UNIVERSITY OF CAMBRIDGE

A Cambridge lesson on building your own fibre network

1992 – Present: Reflecting on the first 25 years

Jon Holgate, Head of Networks

1992 - Present

Proposed in March 1987

Network Working Group S. Romano
Request for Comments: 1020 M. Stahl
Obsoletes RFCs: 997, 990, 960, 943, SRI
923, 900, 870, 820, 790, 776, 770, 762, November 1987
758, 755, 750, 739, 604, 503, 433, 349
Obsoletes IENs: 127, 117, 93

INTERNET NUMBERS

STATUS OF THIS MEMO

This memo is an official status report on the network numbers used in the Internet community. Distribution of this memo is unlimited.

Introduction

The responsibility for the assignment of IP numbers and ASNs has been assumed by Hostmaster at the DDN Network Information Center (NIC). The Hostmaster staff are indebted to Dr. Jon Postel and Ms. Joyce Reynolds of the Information Sciences Institute at the University of Southern California for their ongoing assistance.

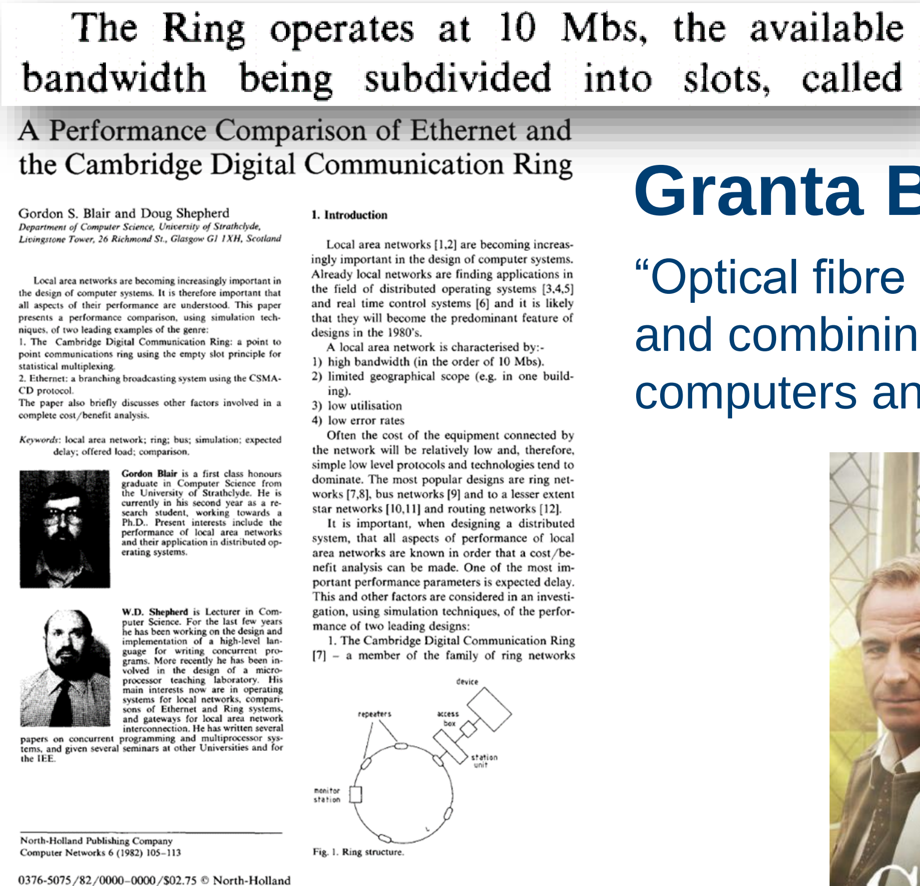
This Network Working Group Request for Comments documents the currently assigned network numbers and gateway autonomous systems.

World Wide Web - 1991

R 128.214.rrr.rrr	FUNET	Finnish Univ Network	[39,JH141]
C*128.215.rrr.rrr	INTEL-NET	INTEL Engineering Network	[12,HC24]
R 128.216.rrr.rrr	CC-PRNET	CENTCOM Packet Radio Net	[39,GIH]
G*128.217.rrr.rrr	NASA-KSC-OIS	NASA-KSC-OIS	[39,GG43]
R 128.218.rrr.rrr	UCSF-NET	Univ of Calif, San Fran	[39,TF6]
R 128.219.rrr.rrr	ORNL-NETB1	ORNL Local Area Network	[24,THD]
R 128.220.rrr.rrr	JHU	Johns Hopkins Univ	[39,MH98]
R 128.221.rrr.rrr	DGPN1	Data General Priv Net 1	[39,PSS1]
C 128.222.rrr.rrr	DGPN2	Data General Priv Net 2	[39,PSS1]
R 128.223.rrr.rrr	UONET	Univ of Oregon Network	[39,DS85]
C*128.224.rrr.rrr	EPILOGUE	Epilogue Technology	[KA4]
C*128.225.rrr.rrr	BOEING-EN	Boeing-East Network	[39,JSY3]
R 128.226.rrr.rrr	BINGHAMTON	UNIVATBINGHAMTON	[39,RM120]
R 128.227.rrr.rrr	UFNET	Univ of Florida Net	[39,AW48]
R 128.228.rrr.rrr	CUNY	City Univ of New York	[39,SMP2]
R 128.229.rrr.rrr	ADSNET	Advanced Decision Sys Net	[39,MB26]
R 128.230.rrr.rrr	SYR-UNIV-NET	Syracuse Univ Network	[39,JW47]
G 128.231.rrr.rrr	NIH-NET	Natl Institutes of Health	[12,RF57]
R*128.232.rrr.rrr	CL-CAM-AC-UK	Univ of Cambridge Comp Lab	[39,MAJ1]
R*128.233.rrr.rrr	USASK	Univ of Saskatchewan Net	[39,LRC7]
R*128.234.rrr.rrr	COS-NET	COS Network	[39,AP25]
R 128.235.rrr.rrr	NJIT	NJIT Network	[39,BM79]
D 128.236.rrr.rrr	USAFA-NET	US Air Force Academy Net	[39,GEOFF]
R 128.237.rrr.rrr	CMU-SEI-NET	SEI Ethernet	[39,PDB5]
R 128.238.rrr.rrr	POLY-U-NET	Polytechnic Univ Net	[39,AMM14]
R 128.239.rrr.rrr	WM-NET	William and Mary Net	[39,SF34]
R 128.240.rrr.rrr	NCL	Newcastle Campus Net	[39,AL46]
R 128.241.rrr.rrr	SESQUINET	SESQUINET	[GTA]
R 128.242.rrr.rrr	MIDNET	Midwest Regional Network	[MM147]
R*128.243.rrr.rrr	NOTT-AC-UK	Univ of Nottingham Net	[39,WA16]
D 128.244.rrr.rrr	APL-NET	Applied Physics Lab Net	[39,SAK3]
R 128.245.rrr.rrr	SRA-CT-NET	SRA-CONNECTICUT-NET	[15,16,JSS4]
C*128.246.rrr.rrr	CGCH-WTRZ	WTRZ Scientific Net	[12,HN3]

Cambridge was always making a difference (engine)

University Network - 1977


The Ring operates at 10 Mbs, the available bandwidth being subdivided into slots, called

A Performance Comparison of Ethernet and the Cambridge Digital Communication Ring

Gordon S. Blair and Doug Shepherd
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Local area networks are becoming increasingly important in the design of computer systems. It is therefore important that all aspects of their performance are understood. This paper presents a performance comparison, using simulation techniques, of two leading examples of the genre:
1. The Cambridge Digital Communication Ring: a point to point communications ring using the empty slot principle for statistical multiplexing.
2. Ethernet: a branching broadcasting system using the CSMA-CD protocol.
The paper also briefly discusses other factors involved in a complete cost/benefit analysis.

Keywords: local area network; ring; bus; simulation; expected delay; offered load; comparison.

Gordon Blair is a first class honours graduate in Computer Science from the University of Strathclyde. He is currently in his second year as a research student, working towards a Ph.D.. Present interests include the performance of local area networks and their application in distributed operating systems.

W.D. Shepherd is Lecturer in Computer Science. For the last few years he has been working on the design and implementation of a high-level language for writing concurrent programs. More recently he has been involved in the design of a microprocessor teaching laboratory. His main interests now are in operating systems for local networks, comparisons of Ethernet and Ring systems, and gateways for local area network interconnection. He has written several papers on concurrent programming and multiprocessor systems, and given several seminars at other Universities and for the IEE.

North-Holland Publishing Company
Computer Networks 6 (1982) 105–113

0376-5075/82/0000–0000/$02.75 © North-Holland

1. Introduction

Local area networks [1,2] are becoming increasingly important in the design of computer systems. Already local networks are finding applications in the field of distributed operating systems [3,4,5] and real time control systems [6] and it is likely that they will become the predominant feature of designs in the 1980's.

A local area network is characterised by:-
1) high bandwidth (in the order of 10 Mbs).
2) limited geographical scope (e.g. in one building).
3) low utilisation
4) low error rates

Often the cost of the equipment connected by the network will be relatively low and, therefore, simple low level protocols and technologies tend to dominate. The most popular designs are ring networks [7,8], bus networks [9] and to a lesser extent star networks [10,11] and routing networks [12].

It is important, when designing a distributed system, that all aspects of performance of local area networks are known in order that a cost/benefit analysis can be made. One of the most important performance parameters is expected delay. This and other factors are considered in an investigation, using simulation techniques, of the performance of two leading designs:

1. The Cambridge Digital Communication Ring [7] – a member of the family of ring networks

Fig. 1. Ring structure.

Granta Backbone Network - 1987

"Optical fibre cabling across University and Colleges, and combining mainframe with other computers and personal machines."

Building a network: 1988 - 1992

£3.9 million (1992)

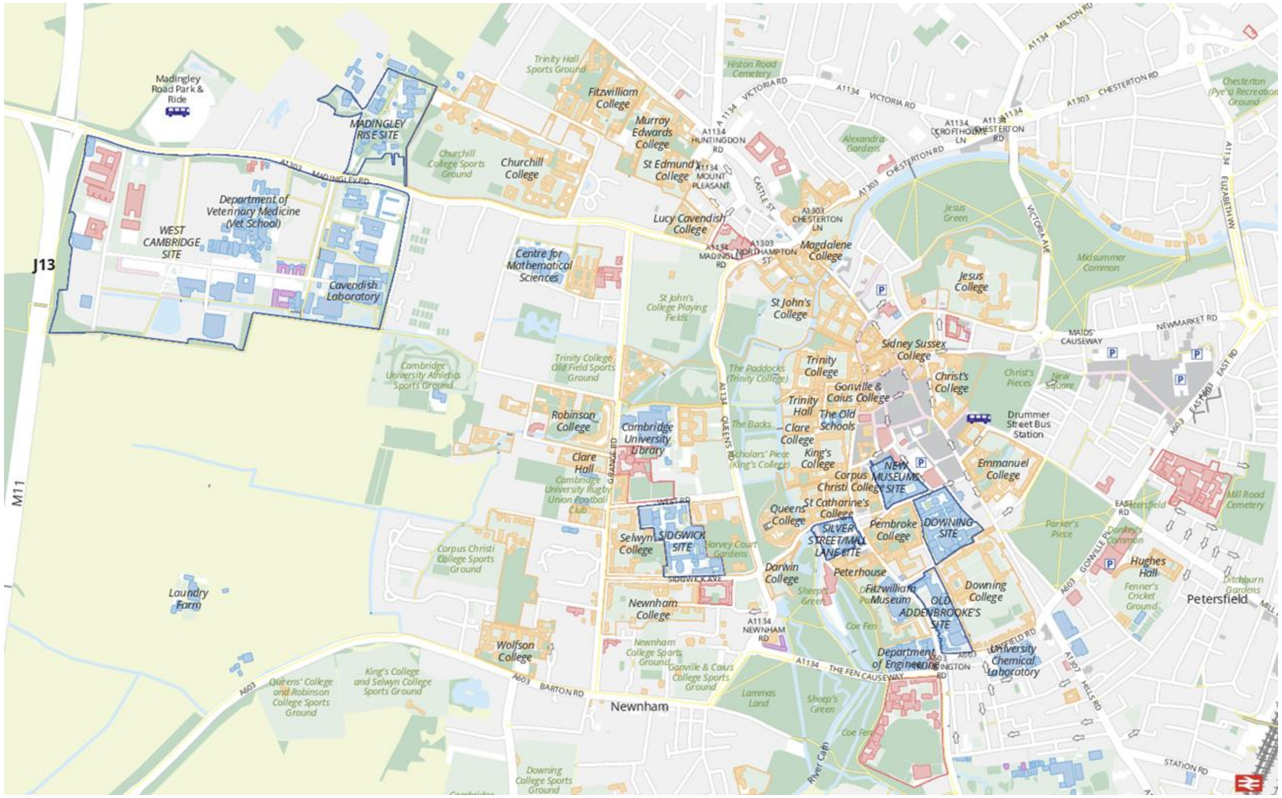
36kms ducting & tray work

Installed in:

1. Wine Cellars ~2.2km
2. Green spaces
3. Carriageway

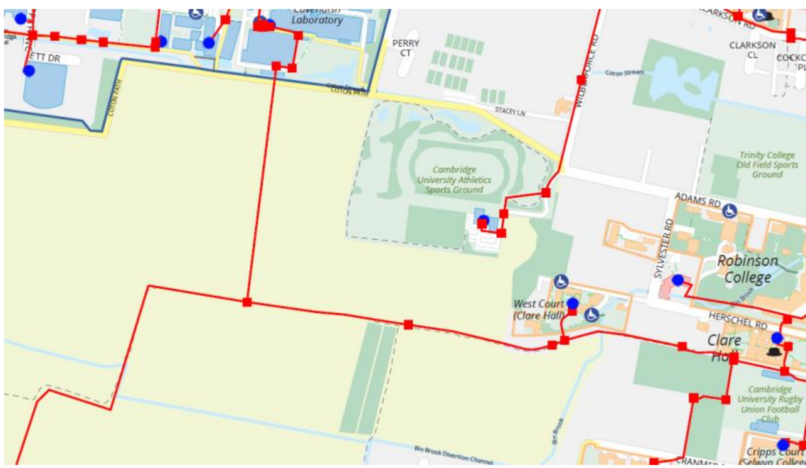
Wine Cellars

Green spaces and the perils of ‘soft dig’

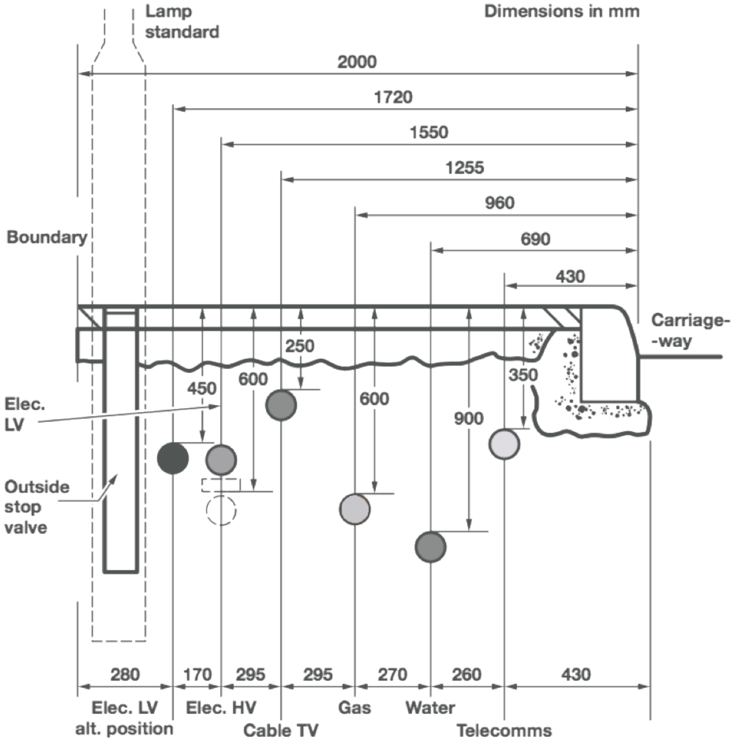


Green spaces and the perils of 'soft dig' cont.

Green spaces and the perils of 'soft dig'



Standards



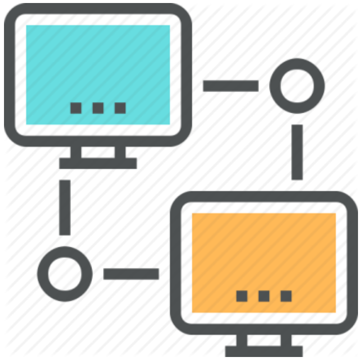
National Joint Utilities Group

Footway: 350mm Depth
Carriageway: 600mm Depth

UNIVERSITY OF CAMBRIDGE

Footway: 600mm Depth
Carriageway: 800mm Depth

What is the fibre used for?



LoRa™

What else is the fibre used for?

Building Management Systems

CCTV

Outside Public Wi-Fi

Data Centre Hosting

College Hostels

GBN Customers

Hills Road Sixth Form College Cambridge

VIRTUTE ET FIDE

British Antarctic Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

MRC Medical Research Council

Cambridgeshire County Council

CANCER RESEARCH UK

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31.

Anglia Ruskin University

long road

Long Road Sixth Form College Cambridge

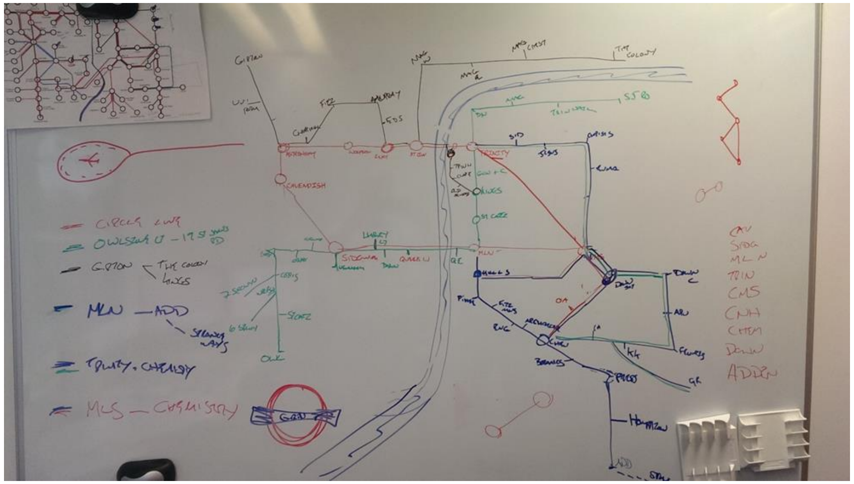
UNIVERSITY OF CAMBRIDGE MUSEUMS & BOTANIC GARDEN

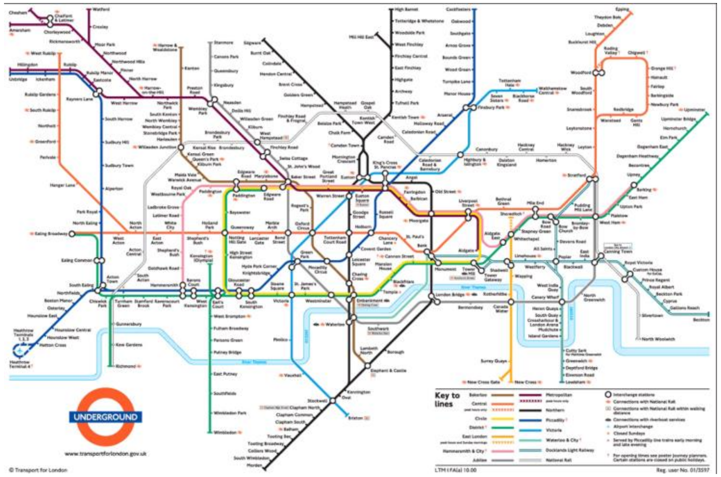
What is the cost of running a private fibre network?

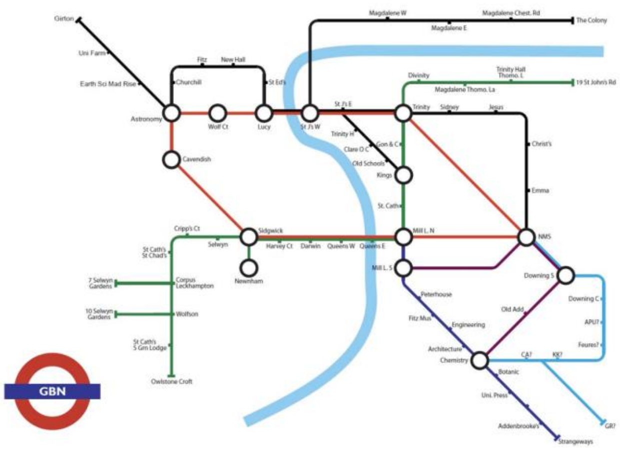
£500,000

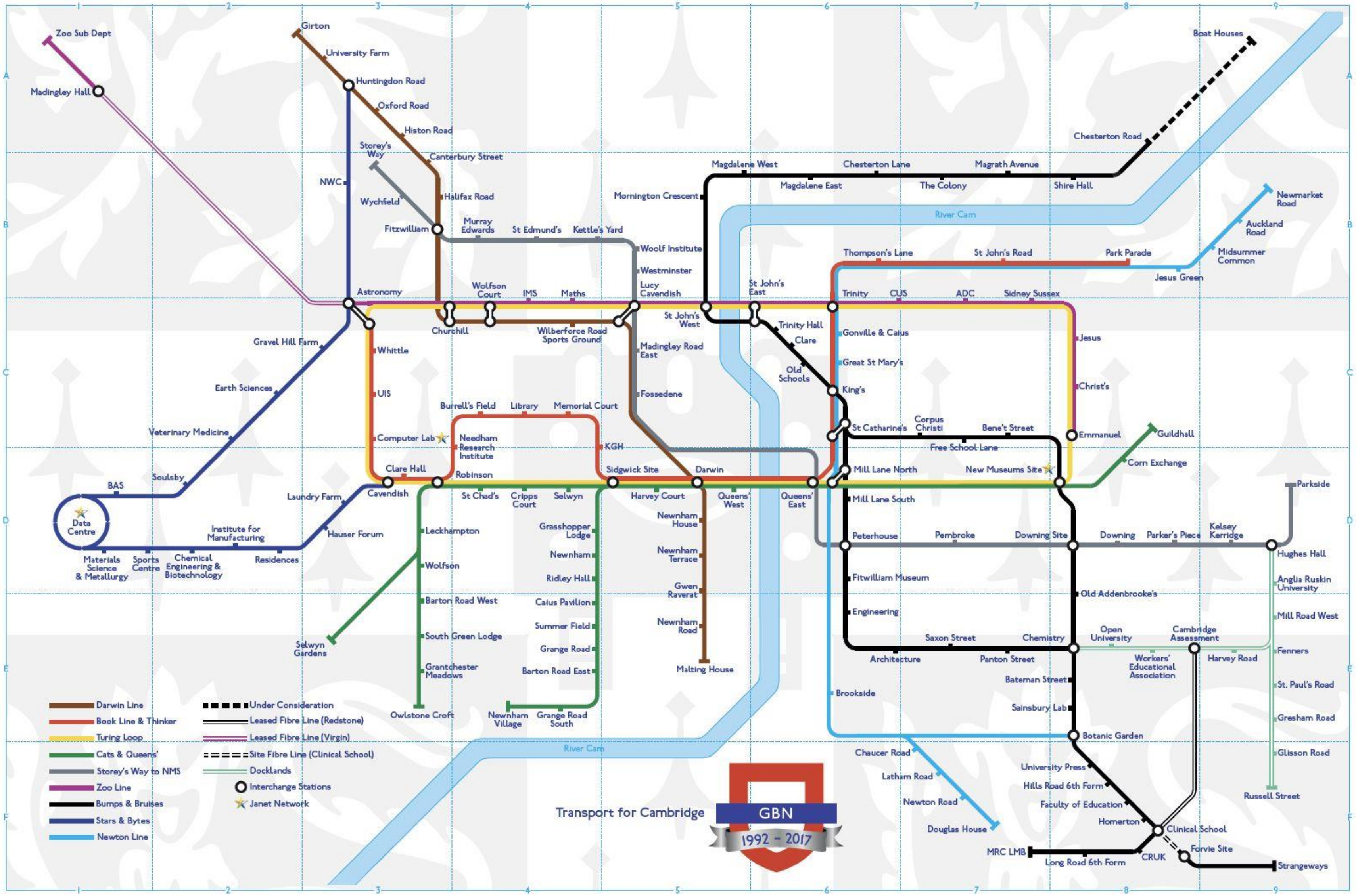
- ~850 active circuits
- £260 per kilometer
- Staff
- Equipment
- Maintenance of the network
- Extensions to the network
- Office overheads
- Promotion

Promoting the network, and the problems of theft







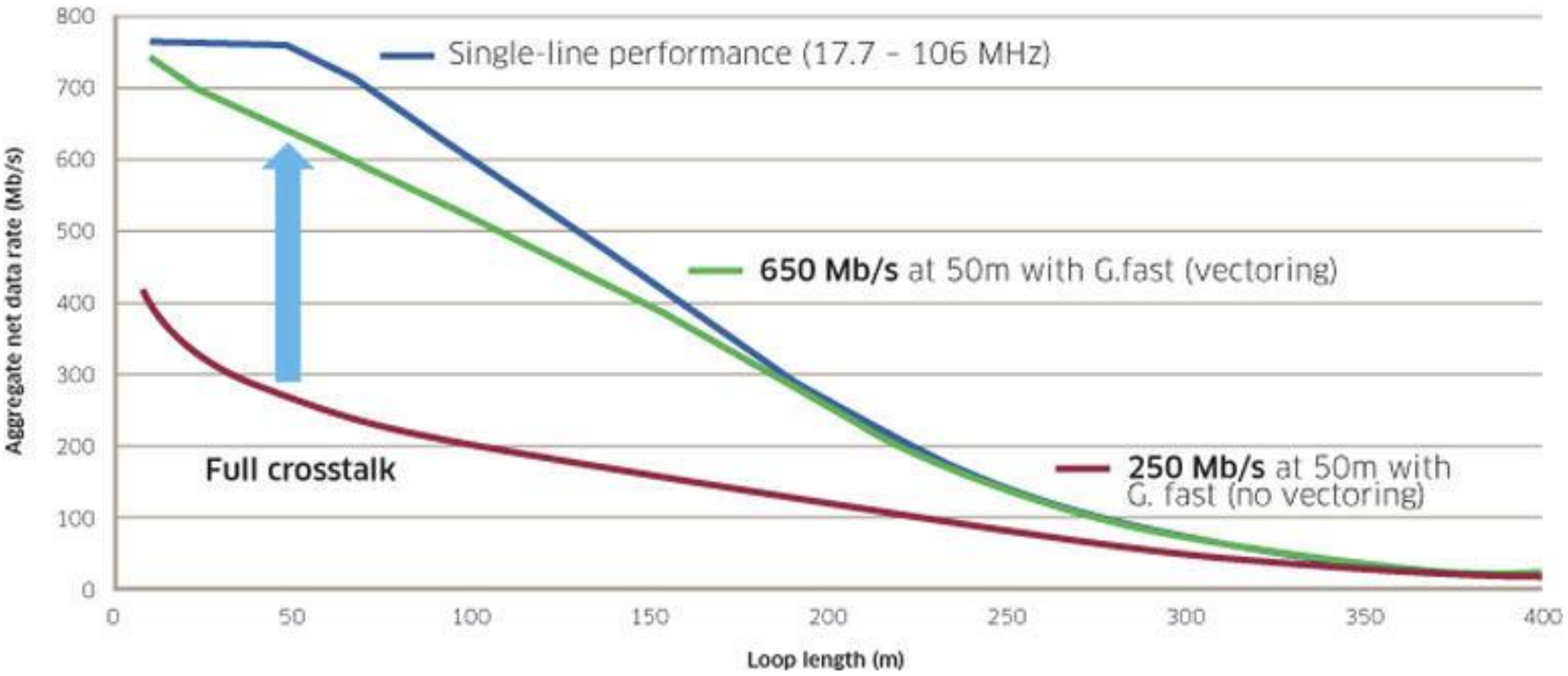


Zoo Sub Dept
Madingley Hall
Girton
University Farm
Huntingdon Road
Oxford Road
Histon Road
Canterbury Street
Storey's Way
Wychfield
NWC
Halifax Road
Fitzwilliam
Murray Edwards
St Edmund's
Kettle's Yard
Woolf Institute
Westminster
Lucy Cavendish
Mornington Crescent
Magdalene West
Magdalene East
Chesterton Lane
The Colony
Magrath Avenue
Shire Hall
Chesterton Road
Boat Houses
River Cam
Newmarket Road
Auckland Road
Midsummer Common
Jesus Green
Thompson's Lane
St John's Road
Park Parade
Astronomy
Wolfson Court
IMS
Maths
St John's East
St John's West
Trinity
CUS
ADC
Sidney Sussex
Churchill
Wilberforce Road Sports Ground
Trinity Hall
Clare
Old Schools
Gonville & Caius
Great St Mary's
Jesus
Christ's
King's
Madingley Road East
Fossedene
Gravel Hill Farm
Whittle
UIS
Earth Sciences
Veterinary Medicine
Burrell's Field
Library
Memorial Court
Computer Lab
Needham Research Institute
KGH
St Catharine's
Corpus Christi
Bene't Street
Free School Lane
Emmanuel
Guildhall
Corn Exchange
Soulsby
BAS
Clare Hall
Robinson
Sidgwick Site
Darwin
Mill Lane North
New Museums Site
Cavendish
Laundry Farm
St Chad's
Cripps Court
Selwyn
Harvey Court
Queens' West
Queens' East
Mill Lane South
Parkside
Data Centre
Hauser Forum
Institute for Manufacturing
Residences
Materials Science & Metallurgy
Sports Centre
Chemical Engineering & Biotechnology
Leckhampton
Grasshopper Lodge
Newnham House
Newnham Terrace
Newnham
Peterhouse
Pembroke
Downing Site
Downing
Parker's Piece
Kelsey Kerridge
Hughes Hall
Wolfson
Ridley Hall
Gwen Raverat
Fitzwilliam Museum
Anglia Ruskin University
Old Addenbrooke's
Barton Road West
Caius Pavilion
Newnham Road
Engineering
Mill Road West
Summer Field
Saxon Street
Chemistry
Open University
Cambridge Assessment
Selwyn Gardens
South Green Lodge
Grange Road
Architecture
Panton Street
Workers' Educational Association
Harvey Road
Fenners
Grantchester Meadows
Barton Road East
Malting House
Bateman Street
St. Paul's Road
Brookside
Sainsbury Lab
Gresham Road
Owlstone Croft
Newnham Village
Grange Road South
Botanic Garden
Chaucer Road
Glisson Road
Latham Road
University Press
Hills Road 6th Form
Russell Street
Newton Road
Faculty of Education
Homerton
Douglas House
Clinical School
Forvie Site
MRC LMB
Long Road 6th Form
CRUK
Strangeways
Darwin Line
Book Line & Thinker
Turing Loop
Cats & Queens'
Storey's Way to NMS
Zoo Line
Bumps & Bruises
Stars & Bytes
Newton Line
Under Consideration
Leased Fibre Line (Redstone)
Leased Fibre Line (Virgin)
Site Fibre Line (Clinical School)
Docklands
Interchange Stations
Janet Network
Transport for Cambridge
GBN
1992 - 2017

European Commission

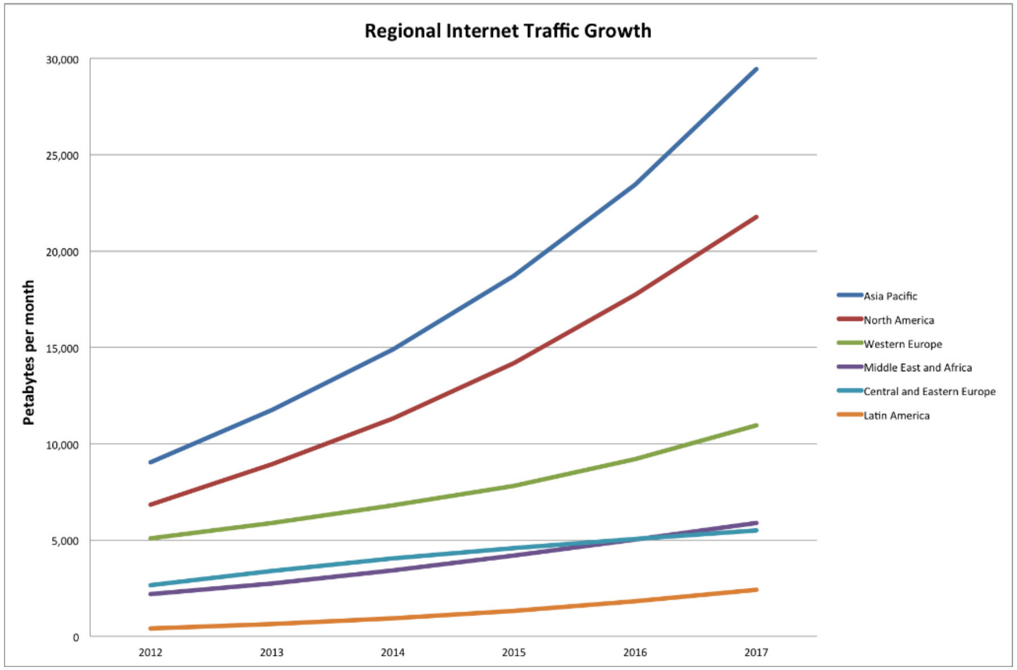
G.fast

The future is unashamedly fibre



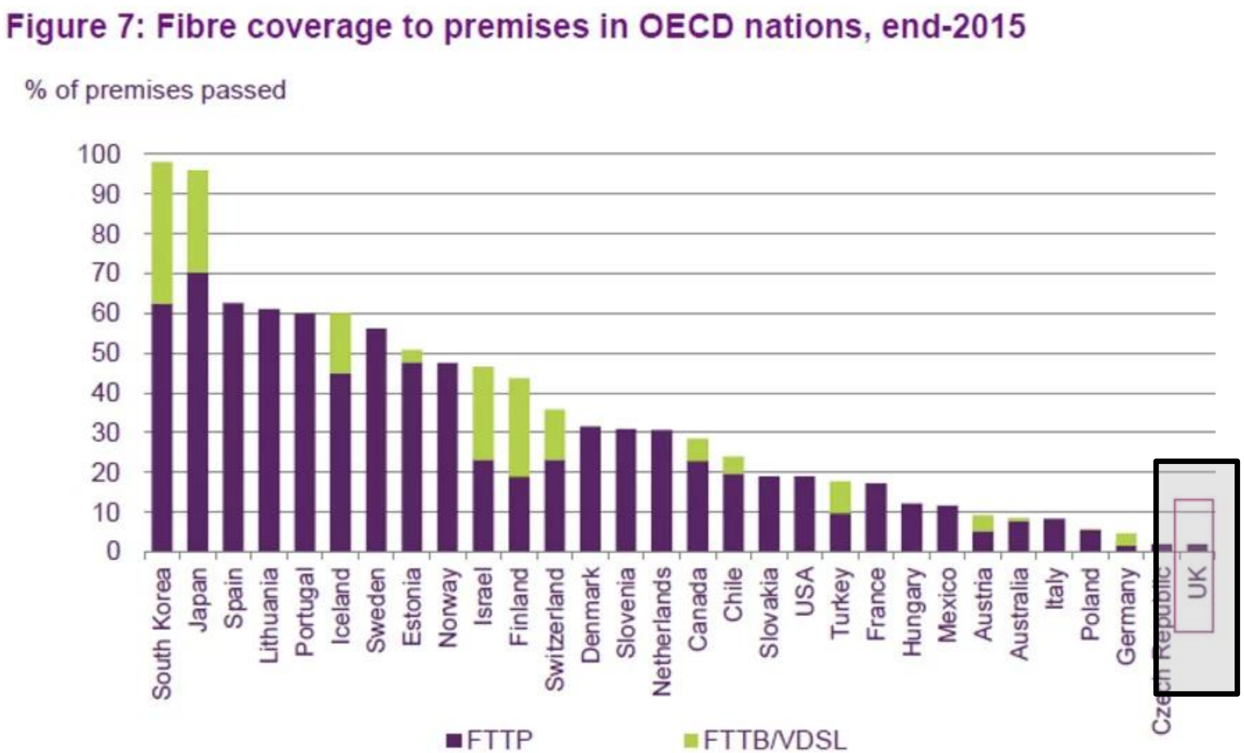
Generic Internet Consumption Chart

DATA



TIME

OECD Fibre Coverage to premises



BIG data

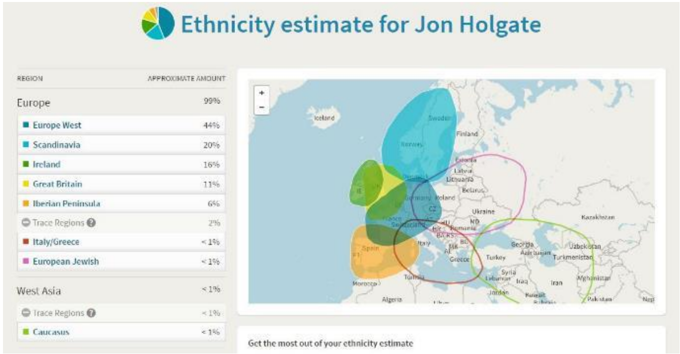
40Gb Internet connection

6 YEARS 9 MONTHS

BIG data is coming to us all

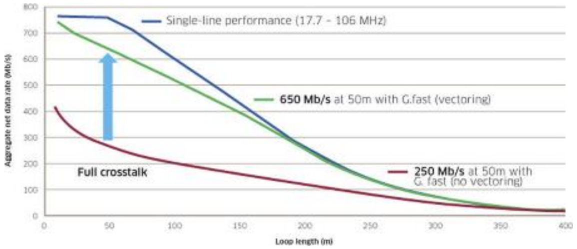
GBN
1992 - 2017

AstraZeneca

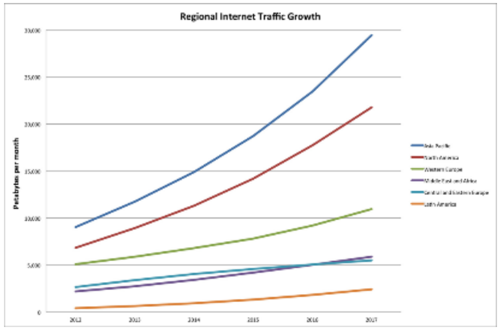


What lessons have we learned

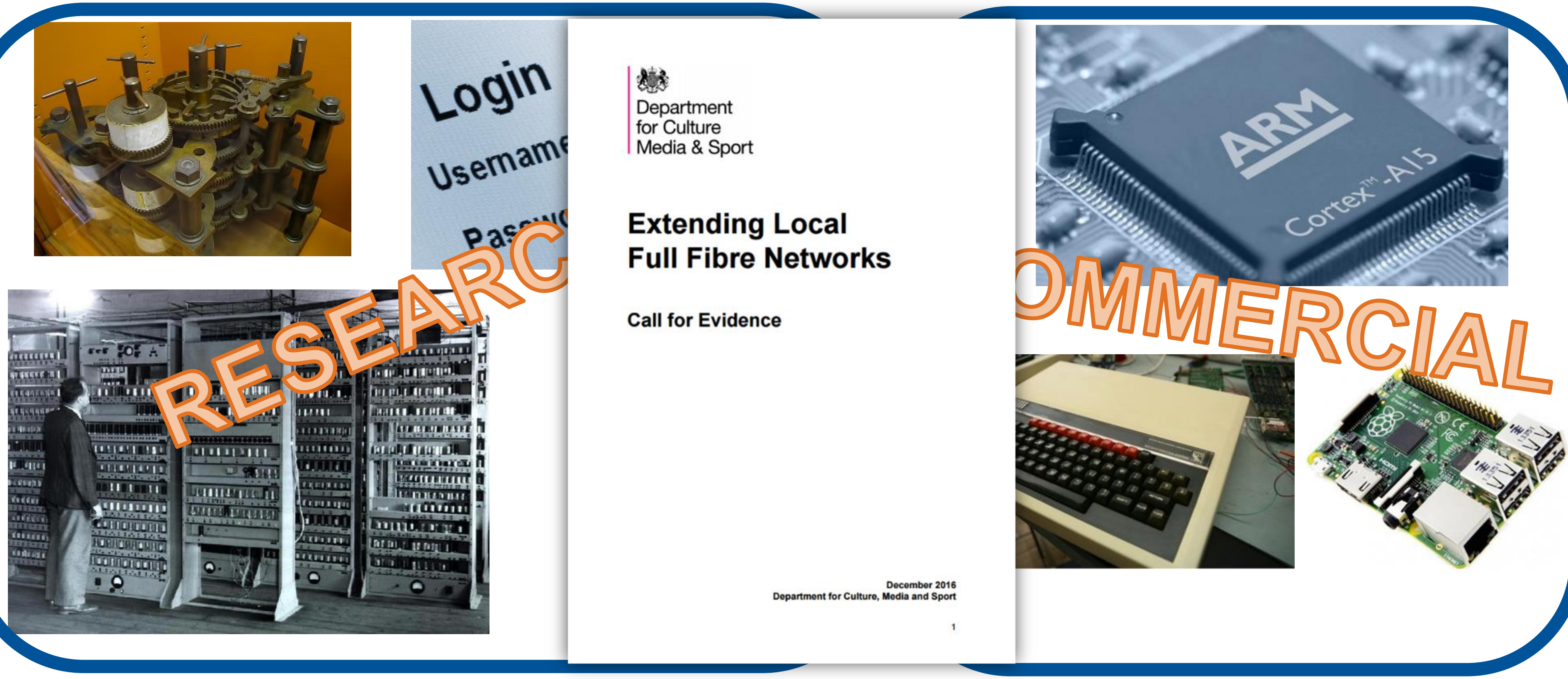
- Standards. Standards. Standards.
- Data demand is growing.
- Fibre IS the solution.
- Fibre is REALLY cheap.
- Private fibre is easy.
- Universities SHOULDN'T be doing this!



£260 km



From research to commodity



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Q&A