Multibeamformer testbed for capacity enhancement of 802.11b networks

Paul Jason Co
MS EE (C&C)

Joel S. Marciano, Ph.D.
Adviser

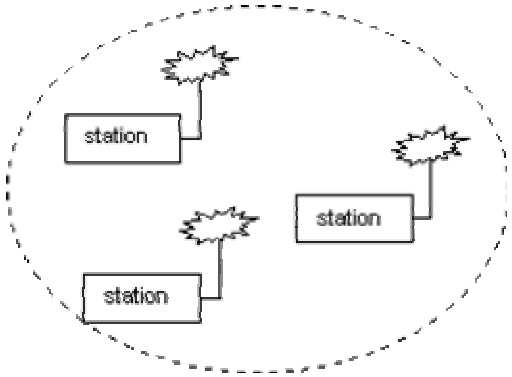
Outline

- Introduction
- Statement of the Problem
- Objectives
- Methodology

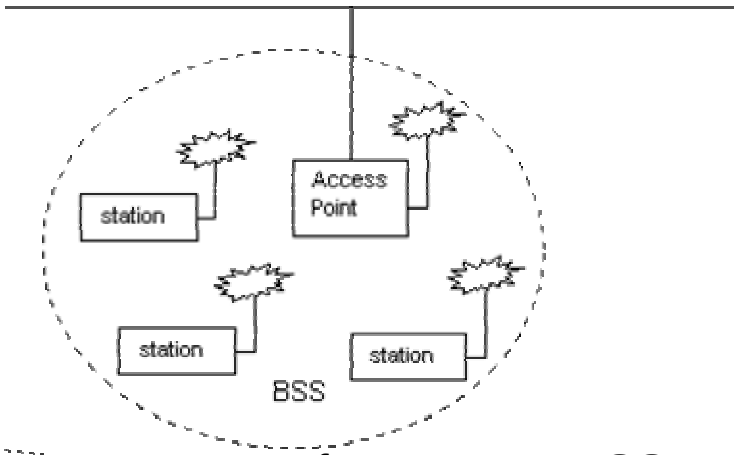
IEEE 802.11b

- Also known as Wi-Fi (Wireless Fidelity)
- Defines the Physical and Media Access Control layers for a LAN with wireless connectivity
  - Operates in the 2.4 GHz ISM band
  - Data rates of up to 11Mbps
  - Uses DSSS modulation
  - Uses CSMA/CA access method
  - Range of up to 300 feet

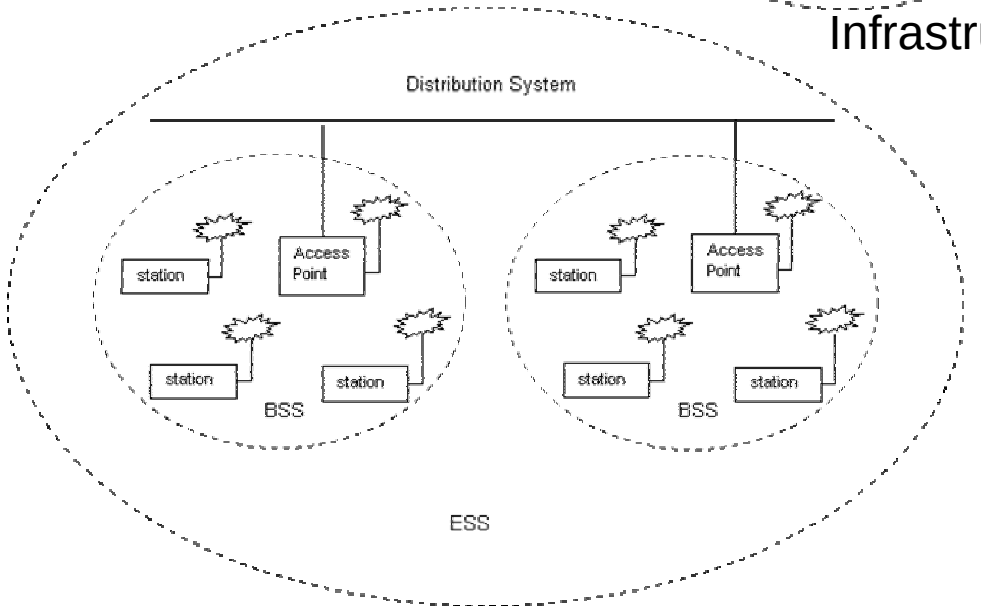
802.11 Topologies



Independent BSS



Infrastructure BSS



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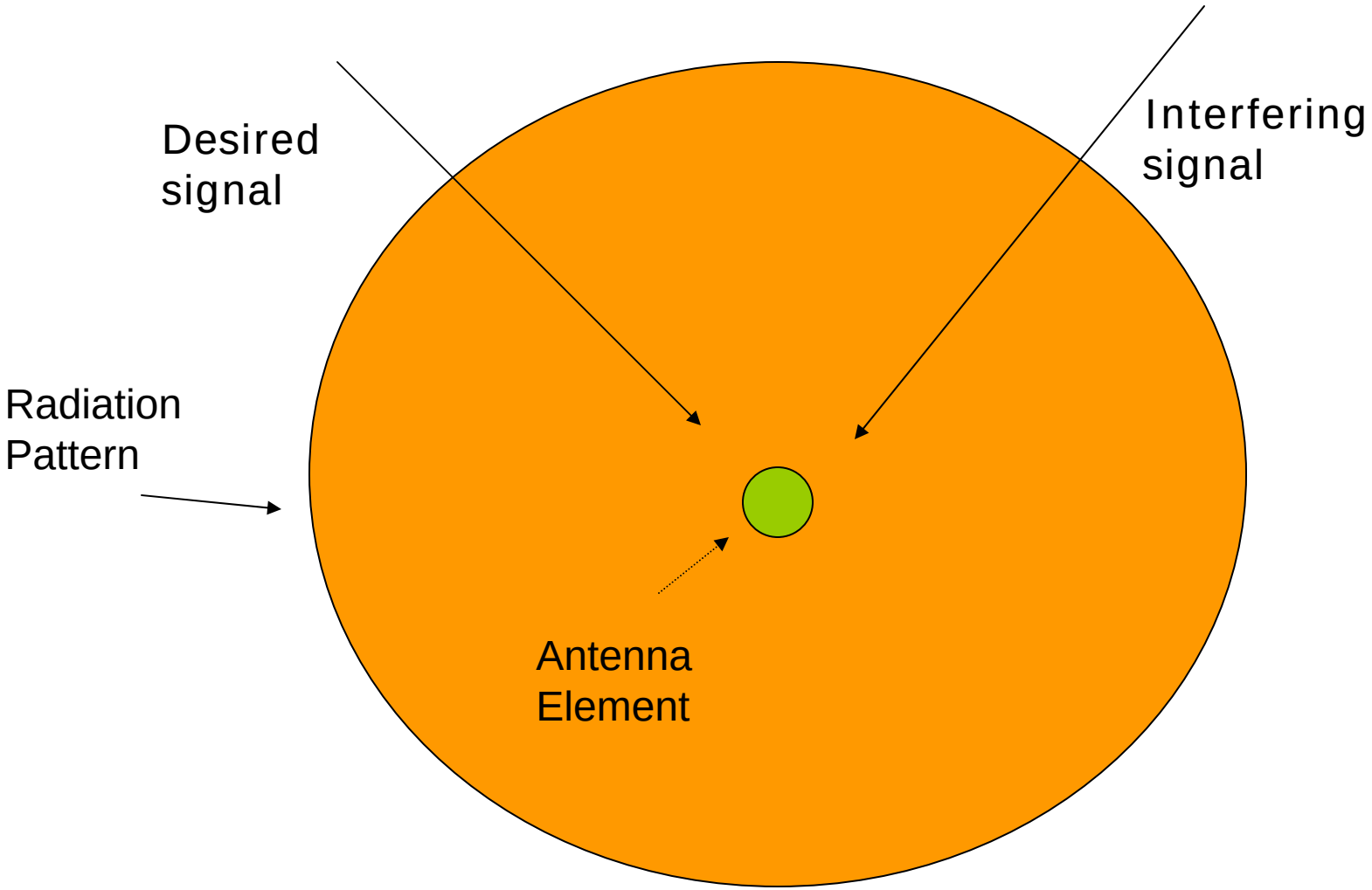
IEEE 802.11b

- Most commercially available clients/access points use omnidirectional antennas
  - More susceptible to interference
  - Smaller range due to small gain
- Use directional antennas!

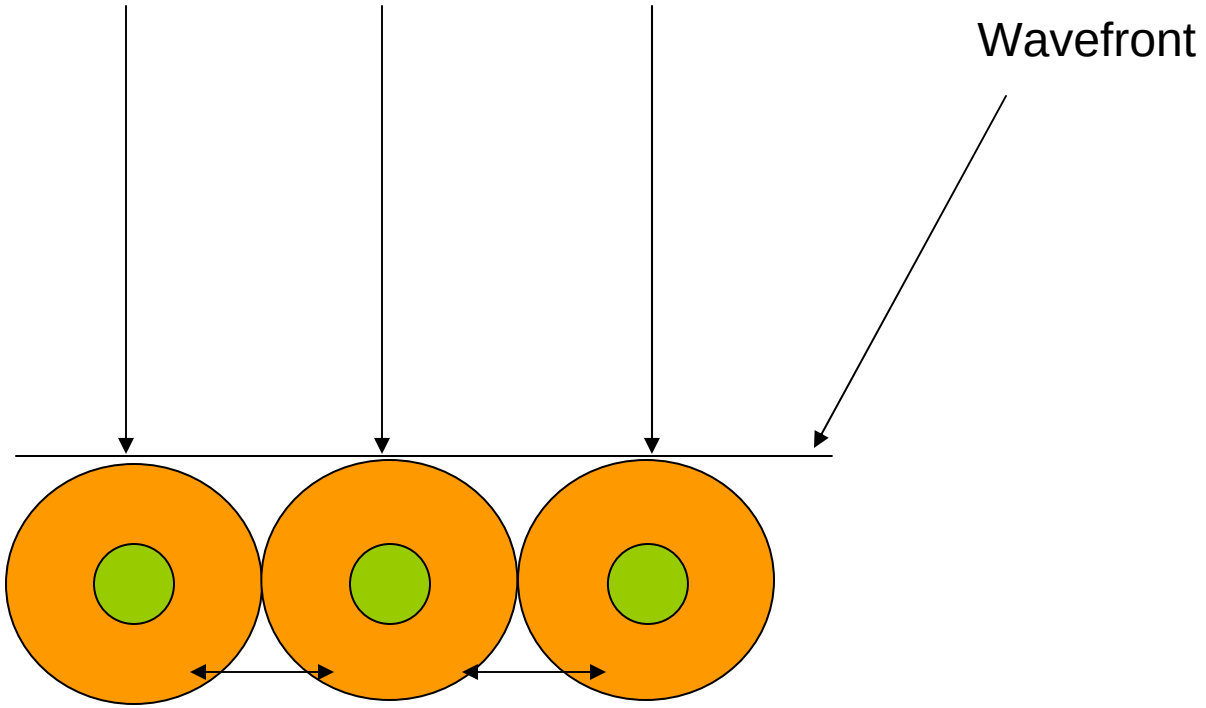
Antenna Array Basics

- Arrangement of antenna elements
  - Linear Array
  - Planar Array
  - Conformal Array
- Improvements over single antenna
  - Gain
  - Directivity
  - Beam steering

Antenna Array Basics

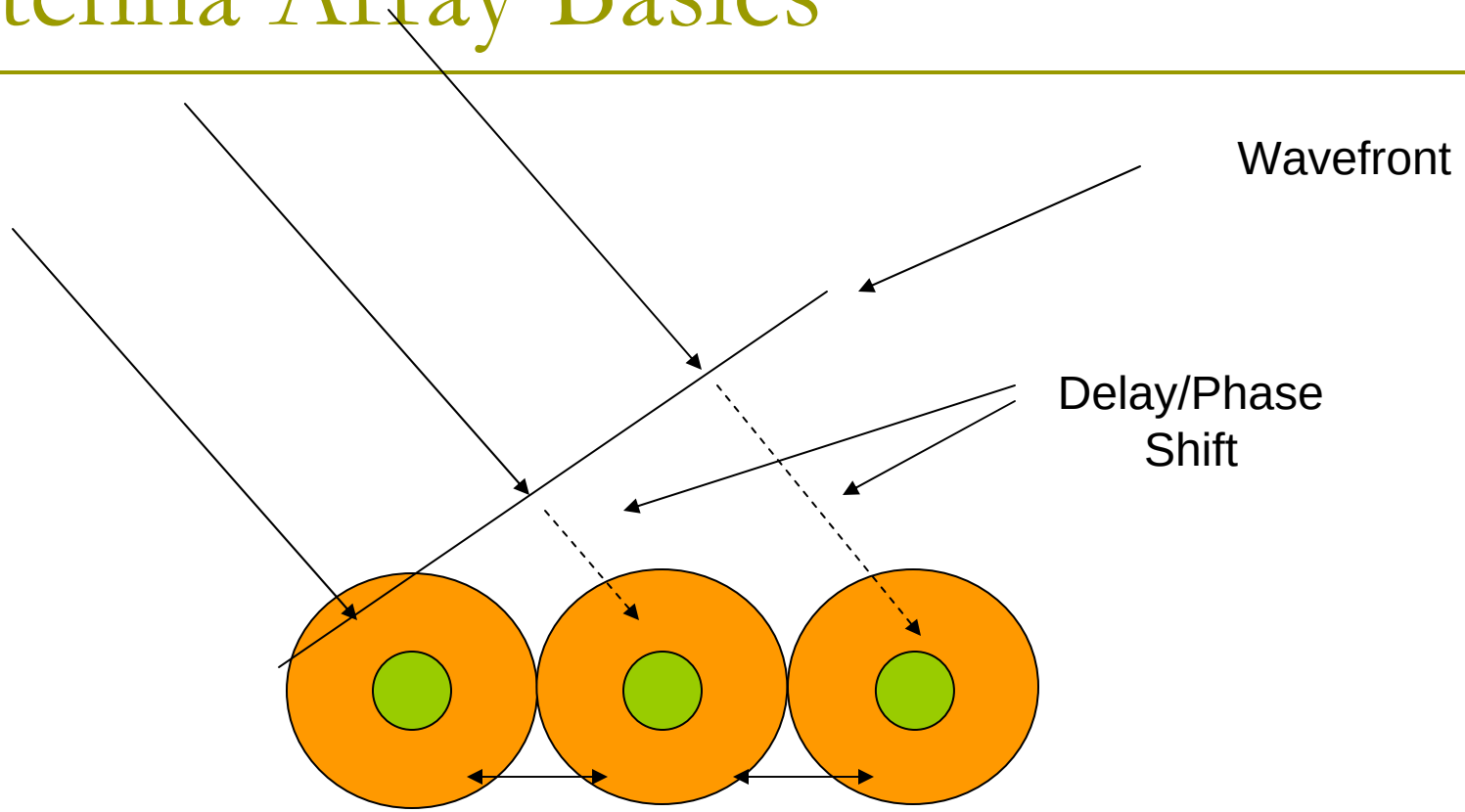


Antenna Array Basics



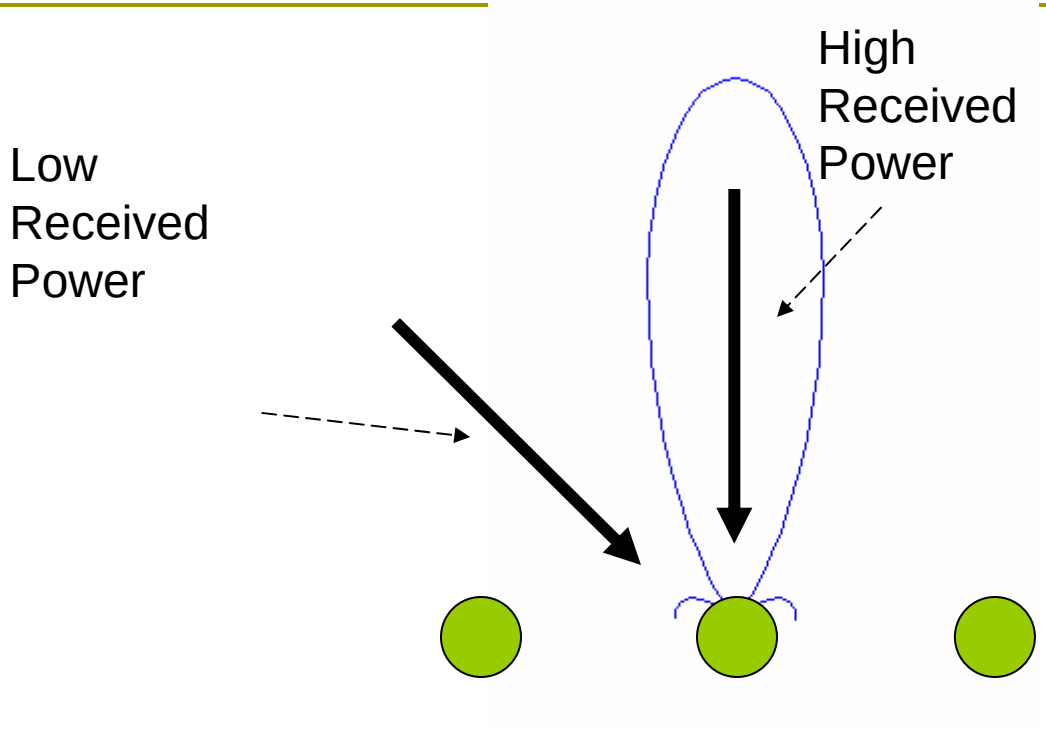
Incident wave perpendicular to array

Antenna Array Basics



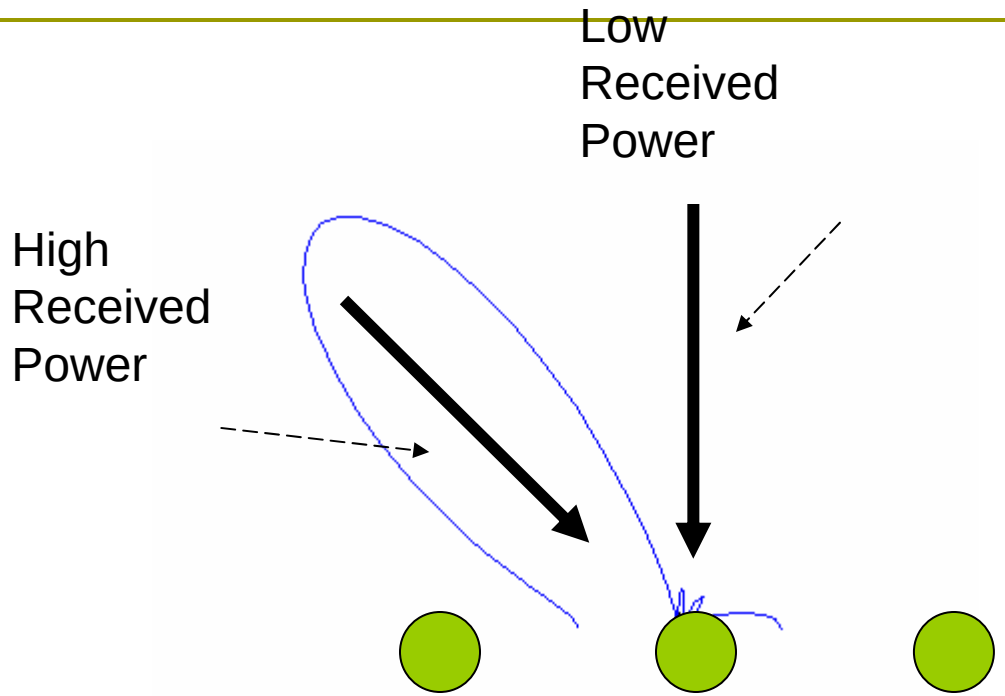
Incident wave at an angle to array

Antenna Array Basics



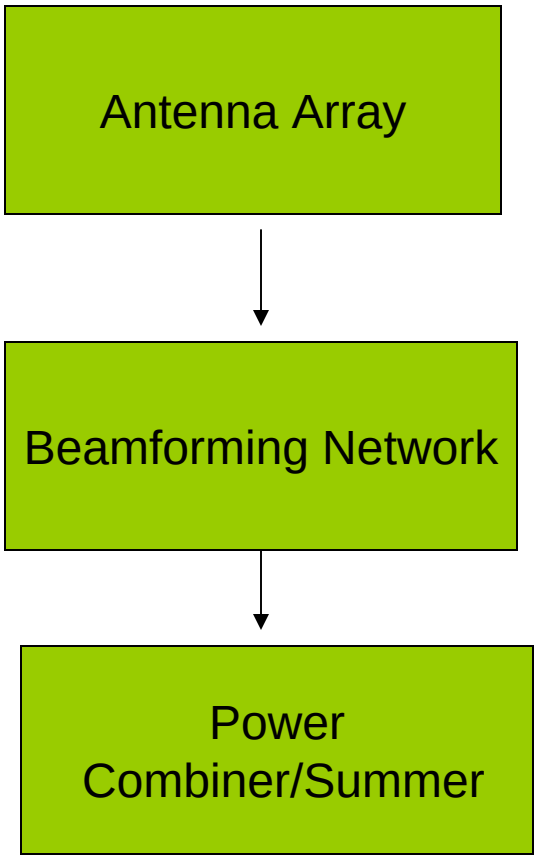
$$AF = \frac{\sin^2(Npi(d/\lambda)(\sin\theta))}{N^2\sin^2(pi(d/\lambda)(\sin\theta))}$$

Antenna Array Basics



$$\phi_n = (n-1) * 2 * pi * (d / \lambda) * \sin\theta_o$$

Antenna Array Beamforming

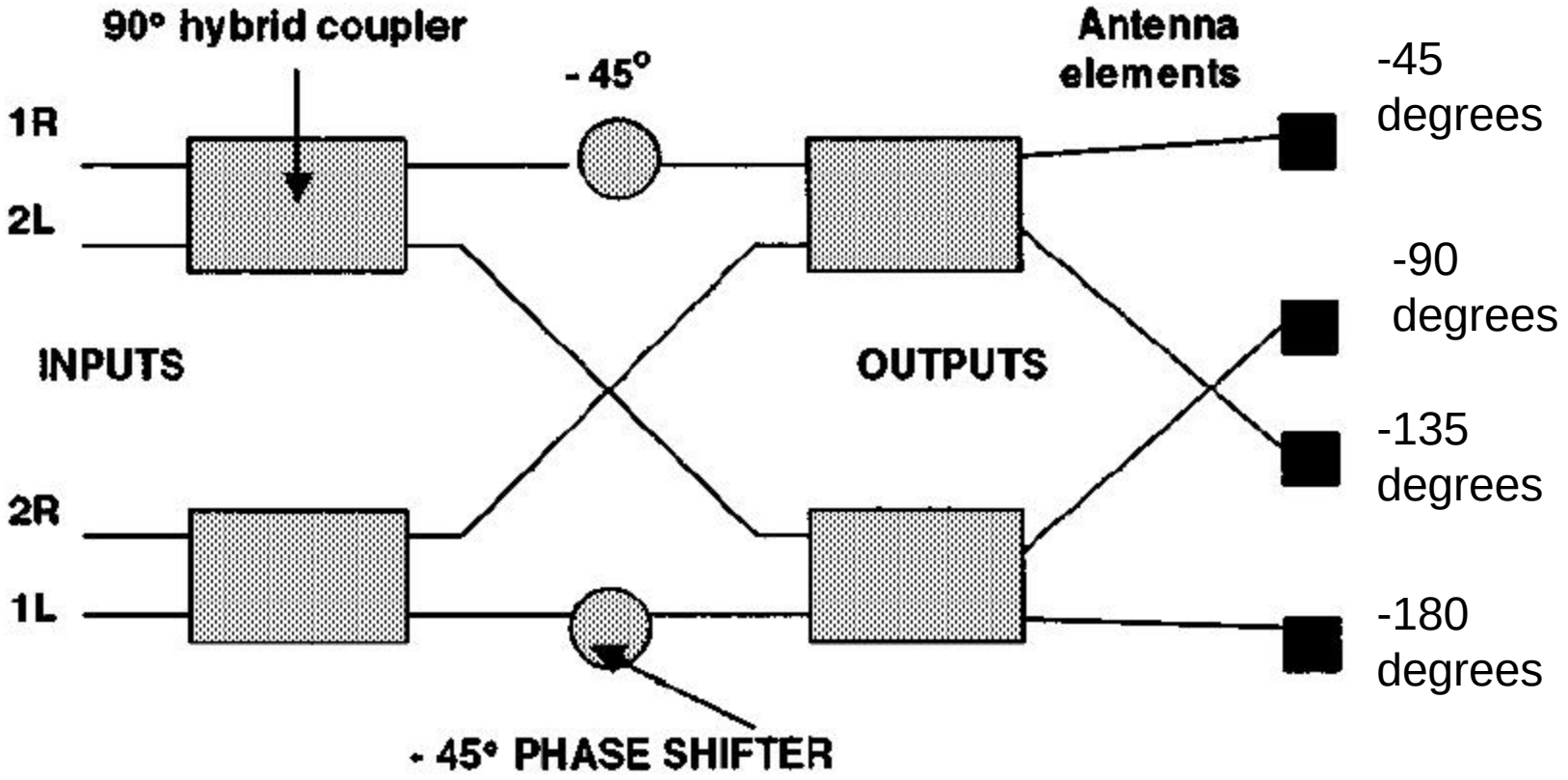


Multiple beamformers

- Blass matrix
  - Arbitrary number of independent beams (M)
  - Requires a large number of transmission lines and couplers (MN couplers; N radiating elements,waveguides,terminations)
- Butler matrix
  - Limited to 2^N independent beams and radiating elements
  - Requires $(N/2)\log_2 N$ couplers and $(n/2)\log_2(N-1)$ phase shifters

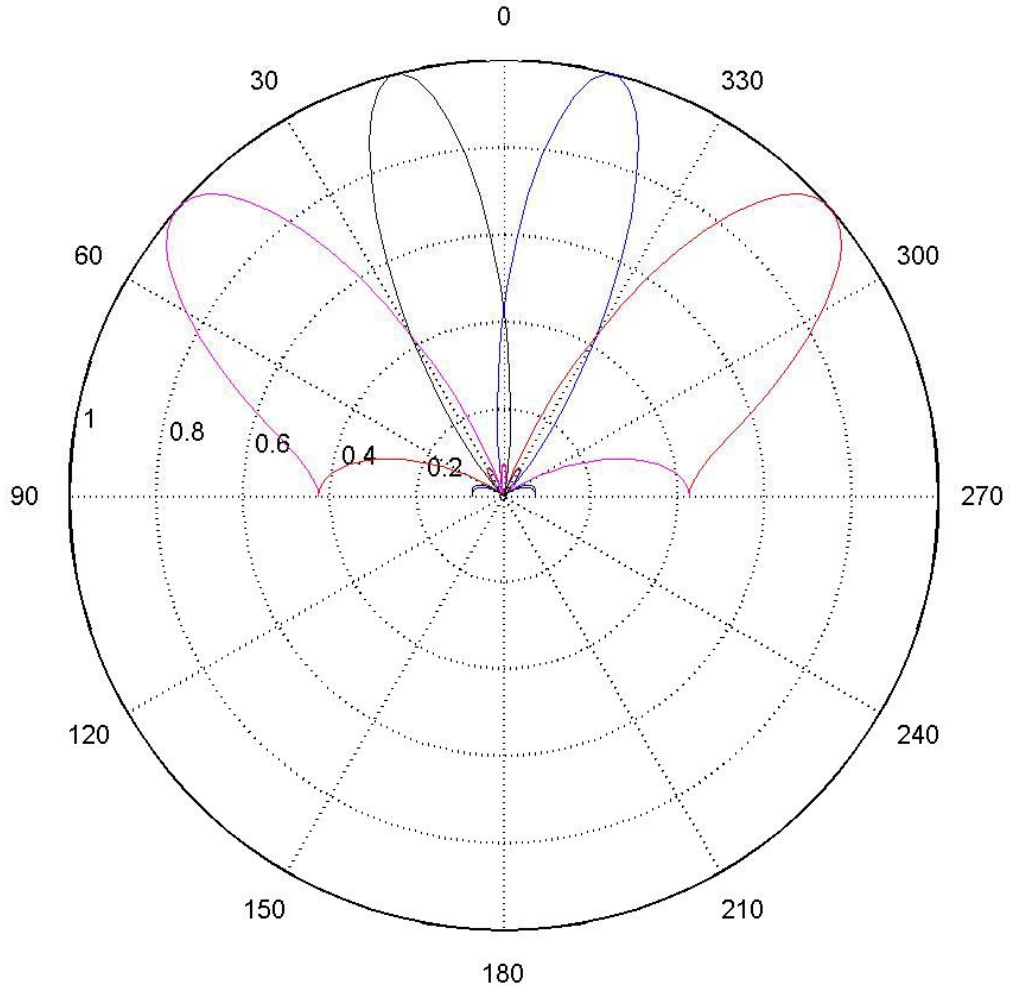
Fixed Multiple Beam Arrays

BUTLER MATRIX BEAMFORMER



Φ=-45 degrees

Fixed Multiple Beam Arrays



Statement of the Problem

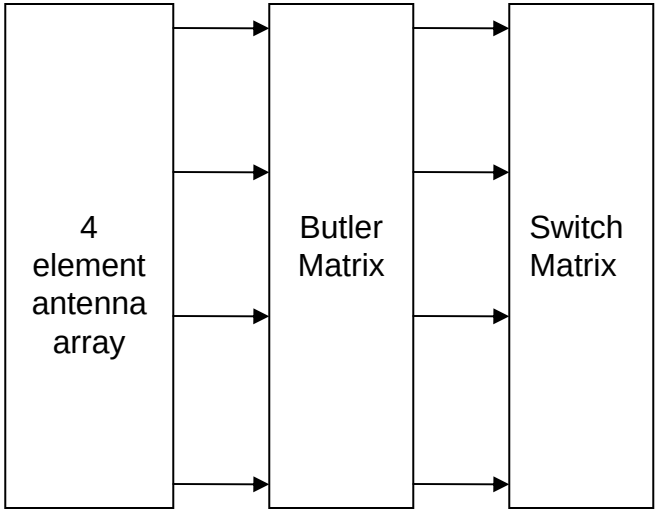
- Most studies on the use of directional antennas on mobile networks require some modification to the MAC of the system
- Physical performance of multi-beam antennas on 802.11b networks need to be investigated

Objectives

- To design and implement a switched multi-beam antenna array prototype that is transparent to the MAC of existing 802.11b networks
- To integrate the prototype with a commercial of the shelf IEEE 802.11b access point
- To measure the performance (throughput, coverage, latency) of a network employing the switched multi-beam prototype and compare its performance with omnidirectional antennas

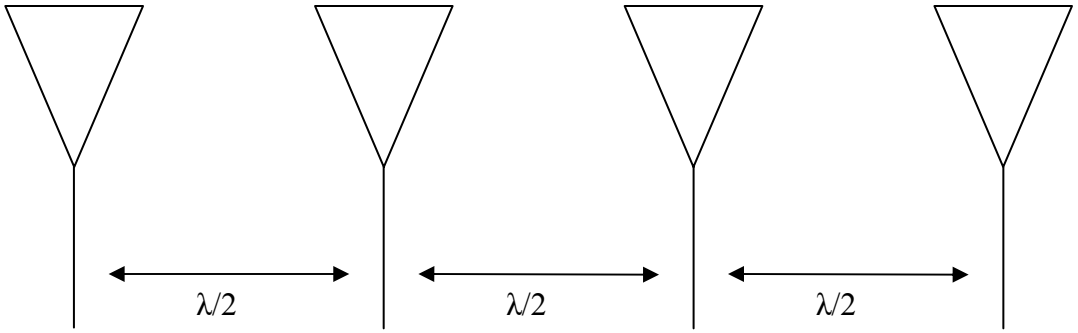
Methodology

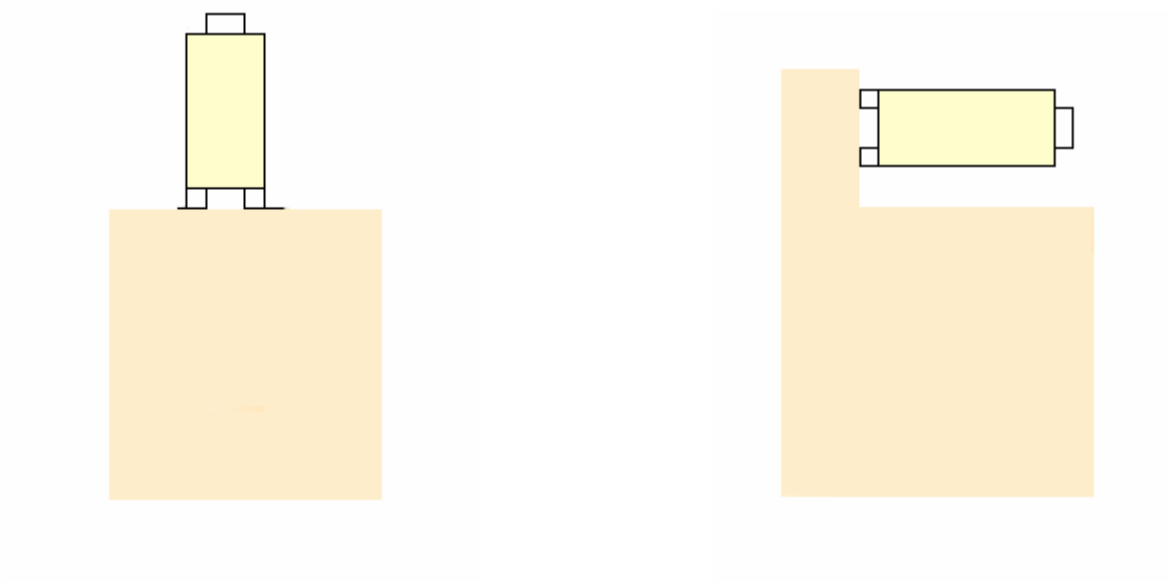
Proposed Switched Multi-beam Prototype



Methodology

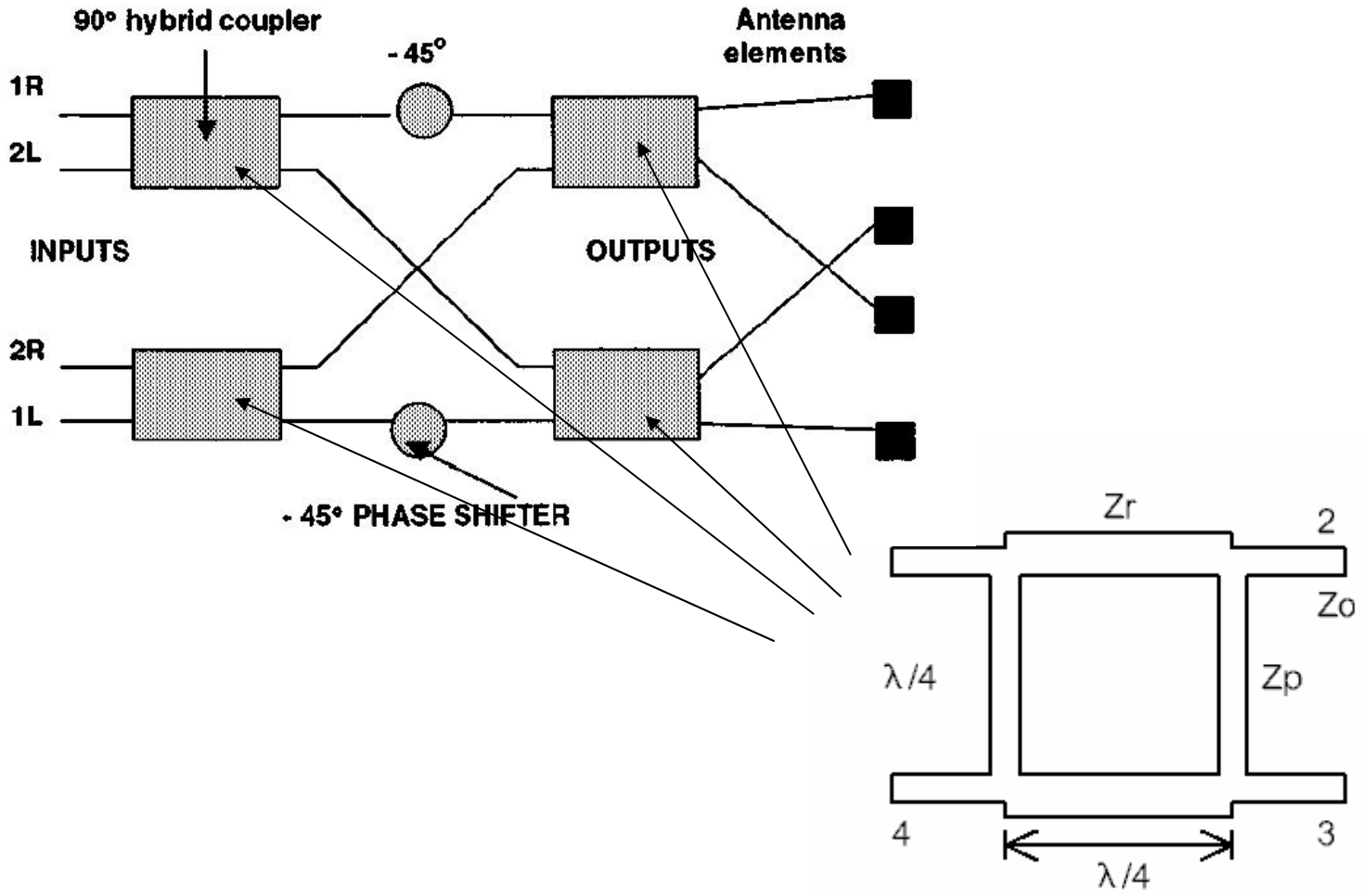
Antenna Array





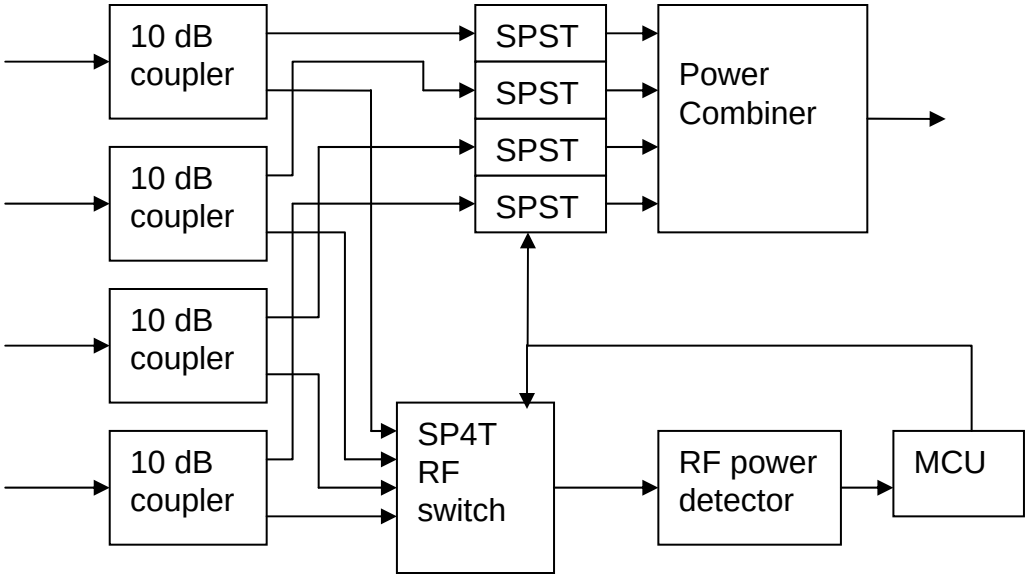
Methodology

Butler Matrix



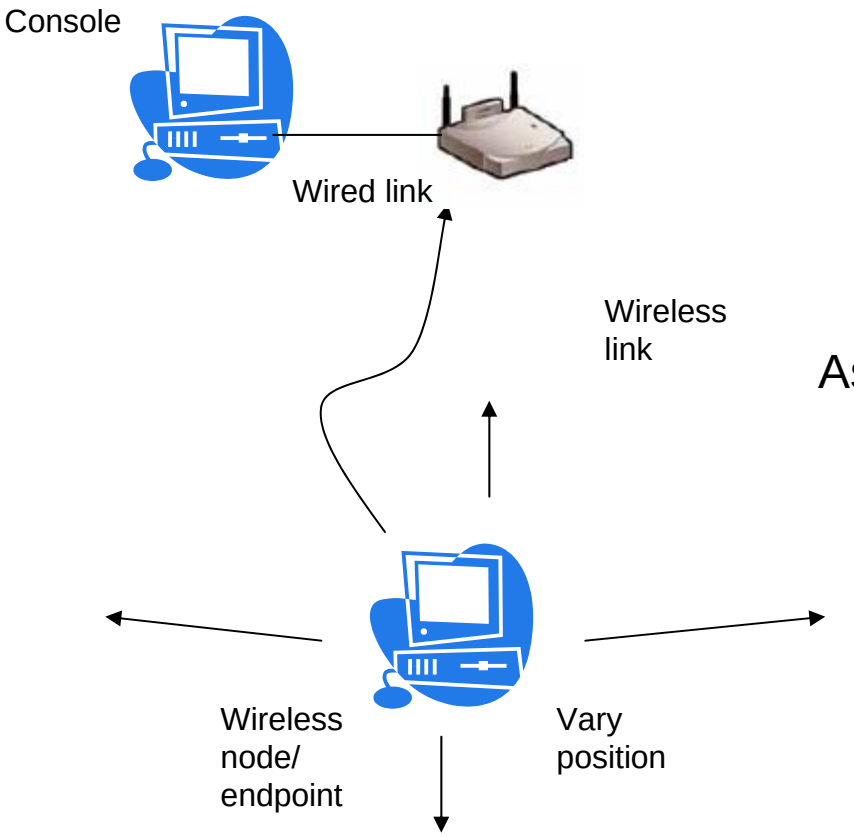
Methodology

Switch Matrix



Test Setup

Single User Setup



Measure

- Throughput
- Packet error rate
- Signal strength
- Latency

As a function of

- Distance
- Azimuthal angle

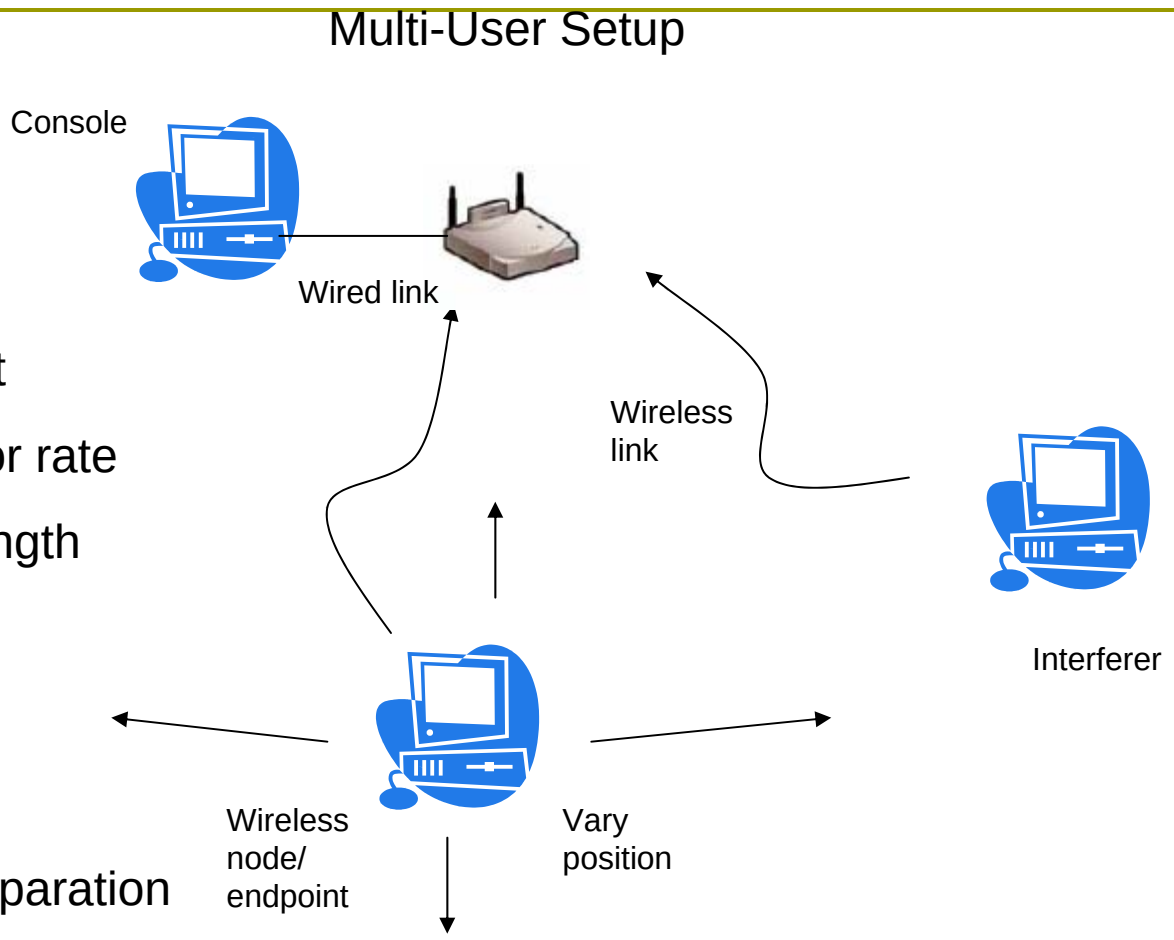
Test Setup

Measure

- •Throughput
- •Packet error rate
- •Signal strength
- •Latency

As a function of

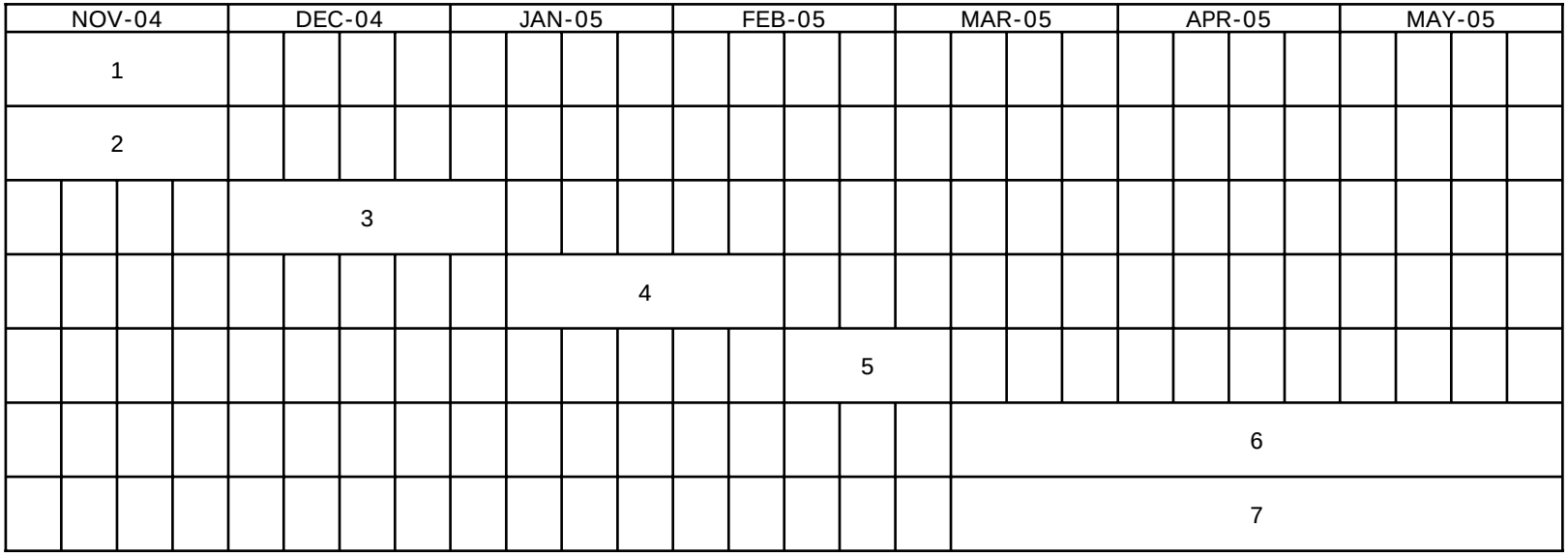
- •Distance
- •Angular Separation
- •Number of clients



Methodology

- Qcheck
  - Measures throughput, response time, packet loss
  - freeware
- Airopeek
  - Data rate, channel, signal strength
  - Proprietary, limited version demo downloadable

Methodology



1 Procurement

2 Implementation of Array

3 Implementation of Butler Matrix

4 Implementation of Switch Matrix

5 Integration

6 Testing

7 Documentation

THANK
YOU