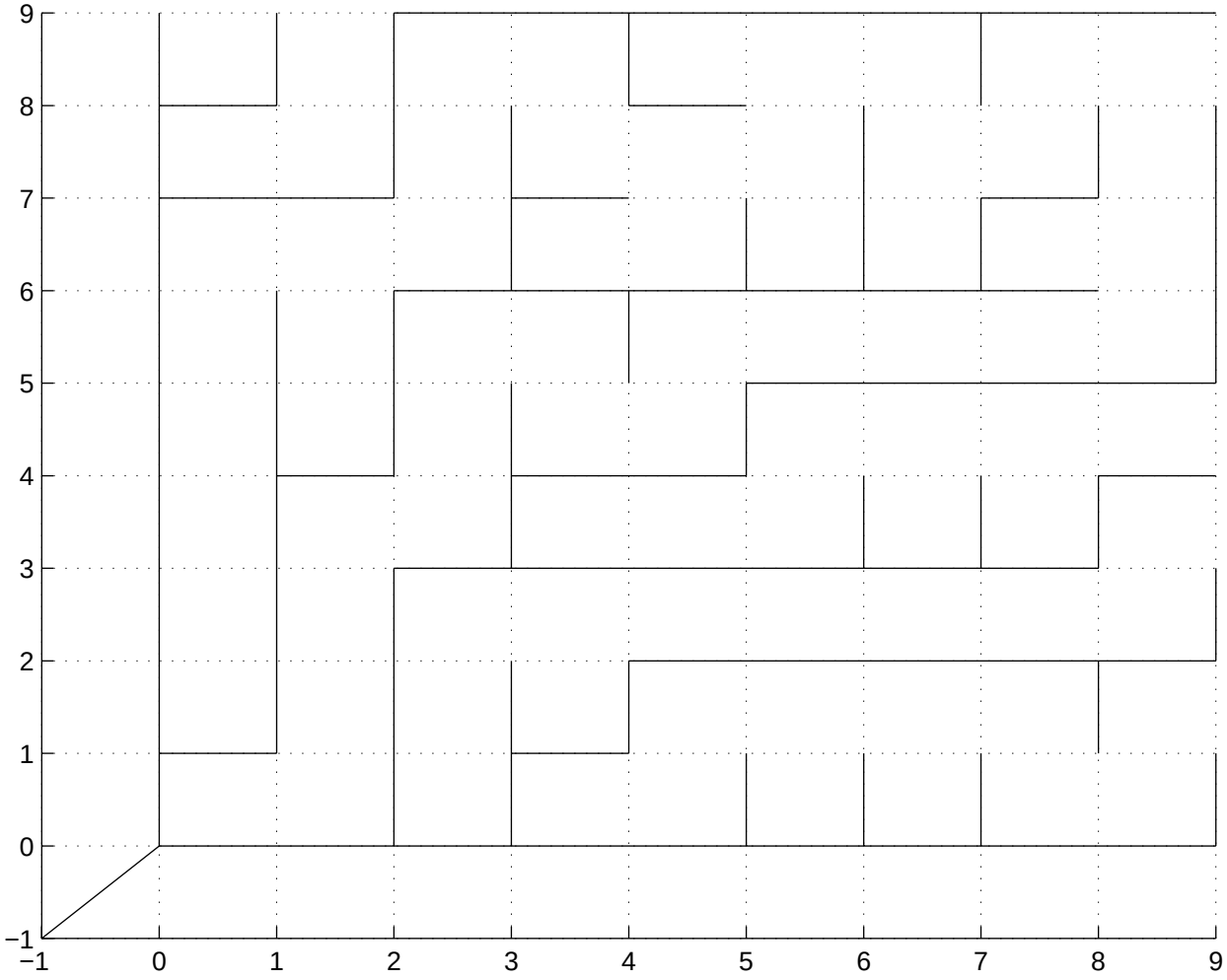
Reference topology for the reliability study.



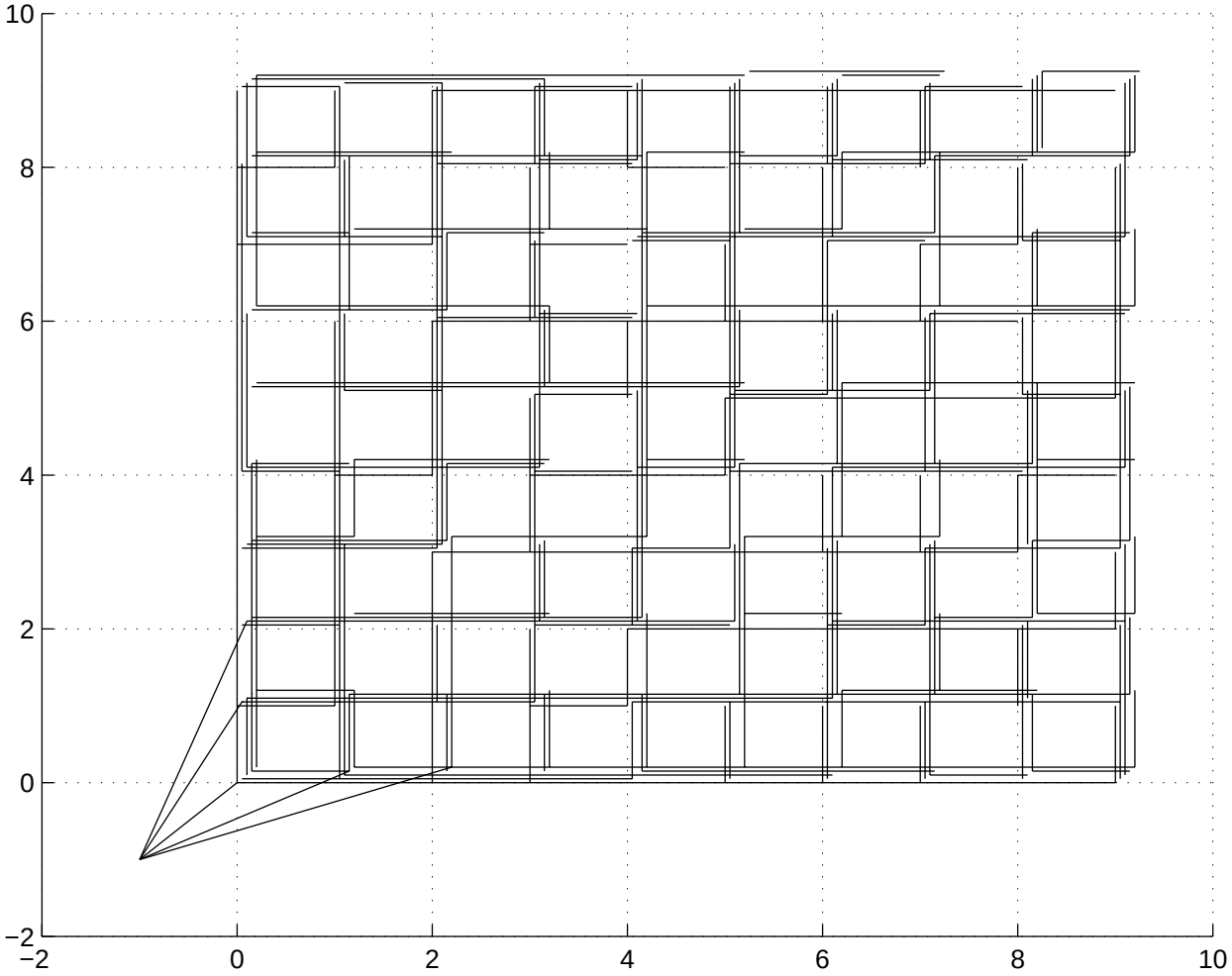
Reference topology for the reliability study.

Mobility management

- uses the Virtal Connection Tree Concept
- at connection setup time, multiple paths are identified and stored for possible later use
- QoS calculations need not be performed in real-time (e.g., during hand-off)
- multiple trees improve efficiency
  - ⋆ algorithm to find multiple trees which have minimum overlap and maximum balance
- admission control must be made stricter to prevent overload



One spanning tree.



Multiple spanning trees.

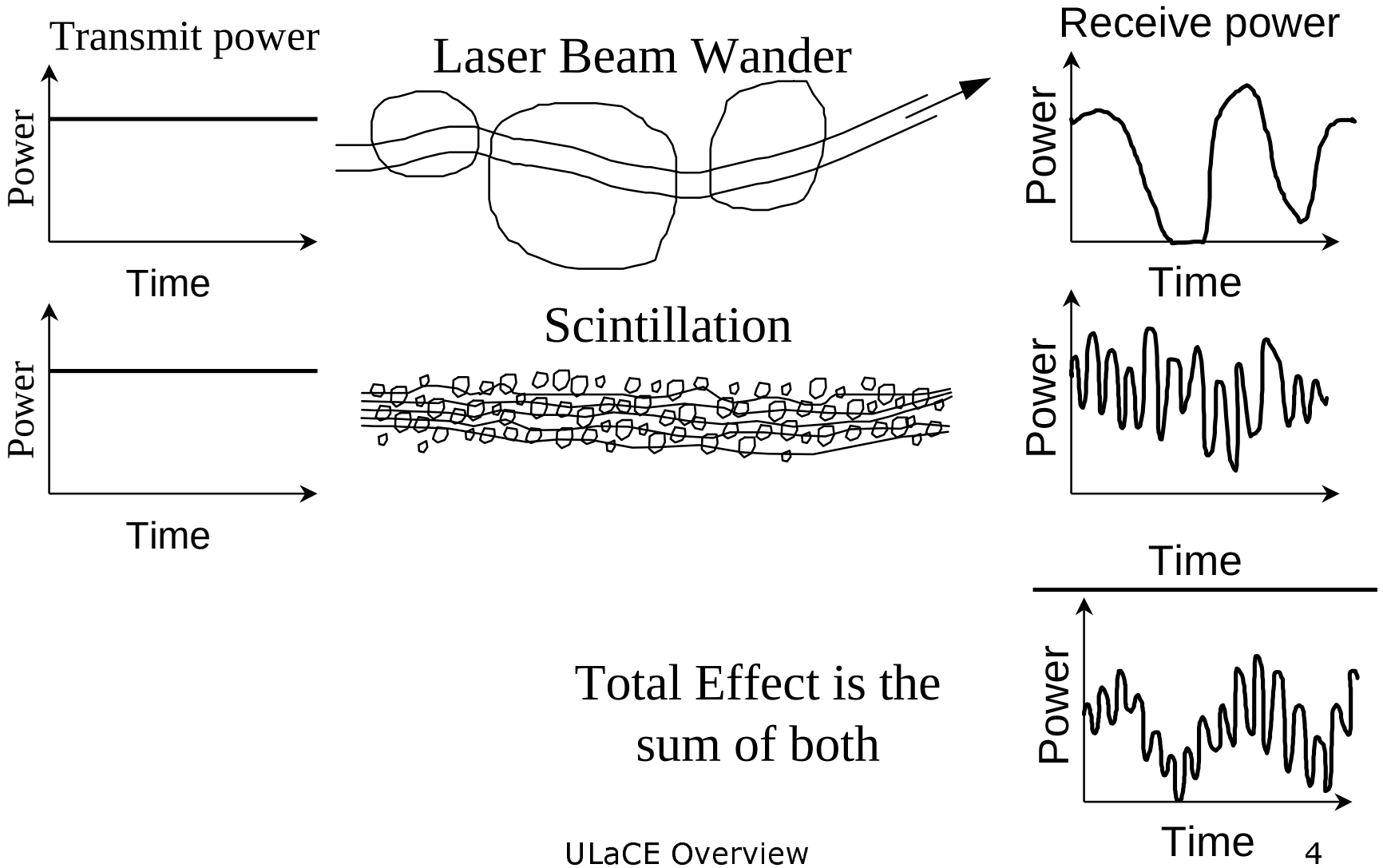
Laser Communications

- Point-to-Point Wireless Access
- Very High Data Rate
  - 622 Mb/s Commercially Available
  - 1.25Gb/s in Development
- No Spectrum Licensing or Right-of-Way Requirements
- Difficult to Intercept or Jam
- Rapidly Deployable - About One Hour

Alternatives and Comparisons

Type	Data Rate	Distance	Cost	Limitations
Microwave	45Mb/s	~20Km	$30,000	Data rate, Line of Sight
Fiber	Several Gb/s	Unlimited	$70,000/km	Right-of-Way
Laser	622Mb/s	5Km	$65,000	Weather, Line of Sight
Laser	155Mb/s	1.5Km	$15,000	Weather, Ling of Sight

Atmospheric Scintillation



Total Effect is the sum of both

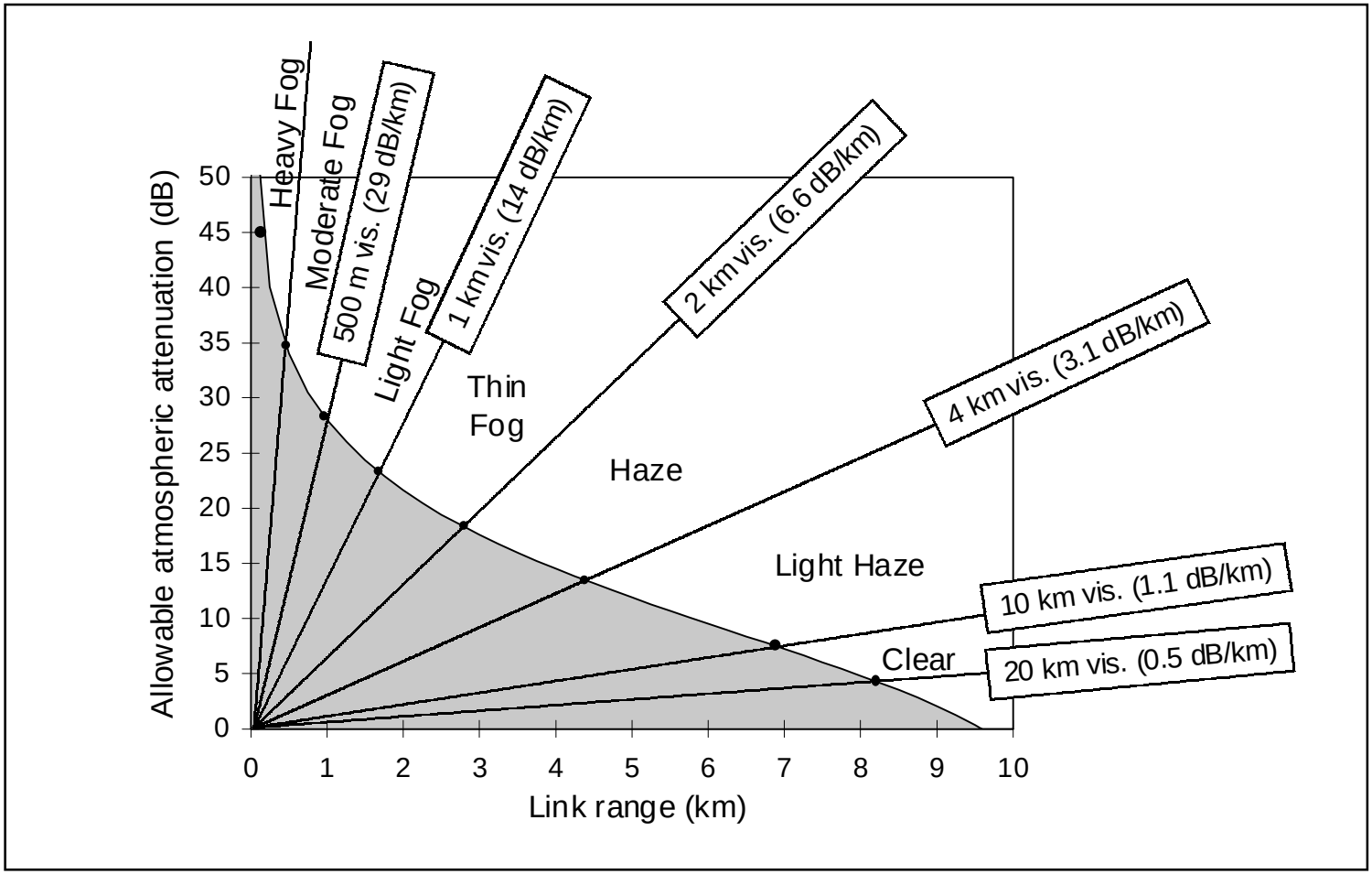
Scintillation Fade Margin

Scintillation Fade Margin

Atmospheric Attenuation

Laser Communication Limitation

Atmospheric Attenuation



LaserNet Overview

- A High Data Rate Wireless WAN
  - 5 wireless links, each capable of 622 Mb/s
  - Nodes at Local Institutions
    - UCSD
    - Qualcomm
    - CERFNET ...
- Demonstration of Feasibility
- Research Platform for
  - Hardware, Software & protocol development

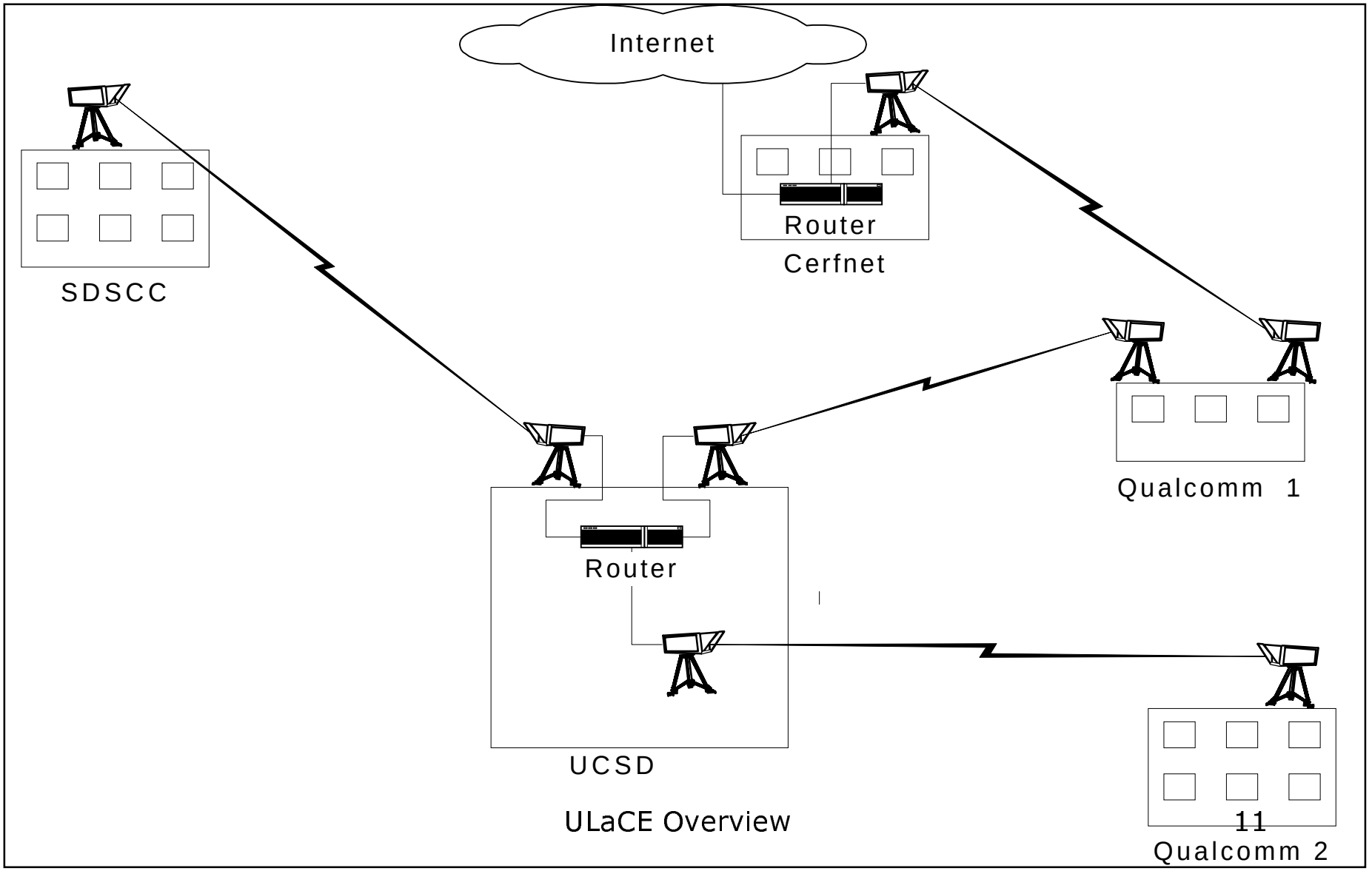
Approach

- Physical Layer
  - Measure Errors
    - Bursty errors due to Scintillation
  - Correlate with Atmospheric Conditions
    - Visibility
    - Humidity
    - Temperature
    - Wind Speed
  - Model the Bursty Channel analytically

Approach

- Higher Layers
  - Study Effect of Burst Errors on
    - SONET, ATM, IP, TCP, FTP, HTTP
  - Investigate Alternate Automated Rerouting Schemes
    - Using Low Data Rate Microwave Backup
    - Using Existing Slow Data Rate Internet Channels

Setup



ULaCE Overview

Ongoing Research

- Impact of Protocol Stacks
  - Protocol stacks modify source and channel characteristics
  - Channel seen by the application is not the raw physical channel
  - Source seen by the channel is not the original application source
- Optimal Error Control allocation
  - How much to fix at what level