Gigabit/s **W**ireless-over-Fibre **S**ystems

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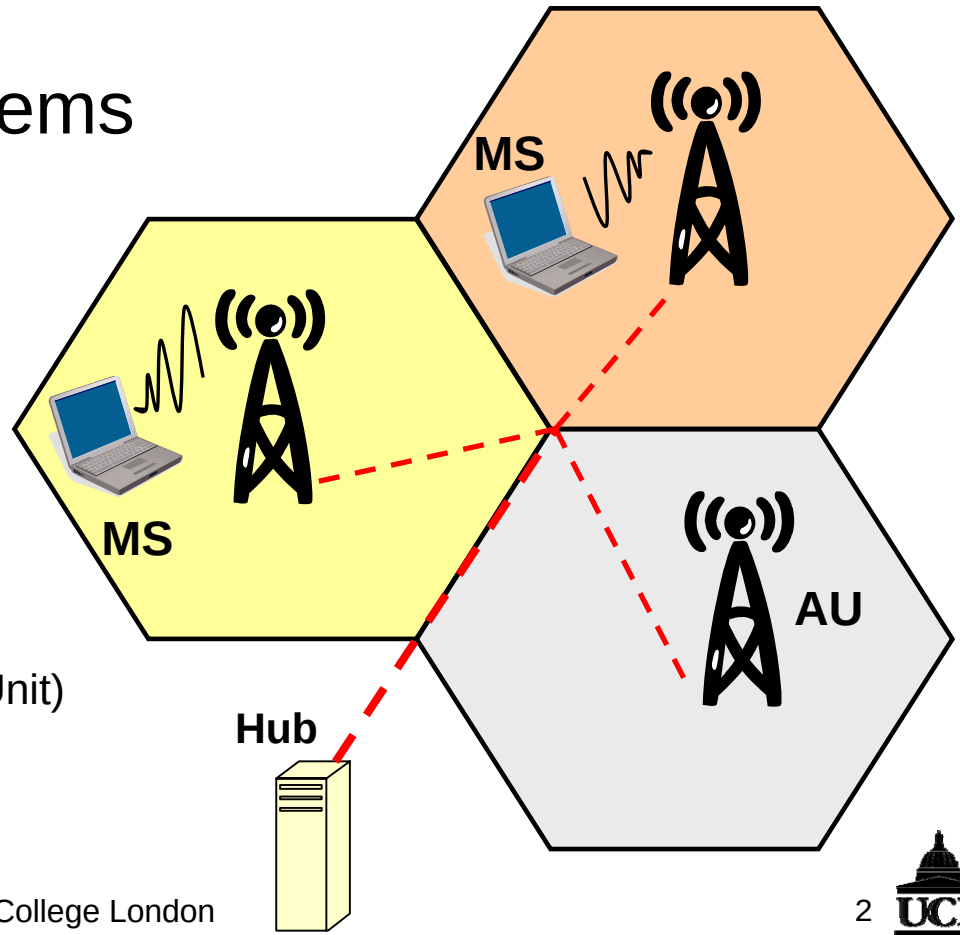
Introduction

Future Gigabit/s Wireless Access Networks

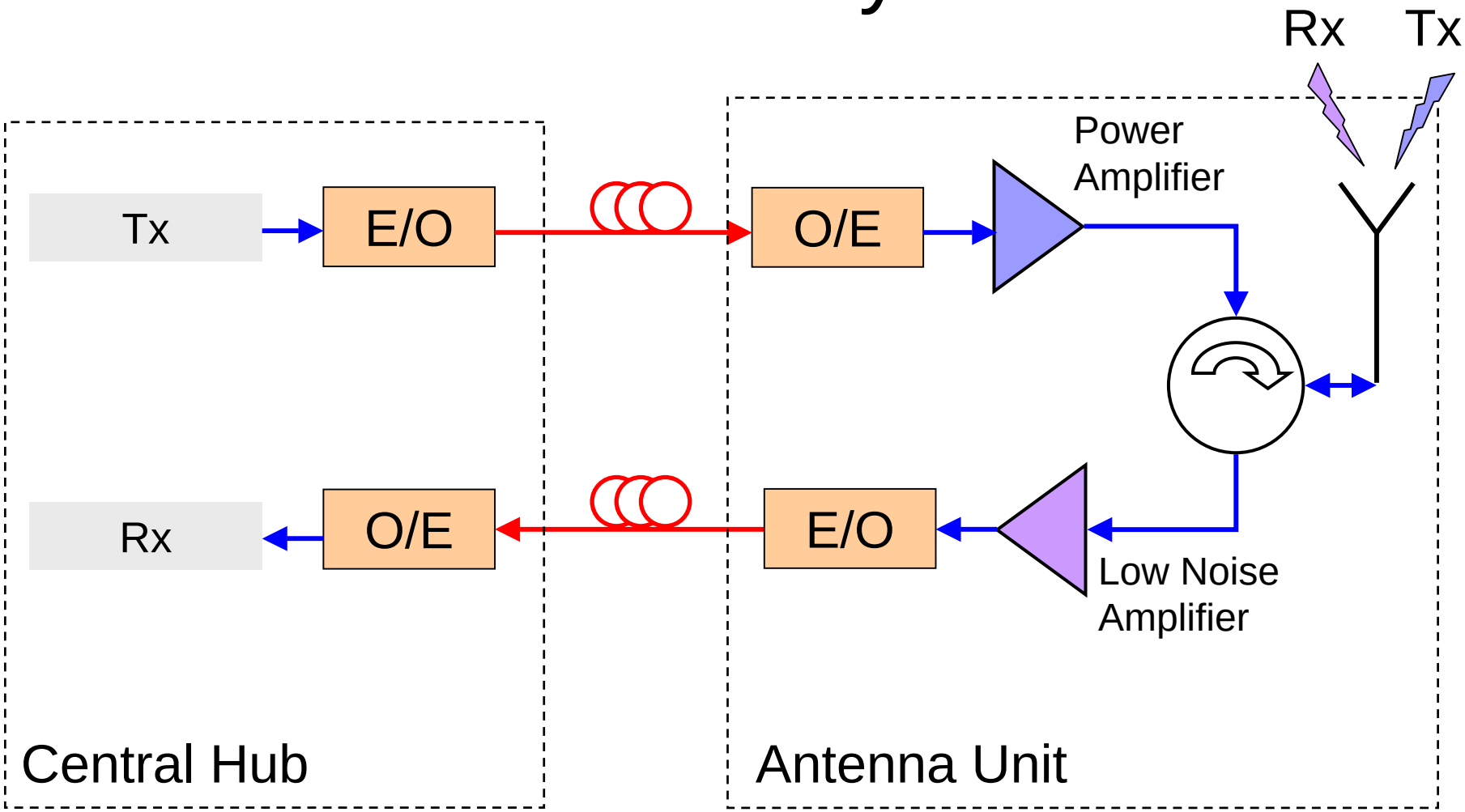
Wireless-over-Fibre systems

Millimetre-waves



Logical Optical Link
AU Antenna Unit
MS Mobile Station
(Mobile, Portable or Fixed Customer Unit)

Wireless over Fibre System



Motivation

- Coverage extension of wireless networks
- Merging optical and wireless networks
- Feasibility study on Wireless-over-Fibre for
  - delivering 1 Gbit/s wireless data to portable or fixed customer units
  - at millimetre-wave frequencies
  - in an indoor/urban environment

Why use Wireless-over-Fibre ?

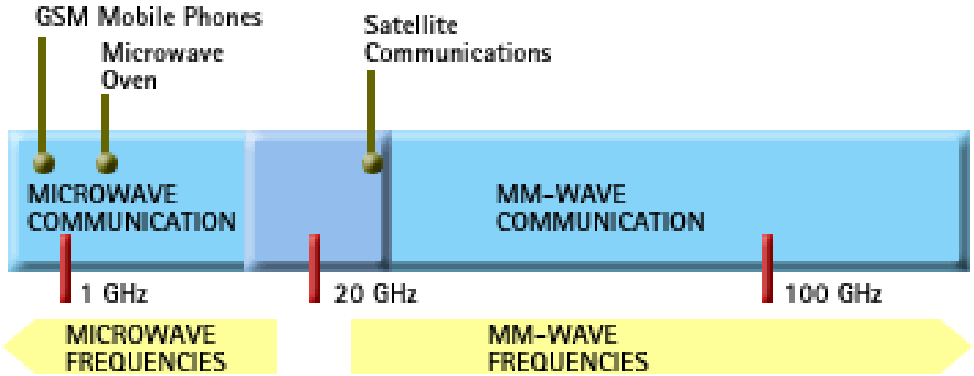
- Transparent to modulation format
  - Multi-service distribution
  - Future-proof
- Higher capacity than copper cable
- Extended reach
  - 0.5 dB per km RF loss penalty
- Higher reliability
  - Immunity to radio frequency interference
  - Privacy and security
  - Low dependence on environmental conditions
- No extra spectrum required for backhaul

Outline

- Wireless Sub-system
  - Millimetre waves, specifications
- Optical Distribution of wireless signals
  - Transport schemes, network architectures
- Initial Experimental work

Wireless Sub-system

Millimetre-waves (mm-waves)

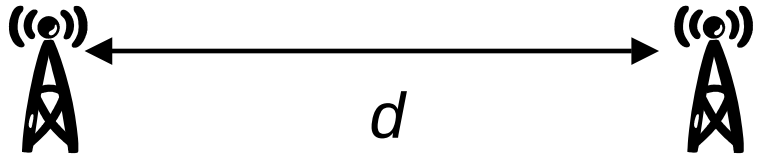


- Features
  - 30 – 300 GHz
  - high atmospheric attenuation and obstruction loss
  - short propagation distances
- Benefits
  - Large available spectrum for Gbit/s transmissions
  - High frequency reuse factor for pico-cellular systems
- Drawbacks
  - Requires Line of Sight (Point-to-Point Links)

Wireless Sub-system Specifications

- Carrier frequency : ~40 GHz
  - Technology useable : 30 – 70 GHz
- Pico-cellular coverage
  - Cell-radius : 10 – 20 m
- Wireless transfer data rates : 1 Gbit/s
- Point-to-Multipoint

Wireless coverage



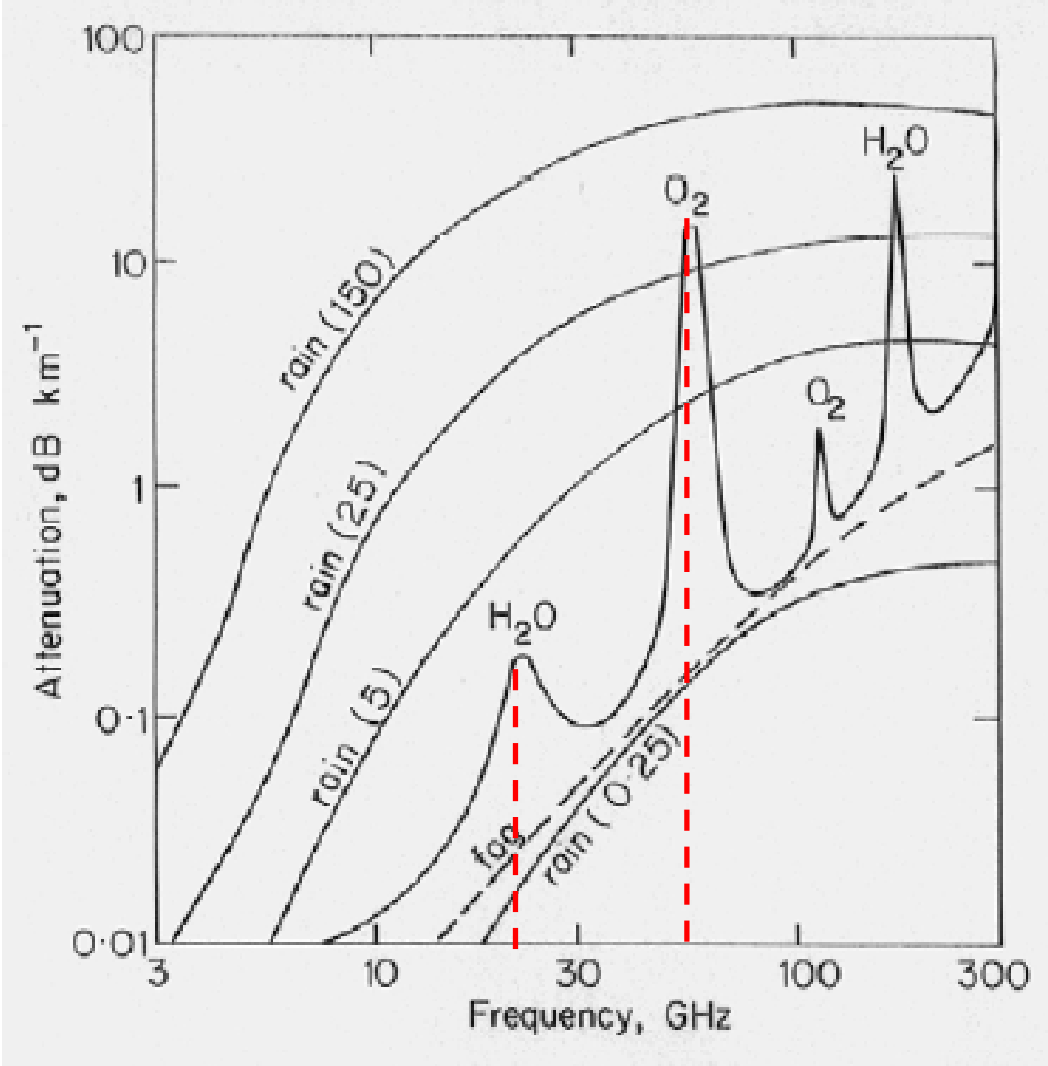
- Free Space Model

$$20 \times Log(d) = EIRP + G_{Rx} - 20 \times Log\left(\frac{4\pi f}{c}\right) - 10 \times Log\left(k_B WT\right) - SNR - NF - Fm - A$$

  - Maximum propagation distance d, carrier frequency f
  - EIRP = 10. Log($P_{Tx}.G_{Tx}$), Rx Antenna Gain (G_{Rx})
  - Fade Margin (Fm), Additional Loss (A)
  - Rx Bandwidth (W), Rx Noise Figure (NF)
  - Temperature (T), Boltzmann's constant k_B

Additional Attenuation factors

- Atmospheric Gases
  - Water Vapour (H_2O)
    0.2 dB/km at 24 GHz
  - Oxygen (O_2)
    15 dB/km at 60 GHz
- Rain
- Foliage Blockage
- Scattering, Diffraction

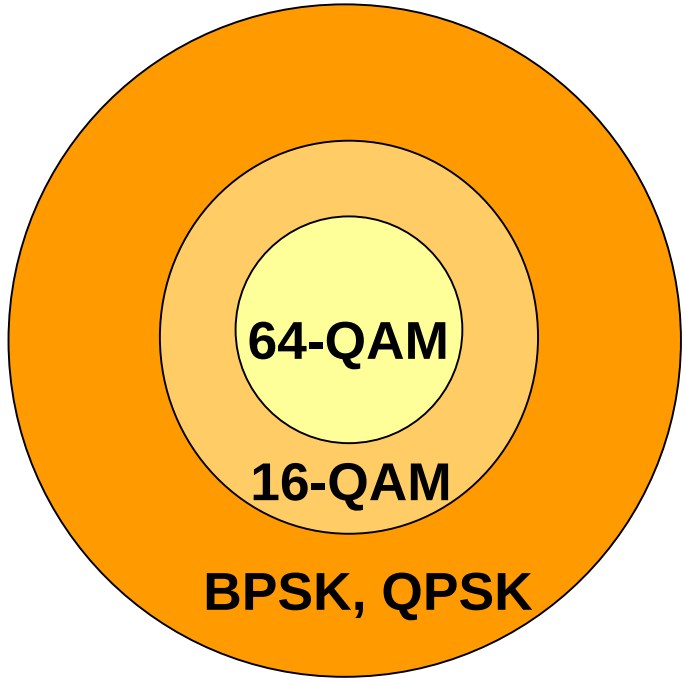


Modelling Parameters

- EIRP : 20 dBm (100 mW)
- Antenna gain : 10 dB
- Carrier frequency : 40 GHz
- Rx noise figure : 5 dB
- Fade Margin : 20 dB (urban environment)
- Temperature : 295 K

Wireless Coverage

- WiMAX (IEEE 802.16)
  - 1 Gbit/s transfer
  - Various modulation schemes

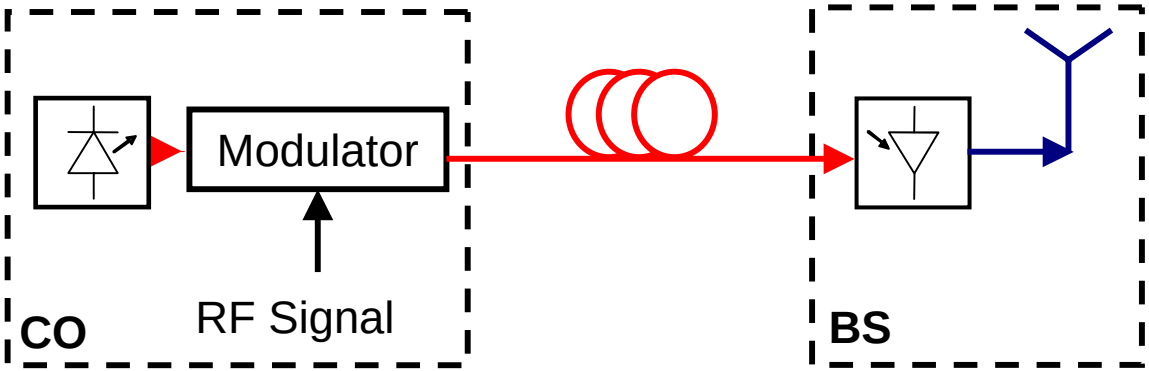


Modulation Scheme	SNR required (dB)	Bandwidth Efficiency (Mbits/s/MHz)	Bandwidth required (MHz) for 1Gbits/s transfer	Distance d (m)
64-QAM	22	4.8	208.33	3.6
16-QAM	16	3.2	312.50	5.9
QPSK	9	1.6	625.00	9.4
BPSK	6	0.8	1250.00	9.4

Optical Distribution Network

Wireless-over-Fibre Transportation Schemes

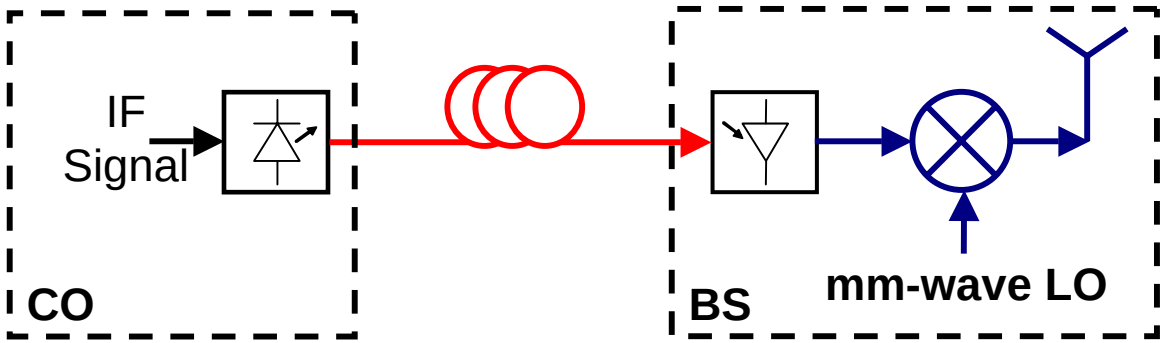
- Radio Frequency (RF) over Fibre



Benefit
No frequency conversion

Drawbacks
Expensive components
Dispersion effects

- Intermediate Frequency (IF) over Fibre

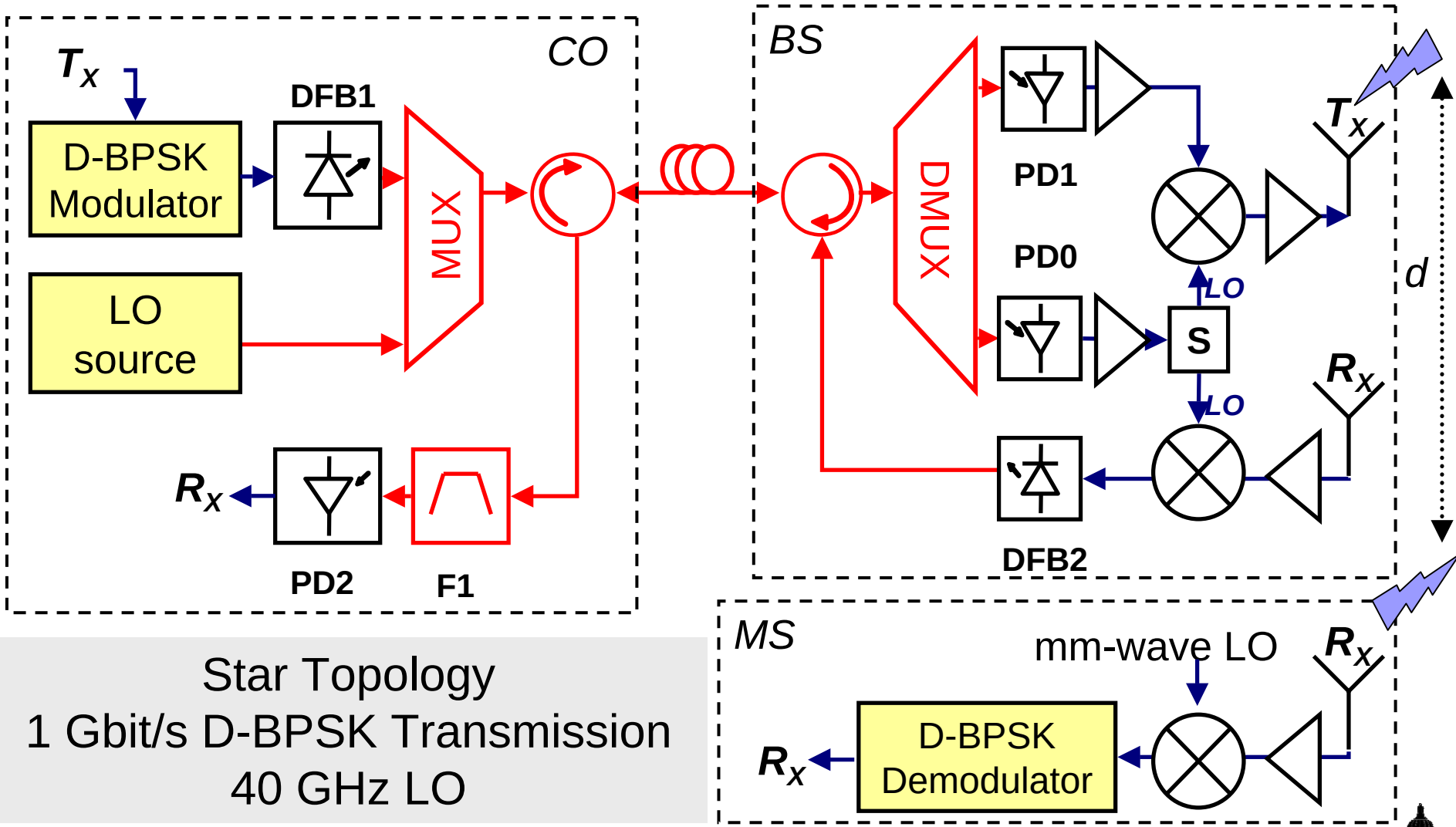


Benefits
Cheaper components
Reduced dispersion effects

Drawback
Frequency conversion

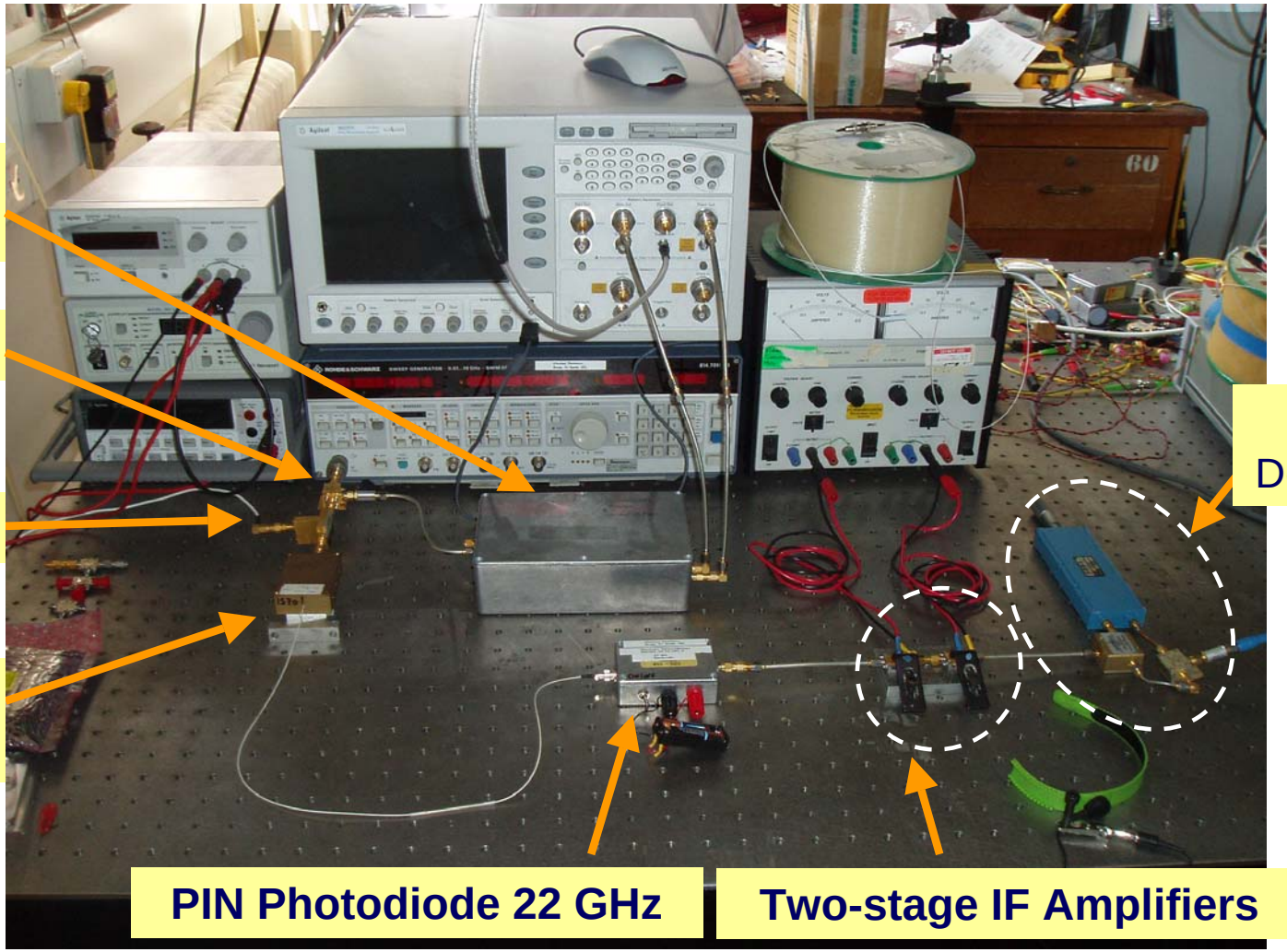
Experimental work

Experimental Demonstrator



Star Topology
1 Gbit/s D-BPSK Transmission
40 GHz LO

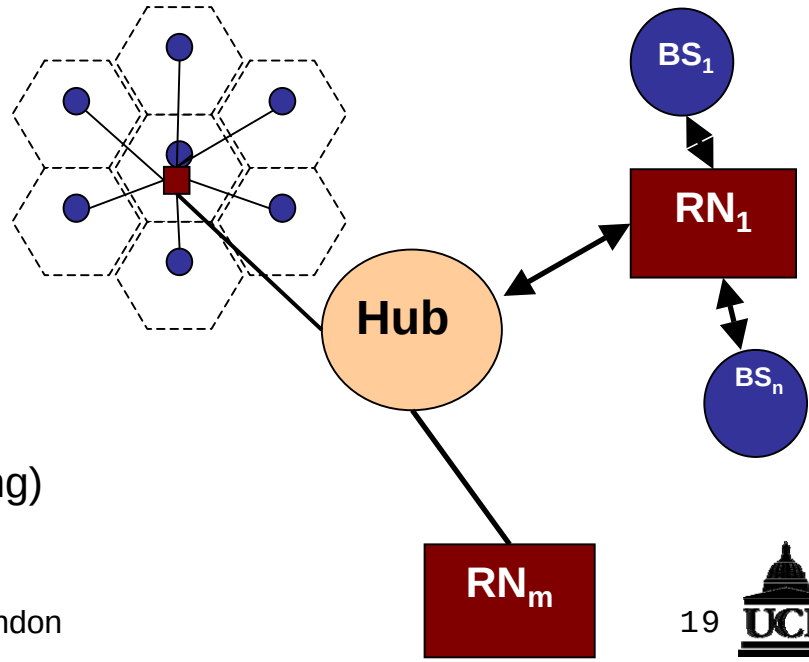
Demonstrator



Optical Distribution Network

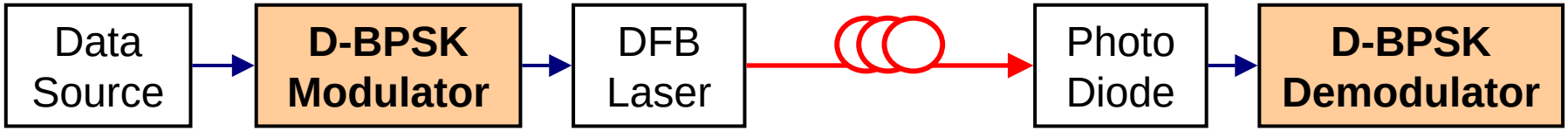
In this project,

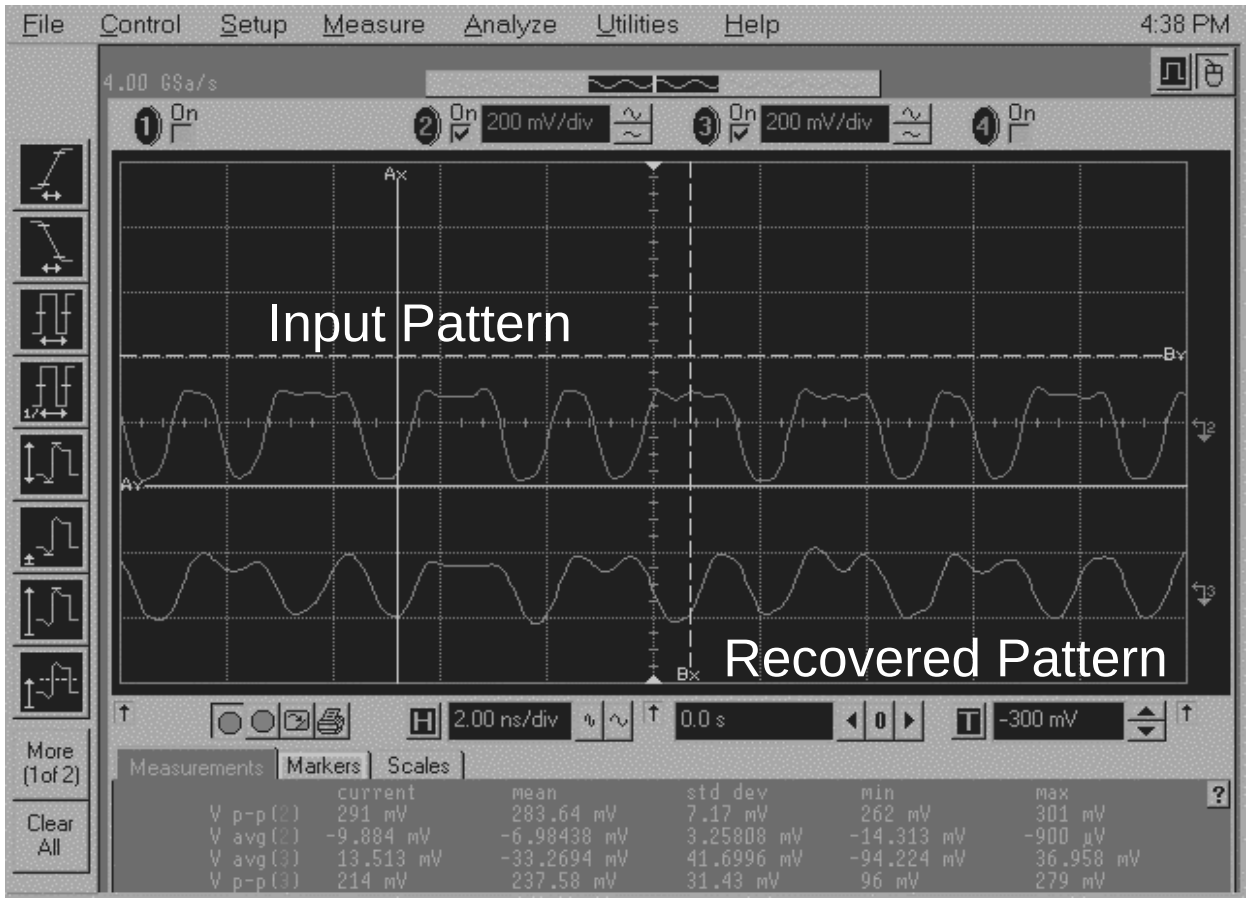
- IF-over-Fibre
  - Direct modulation of uncooled CWDM DFB lasers
  - Optical delivery of a mm-wave reference LO
  - Bidirectional links (SMF)
- Network Topologies
  - Star (Indoor)
  - Star-Tree (Outdoor)



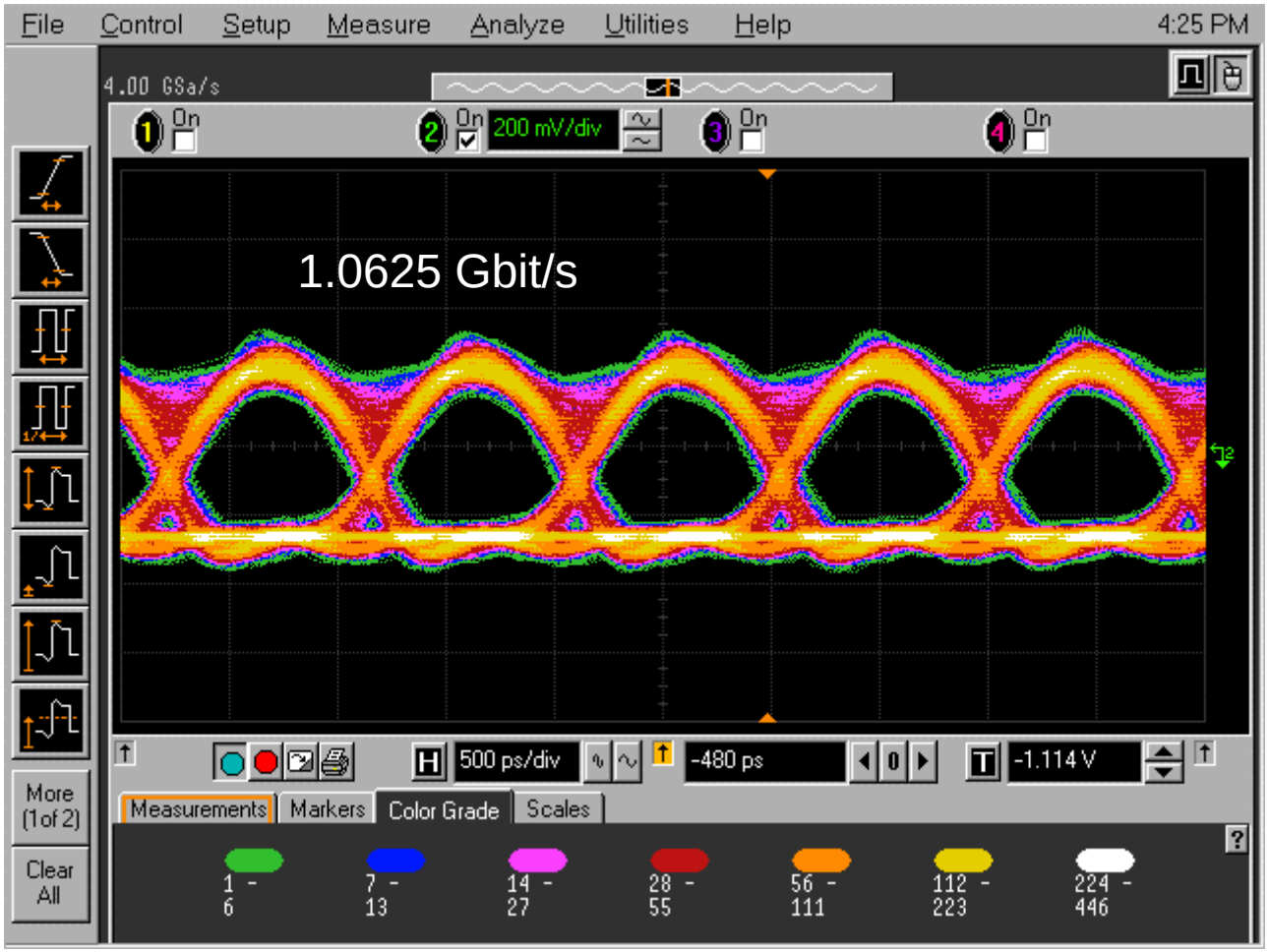
(CWDM : Coarse Wavelength Division Multiplexing)
(RN : Remote Node, AU : Antenna Unit)

Preliminary Results





Demodulated Eye-Diagram



Conclusion

- mm-wave over Fibre : a suitable solution for merging optical and wireless networks to allow future Gigabit/s last-mile access
- Experimental demonstration of 1 Gbit/s D-BPSK wireless over fibre transmission at mm-wave frequency in progress