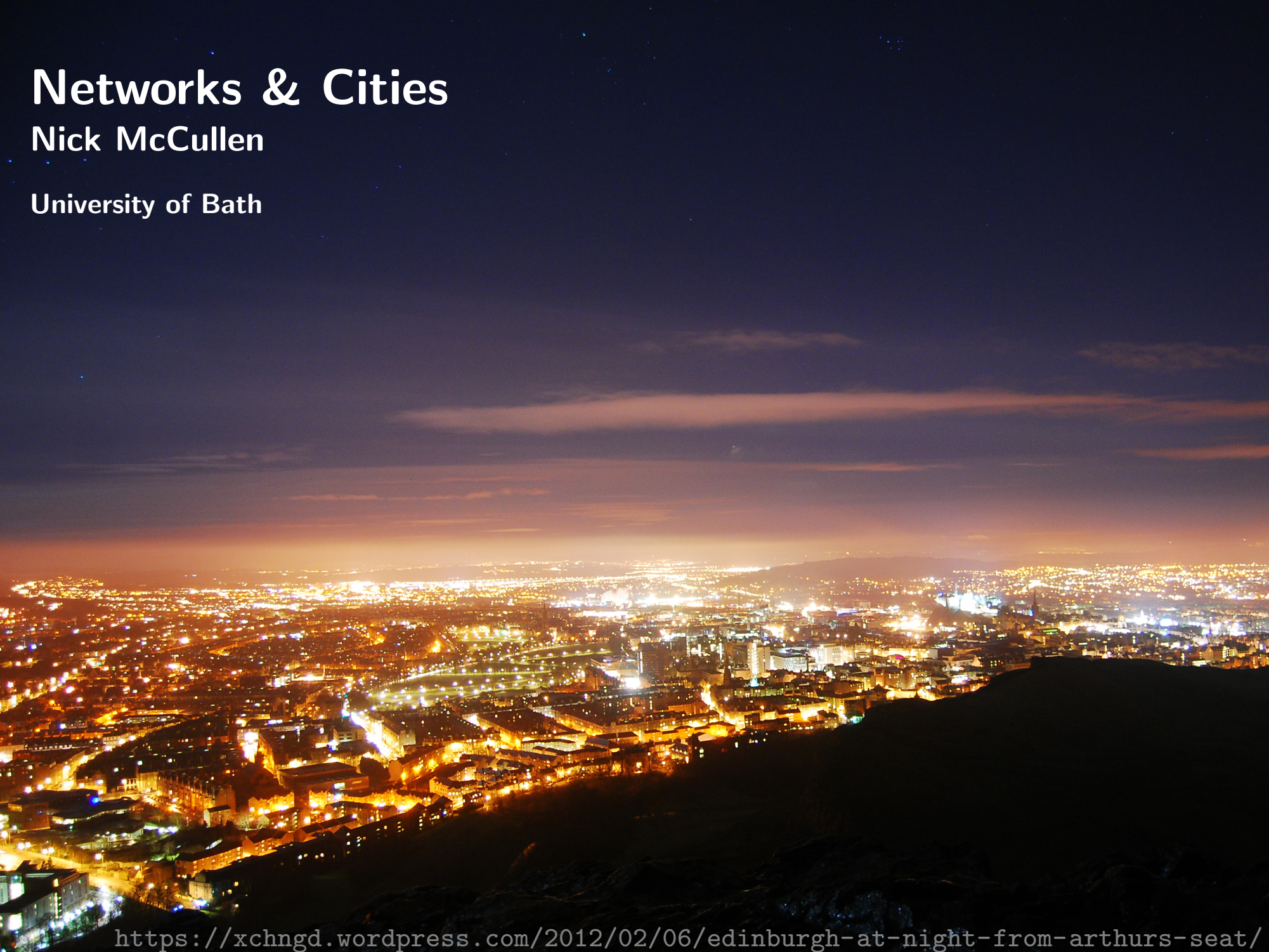
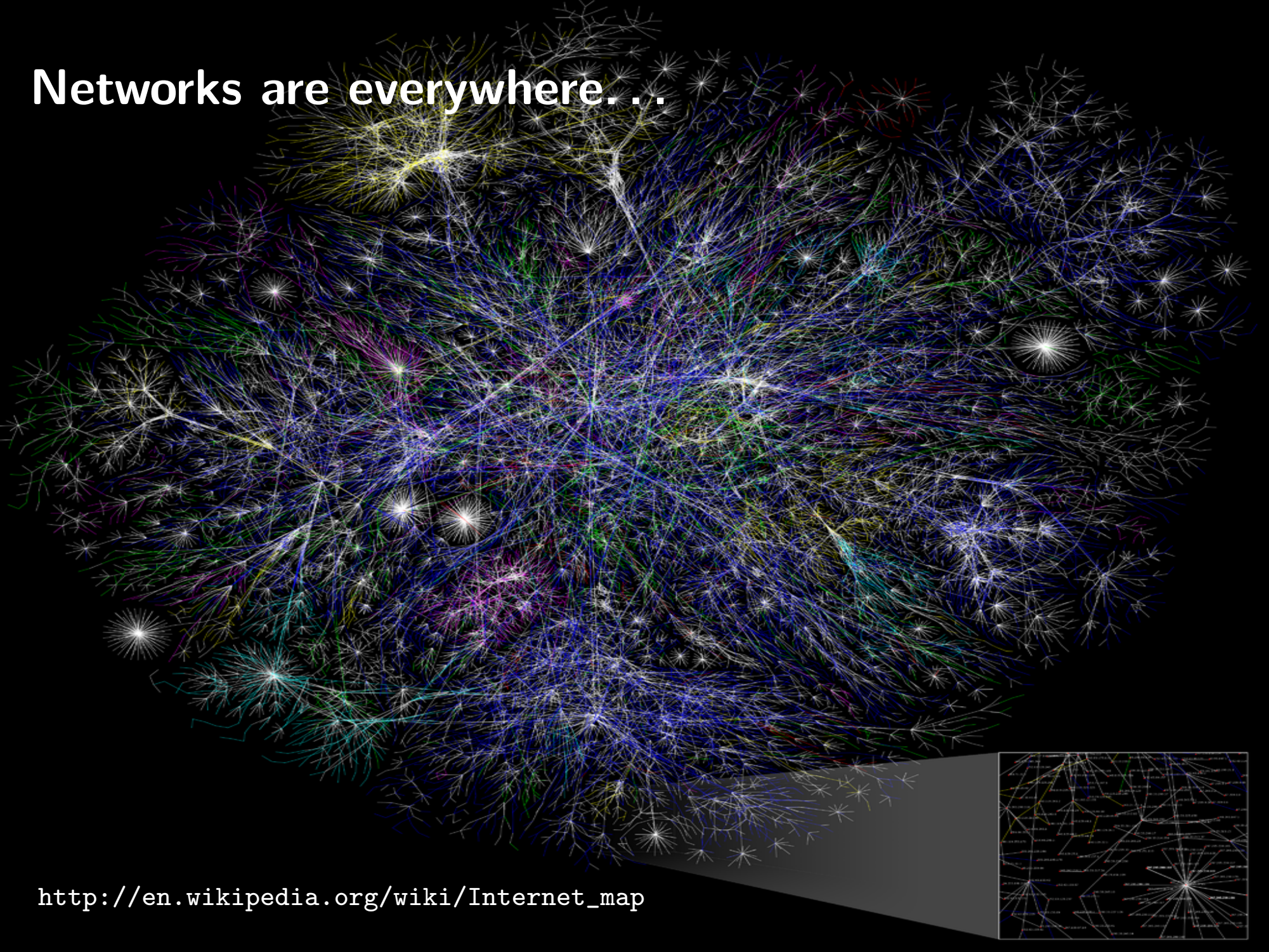
Networks & Cities

Nick McCullen

University of Bath



Networks are everywhere...

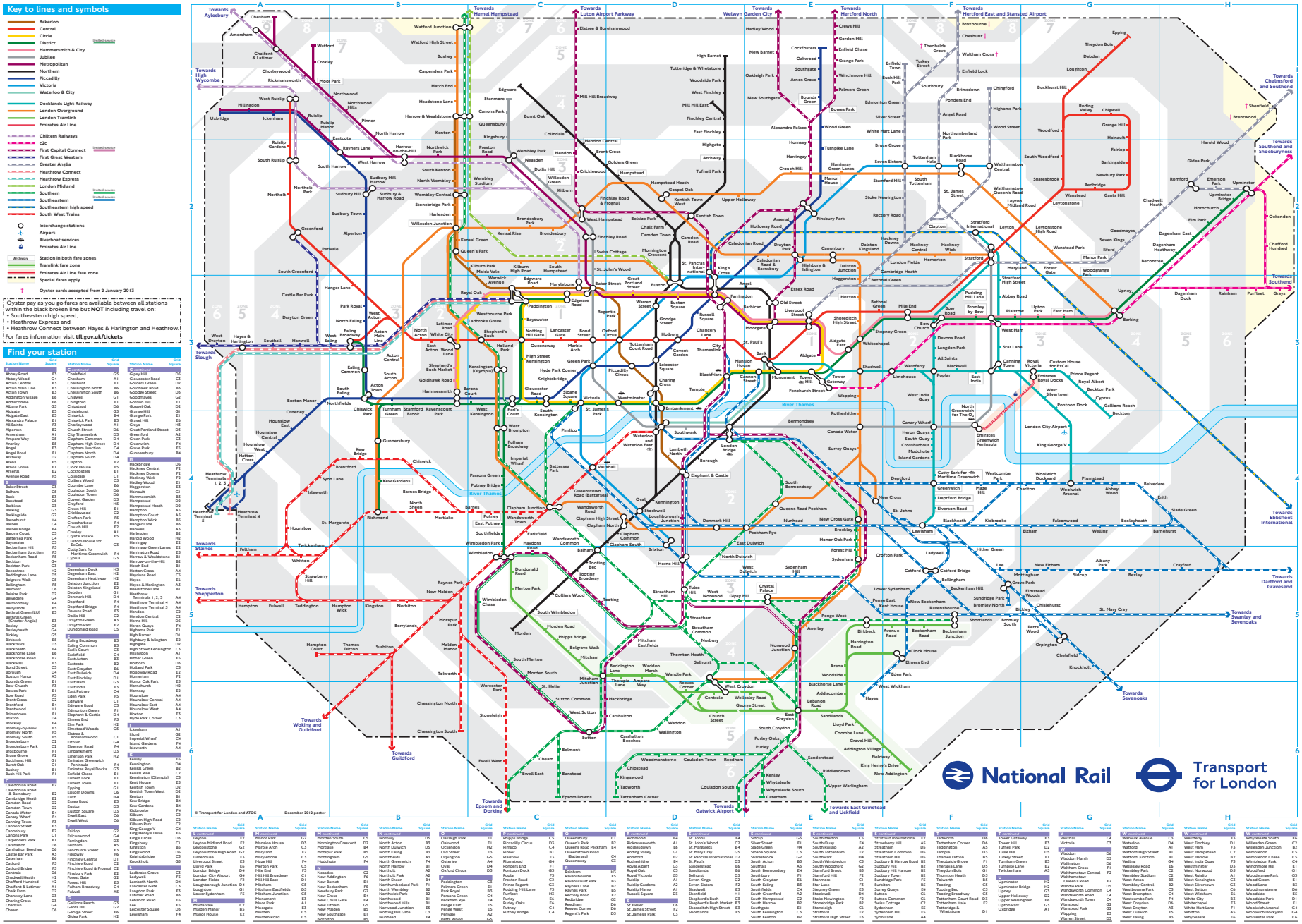


http://en.wikipedia.org/wiki/Internet_map

London's Rail & Tube services

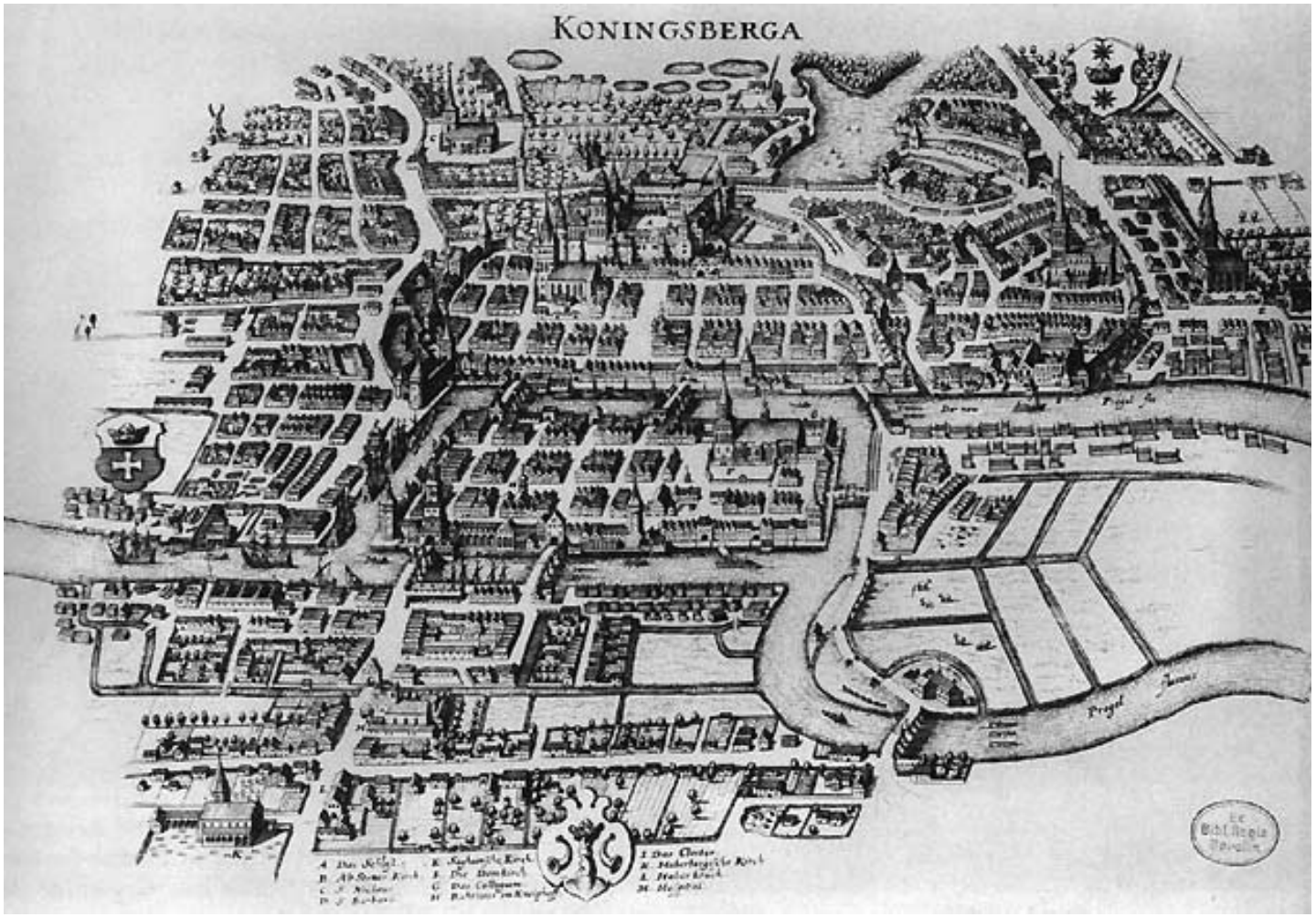
tfl.gov.uk

Website nationalrail.co.uk



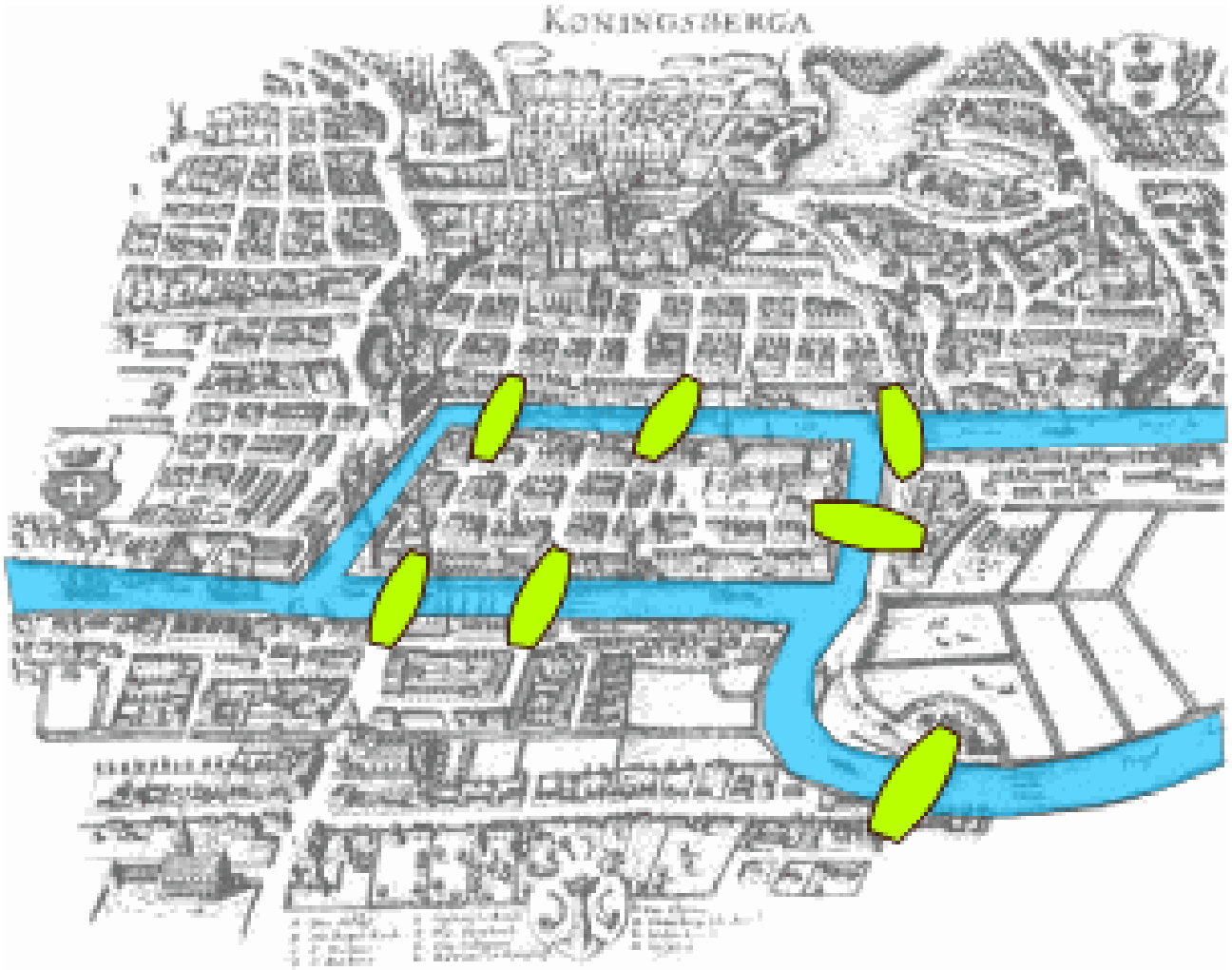
http://www.nationalrail.co.uk/passenger_services/maps/

A Brief History of Network Theory



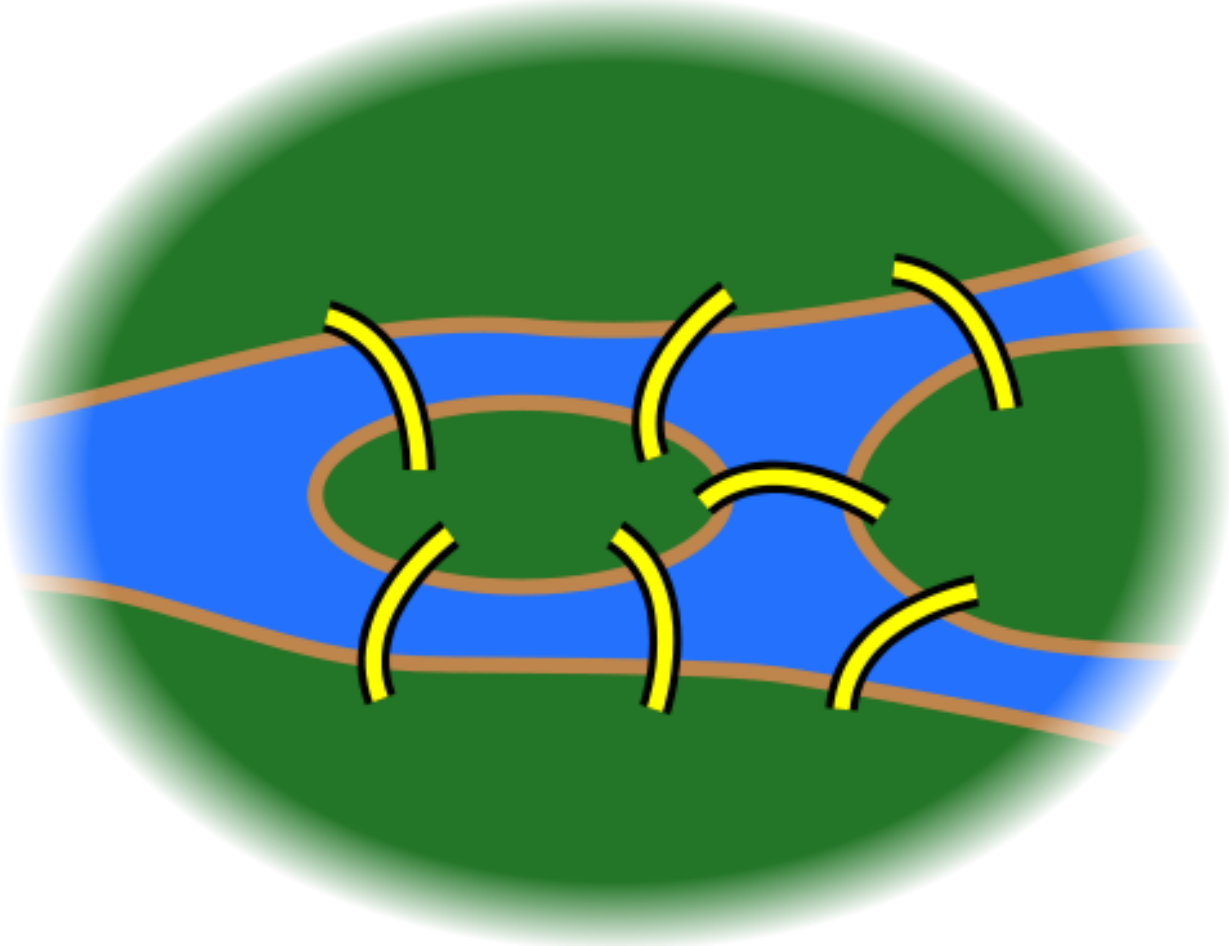
By Merian-Erben [Public domain], via Wikimedia Commons

A Brief History of Network Theory



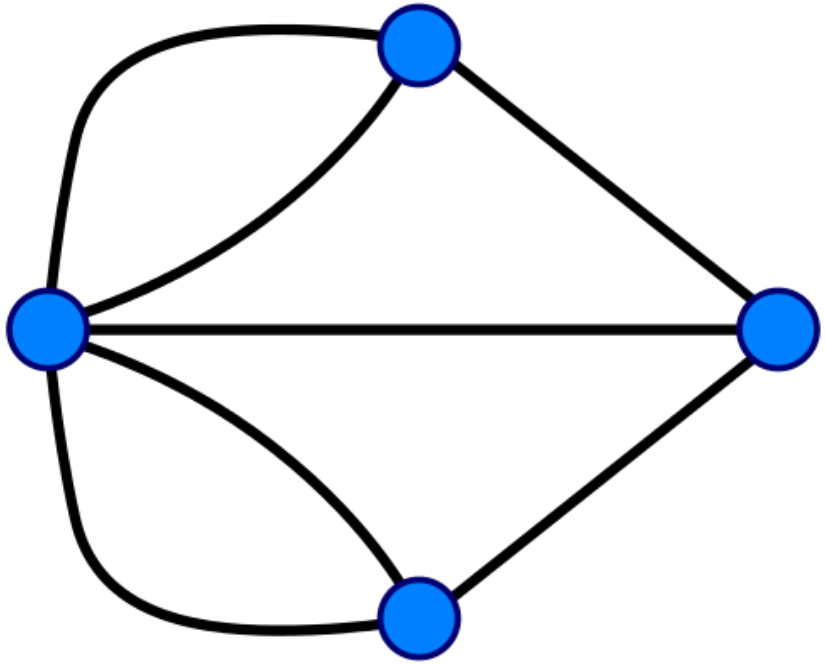
By Bogdan Giuşcă (Public domain (PD)) [GFDL (http://www.gnu.org/copyleft/fdl.html)], via Wikimedia Commons

A Brief History of Network Theory

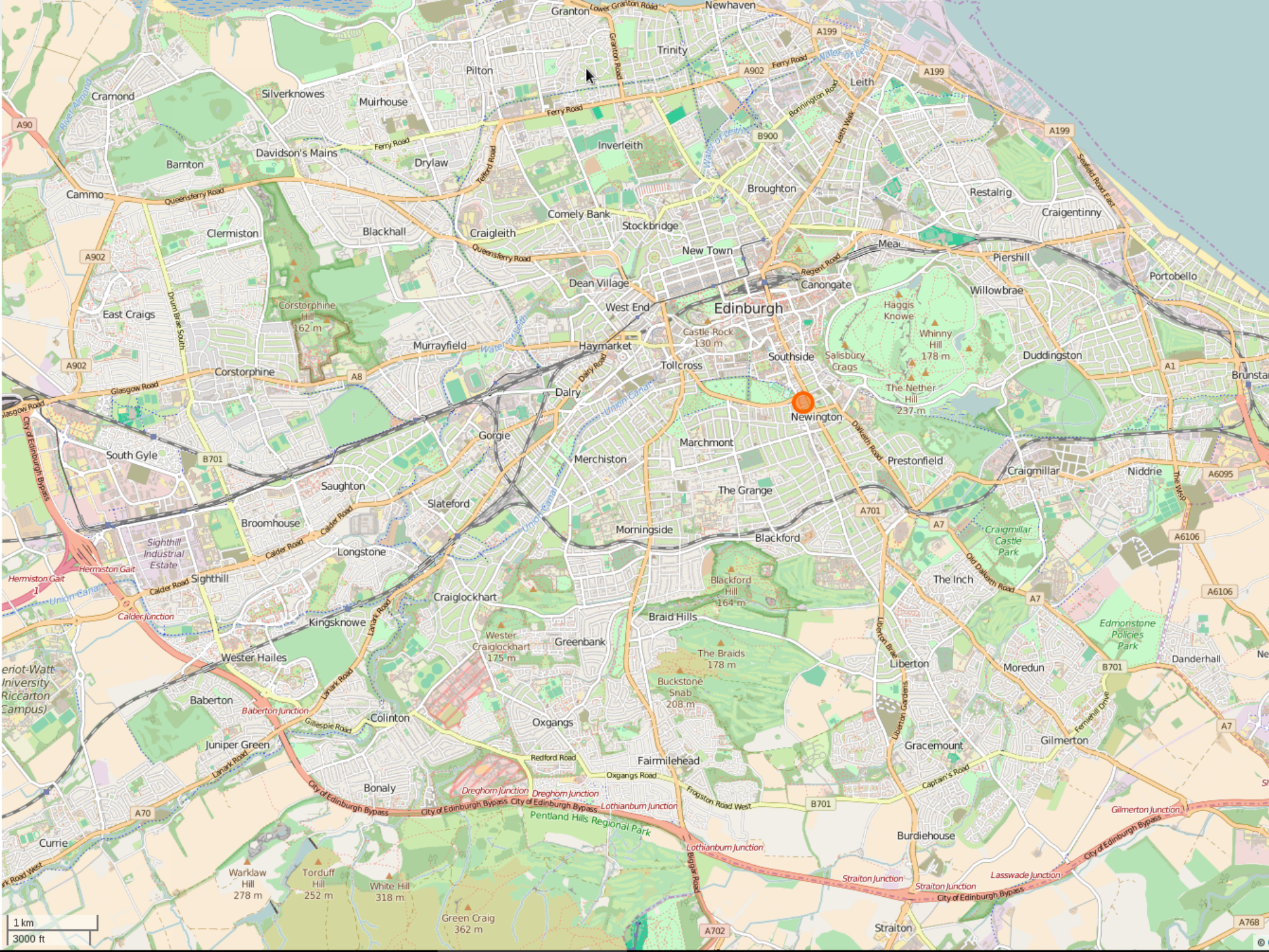


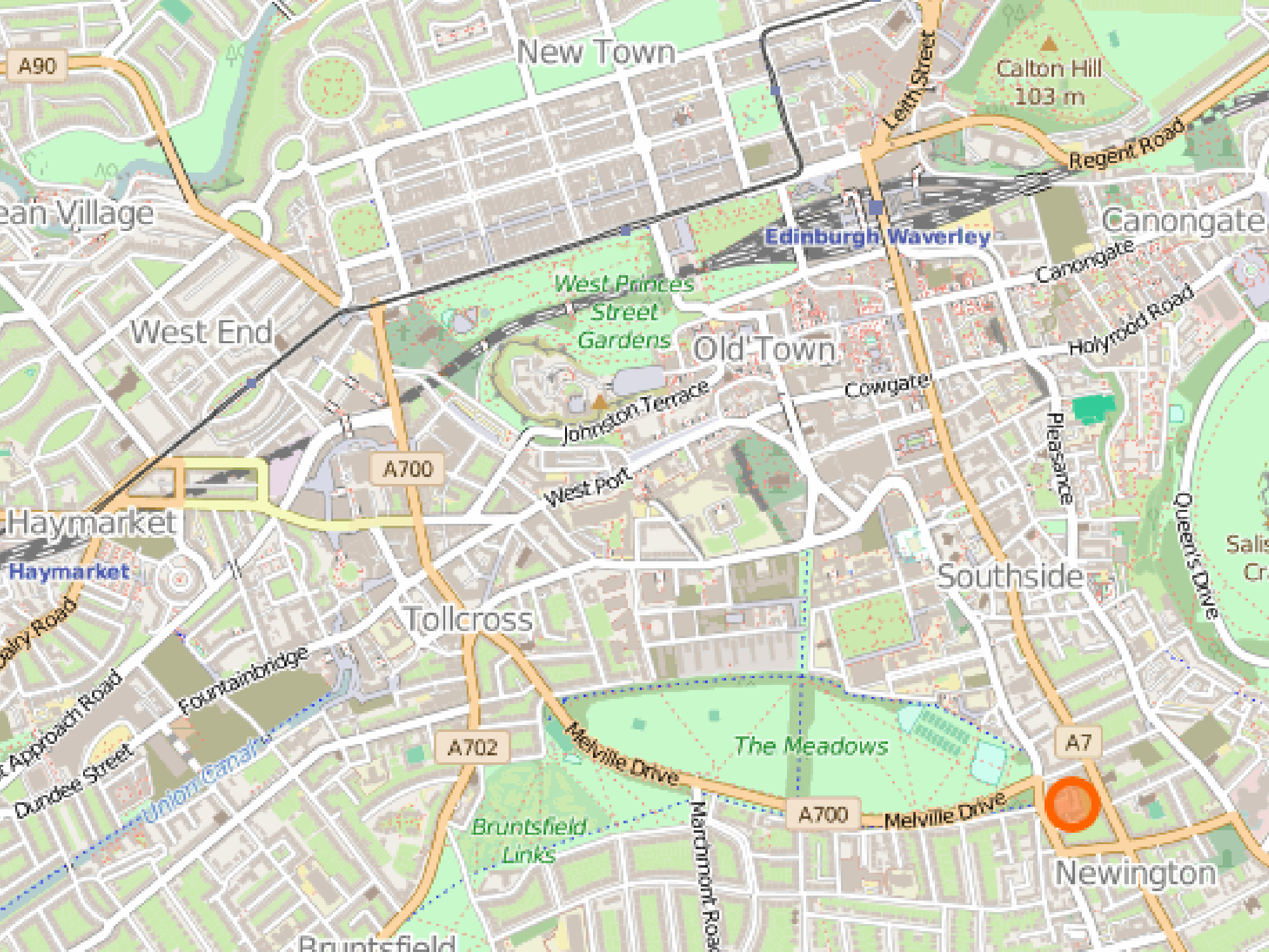
https://en.wikipedia.org/wiki/Seven_Bridges_of_Königsberg

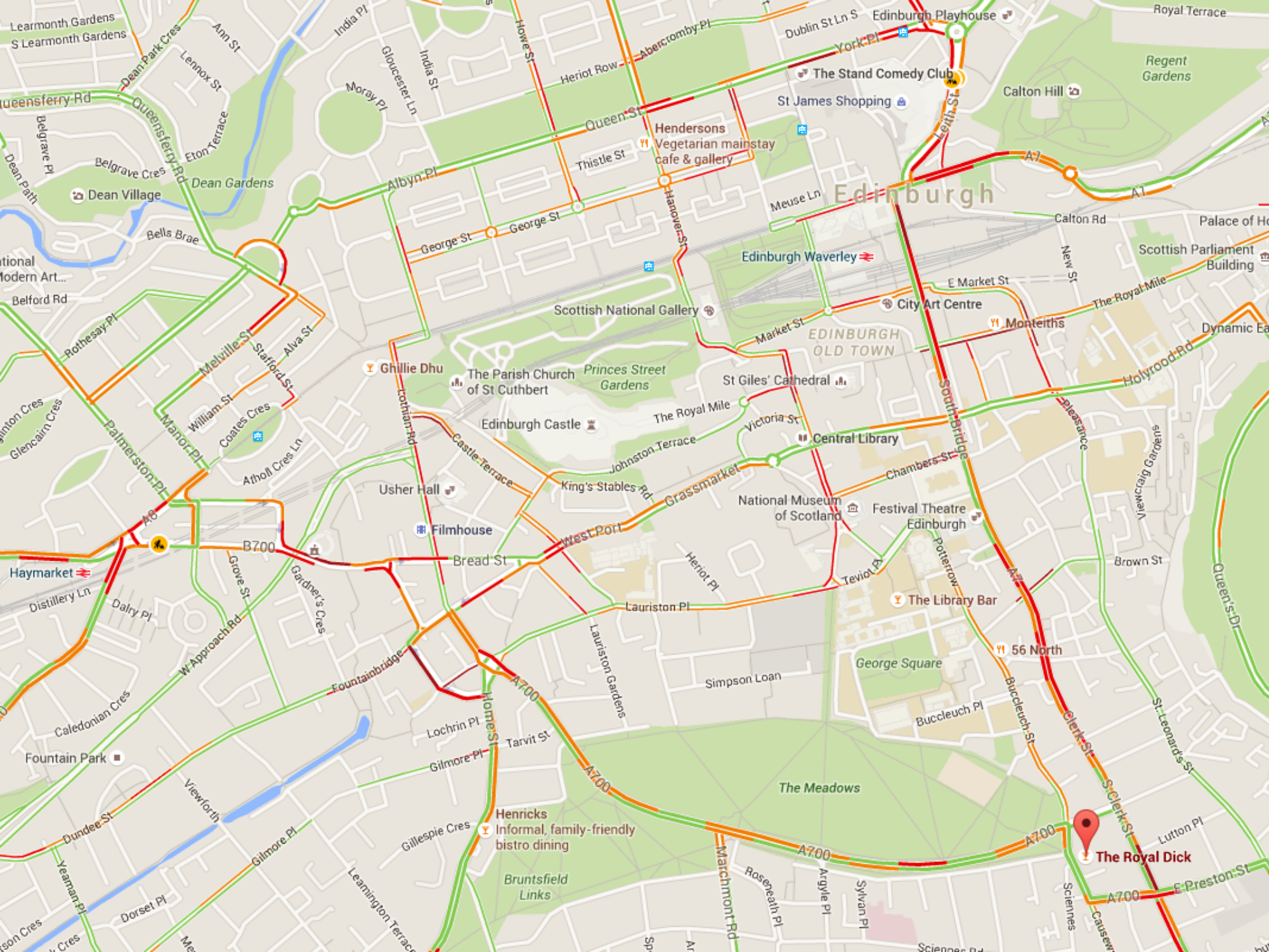
A Brief History of Network Theory

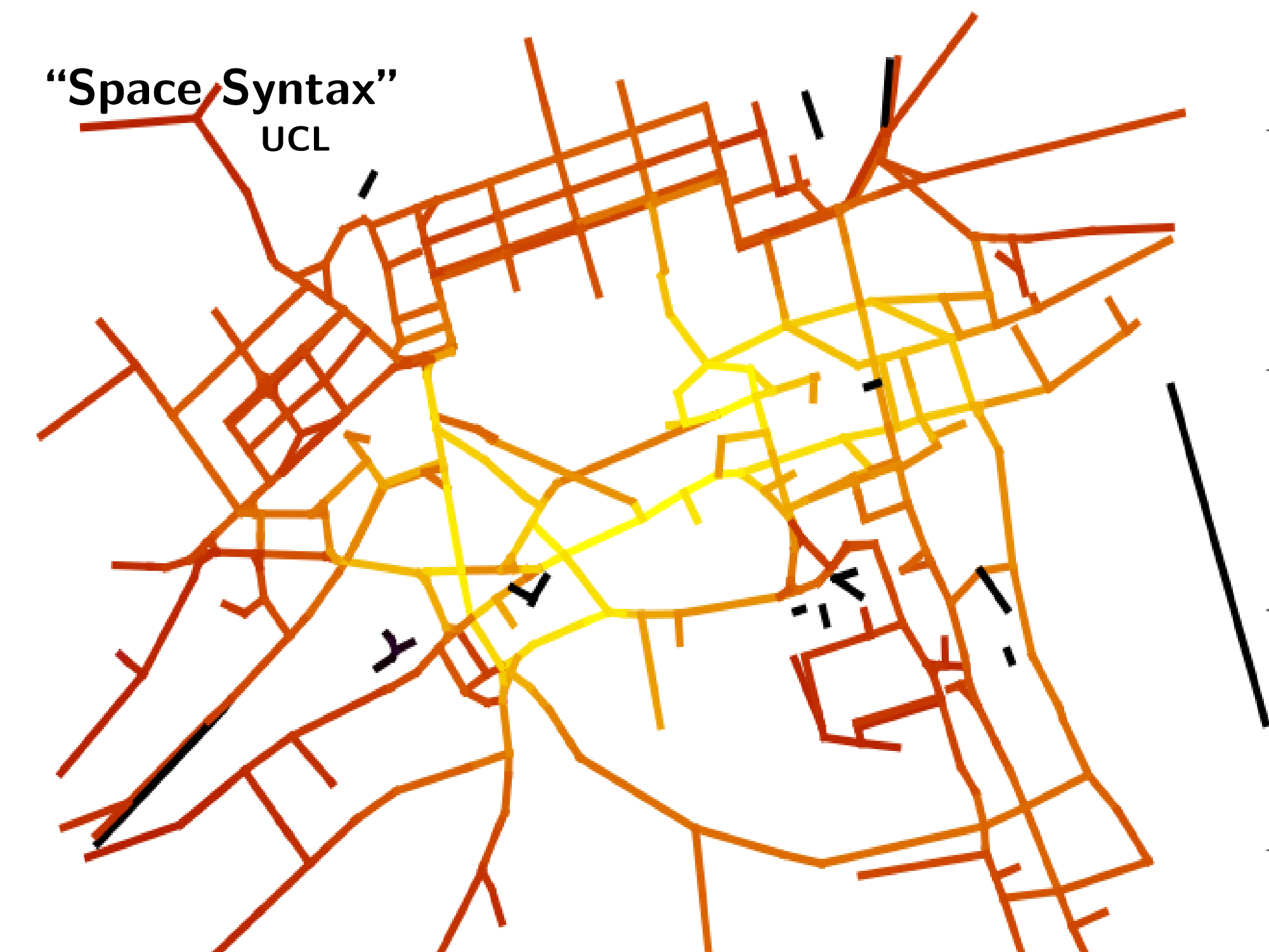


https://en.wikipedia.org/wiki/Seven_Bridges_of_Königsberg


Granton
Newhaven
Trinity
Pilton
Silverknowes
Muirhouse
Cramond
Leith
Barnton
Davidson's Mains
Drylaw
Inverleith
Broughton
Restalrig
Craigentinny
Cammo
Clermiston
Blackhall
Craigleith
Comely Bank
Stockbridge
New Town
Meadowbank
Piershill
Portobello
Willowbrae
Dean Village
Canongate
West End
Edinburgh
Haggis Knowe
East Craigs
Corstorphine Hill
162 m
Murrayfield
Haymarket
Castle Rock
130 m
Whinny Hill
178 m
Duddingston
Corstorphine
Tollcross
Southside
Salisbury Crags
Dalry
The Nether Hill
237 m
Newington
Gorgie
Marchmont
South Gyle
Merchiston
Prestonfield
Craigmillar
Niddrie
Saughton
The Grange
Slateford
Broomhouse
Morningside
Blackford
Craigmillar Castle Park
Sighthill Industrial Estate
Longstone
Sighthill
The Inch
Craiglockhart
Blackford Hill
164 m
Braid Hills
Kingsknowe
Wester Craiglockhart
175 m
Greenbank
Edmonstone Policies Park
Wester Hailes
The Braids
178 m
Liberton
Moredun
Danderhall
Buckstone Snab
208 m
Baberton
Colinton
Oxgangs
Juniper Green
Gracemount
Gilmerton
Fairmilehead
Bonaly
Pentland Hills Regional Park
Burdiehouse
Currie
Warklaw Hill
278 m
Torduff Hill
252 m
White Hill
318 m
Green Craig
362 m
Straiton
Water of Leith
Union Canal
Calder Junction
Baberton Junction
Dreghorn Junction
Lothianburn Junction
Straiton Junction
Lasswade Junction
Gilmerton Junction
City of Edinburgh Bypass
Glasgow Road
Queensferry Road
Ferry Road
Calder Road
Lanark Road
Gillespie Road
Redford Road
Oxgangs Road
Frogston Road West
Captain's Road
Old Dalkeith Road
Dalkeith Road
Regent Road
Bonnington Road
Leith Walk
Seafield Road East
Telford Road
Drum Brae South
Dairy Road
Liberton Brae
Liberton Gardens
Fernielhill Drive
Bridge Road
A90
A902
A8
A701
A7
A199
B900
B701
A70
A702
A6106
A6095
A768
A1
1 km
3000 ft


New Town
Calton Hill
103 m
Leith Street
Regent Road
A90
ean Village
Edinburgh Waverley
Canongate
Canongate
West Princes
Street
Gardens
West End
Old Town
Holyrood Road
Cowgate
Johnston Terrace
A700
West Port
Haymarket
Haymarket
Pleasance
Queen's Drive
Southside
Tollcross
Fountainbridge
Dundee Street
A702
Melville Drive
The Meadows
A7
Union Canal
Bruntsfield
Links
Melville Drive
A700
Marchmont Road
Newington
Bruntsfield


Edinburgh
Edinburgh Playhouse
The Stand Comedy Club
St James Shopping
Calton Hill
Regent Gardens
Royal Terrace
Hendersons
Vegetarian mainstay
cafe & gallery
Dean Village
Dean Gardens
Edinburgh Waverley
Scottish National Gallery
City Art Centre
Monteiths
EDINBURGH
OLD TOWN
Princes Street
Gardens
Ghillie Dhu
The Parish Church
of St Cuthbert
St Giles' Cathedral
Edinburgh Castle
The Royal Mile
Central Library
Usher Hall
Filmhouse
National Museum
of Scotland
Festival Theatre
Edinburgh
Haymarket
Bread St
West Port
Grassmarket
The Library Bar
56 North
George Square
Simpson Loan
The Meadows
Bruntsfield
Links
Fountain Park
Henricks
Informal, family-friendly
bistro dining
The Royal Dick
Scottish Parliament
Building
Palace of Ho
Dynamic Ea
Queensferry Rd
Dean Park Cres
Lennox St
Ann St
India Pl
Gloucester Ln
India St
Howe St
Heriot Row
Abercromby Pl
Dublin St Ln S
York Pl
Queen St
Moray Pl
Belgrave Pl
Belgrave Cres
Eton Terrace
Dean Path
Albyn Pl
Thistle St
George St
Hanover St
Meuse Ln
Leith St
A1
Calton Rd
New St
E Market St
The Royal Mile
Market St
Holyrood Rd
Bells Brae
Belford Rd
Rothesay Pl
Melville St
Stafford St
Alva St
William St
Coates Cres
Atholl Cres Ln
Manor Pl
Palmerston Pl
Glencairn Cres
Glencairn Cres
Lothian Rd
Castle Terrace
Johnston Terrace
King's Stables Rd
Victoria St
Chambers St
South Bridge
Pleasance
Holyrood Rd
Viewcraig Gardens
Queen's Dr
A8
B700
Grove St
Gardner's Cres
Distillery Ln
Dalry Pl
W Approach Rd
Fountainbridge
Caledonian Cres
Heriot Pl
Teviot Pl
Potterrow
Brown St
Lauriston Pl
Lauriston Gardens
Home St
A700
Lochrin Pl
Tarvit St
Gilmore Pl
Gillespie Cres
Buccleuch Pl
Buccleuch St
Clerk St
S Clerk St
St Leonard's St
Lutton Pl
E Preston St
Marchmont Rd
Roseneath Pl
Argyle Pl
Sylvan Pl
Sciennes
Causewayside
Dundee St
Viewforth
Gilmore Pl
Yeaman Pl
Dorset Pl
Leamington Terrace


“Space Syntax”
UCL

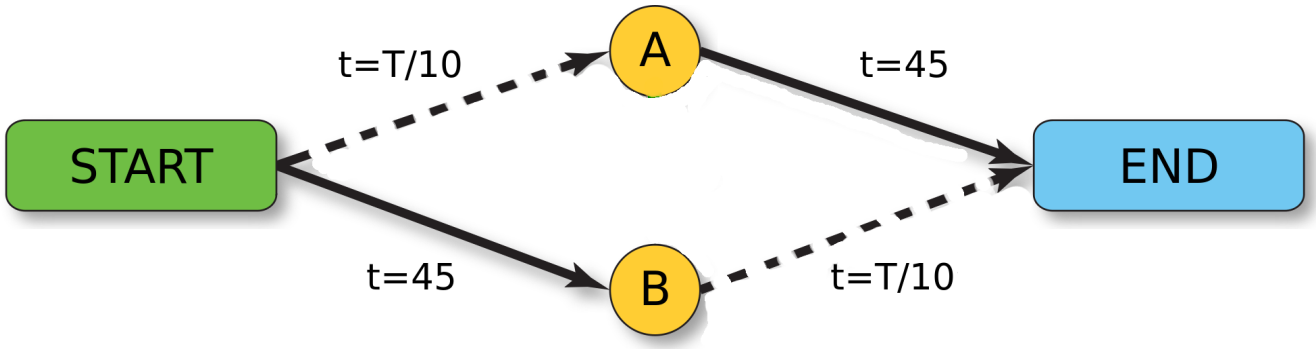
What if They Closed 42d Street and Nobody Noticed?

By GINA KOLATA
Published: December 25, 1990

ON Earth Day this year, New York City's Transportation Commissioner decided to close 42d Street, which as every New Yorker knows is always congested. "Many predicted it would be doomsday," said the Commissioner, Lucius J. Riccio. "You didn't need to be a rocket scientist or have a sophisticated computer queuing model to see that this could have been a major problem."

But to everyone's surprise, Earth Day generated no historic traffic jam. Traffic flow actually improved when 42d Street was closed.

“Braess’ paradox”



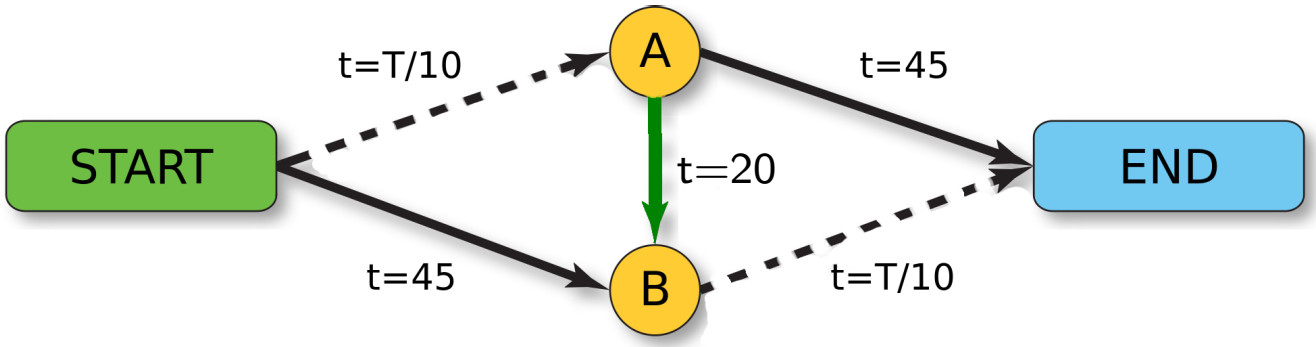
150 Cars: START$\Rightarrow$ A $\Rightarrow$END: time $= \frac{150}{10} + 45 = 60$min

150 Cars: START$\Rightarrow$ B $\Rightarrow$END: time $= 45 + \frac{150}{10} = 60$min

Average: 60min.

Modified from: `http://en.wikipedia.org/wiki/Braess's_paradox`

“Braess’ paradox”



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150 Cars: START⇒ B ⇒END: time $= 45 + \frac{150}{10} = 60$min

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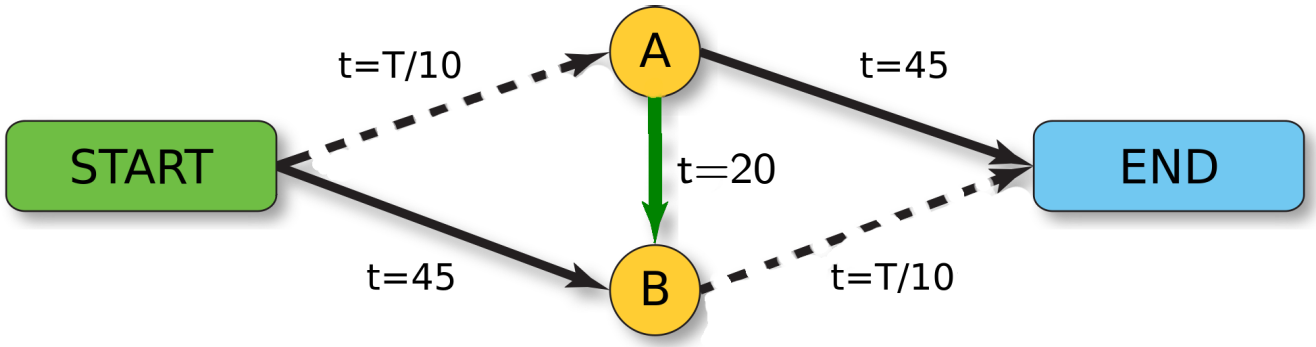

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150 Cars: START$\Rightarrow B \Rightarrow$END: time $= 45 + \frac{150}{10} = 60$min

Average: 60min.

---

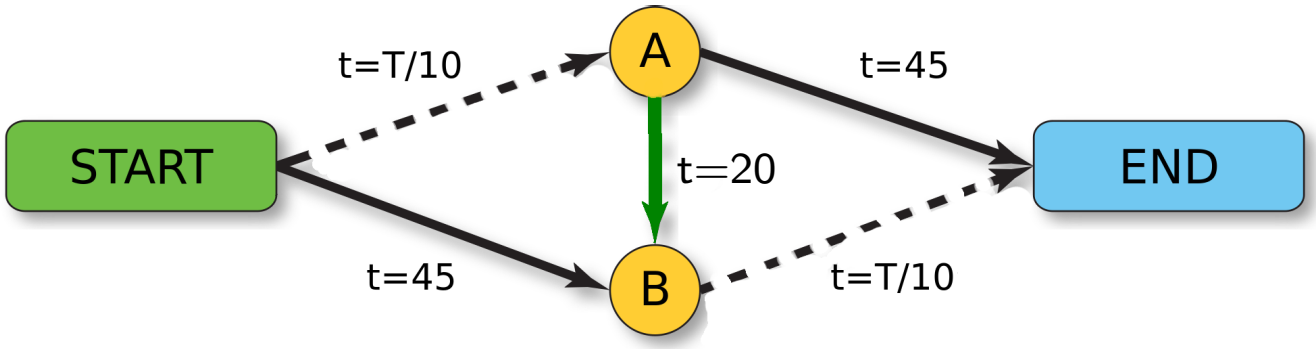
50 Cars: START$\Rightarrow A \Rightarrow B \Rightarrow$END: time $= \frac{150}{10} + 20 + \frac{200}{10} = 55$min

100 Cars: START$\Rightarrow A \Rightarrow$END: time $= \frac{150}{10} + 45 = 60$min

150 Cars: START$\Rightarrow B \Rightarrow$END: time $= 45 + \frac{200}{10} = 65$min

Modified from: `http://en.wikipedia.org/wiki/Braess's_paradox`

“Braess’ paradox”



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150 Cars: START$\Rightarrow B \Rightarrow$END: time $= 45 + \frac{150}{10} = 60$min

Average: 60min.

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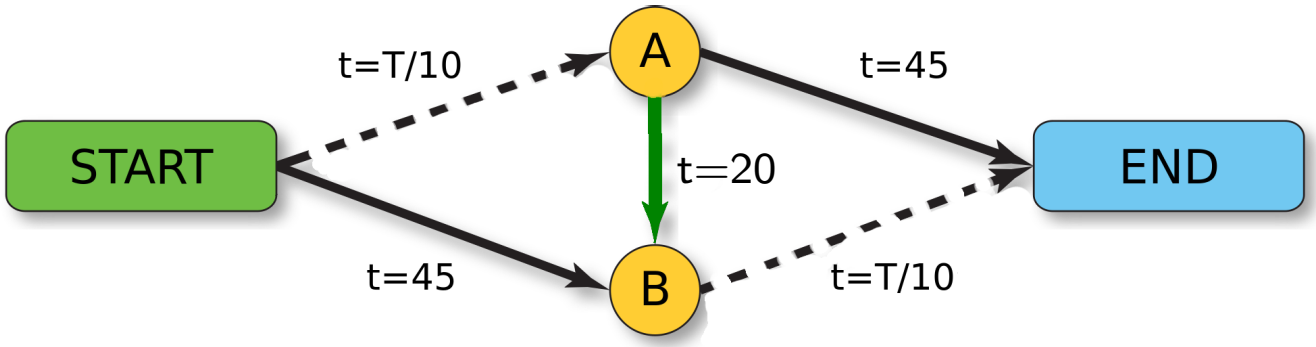
100 Cars: START$\Rightarrow A \Rightarrow$END: time $= \frac{150}{10} + 45 = 60$min

150 Cars: START$\Rightarrow B \Rightarrow$END: time $= 45 + \frac{200}{10} = 65$min

Average: $\frac{(50\times55)+(100\times60)+(150\times65)}{300} \approx 62$min!

Modified from: `http://en.wikipedia.org/wiki/Braess's_paradox`

“Braess’ paradox”



150 Cars: START$\Rightarrow A \Rightarrow$END: time $= \frac{150}{10} + 45 = 60$min

150 Cars: START$\Rightarrow B \Rightarrow$END: time $= 45 + \frac{150}{10} = 60$min

Average: 60min.

---

50 Cars: START$\Rightarrow A \Rightarrow B \Rightarrow$END: time $= \frac{150}{10} + 20 + \frac{200}{10} = 55$min

100 Cars: START$\Rightarrow A \Rightarrow$END: time $= \frac{150}{10} + 45 = 60$min

150 Cars: START$\Rightarrow B \Rightarrow$END: time $= 45 + \frac{200}{10} = 65$min

Average: $\frac{(50\times55)+(100\times60)+(150\times65)}{300} \approx 62$min!

---

100 Cars: START$\Rightarrow A \Rightarrow B \Rightarrow$END: time $= \frac{150}{10} + 20 + \frac{250}{10} = 60$min

System Average: $= 65$min!

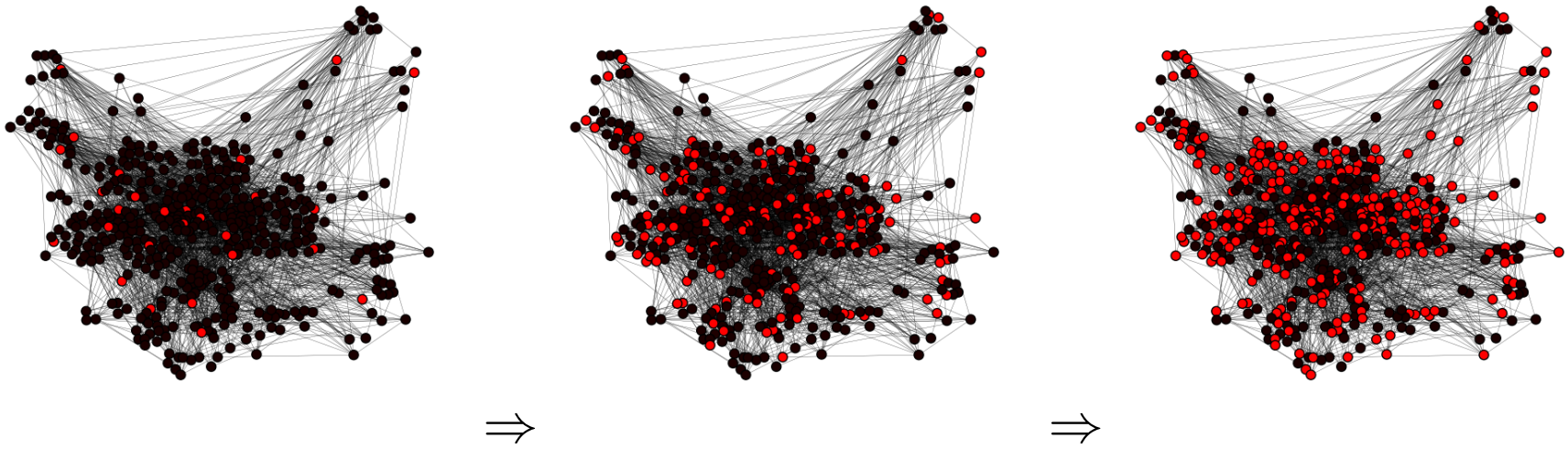
Modified from: `http://en.wikipedia.org/wiki/Braess's_paradox`

Modelling Technology Uptake via Social Networks

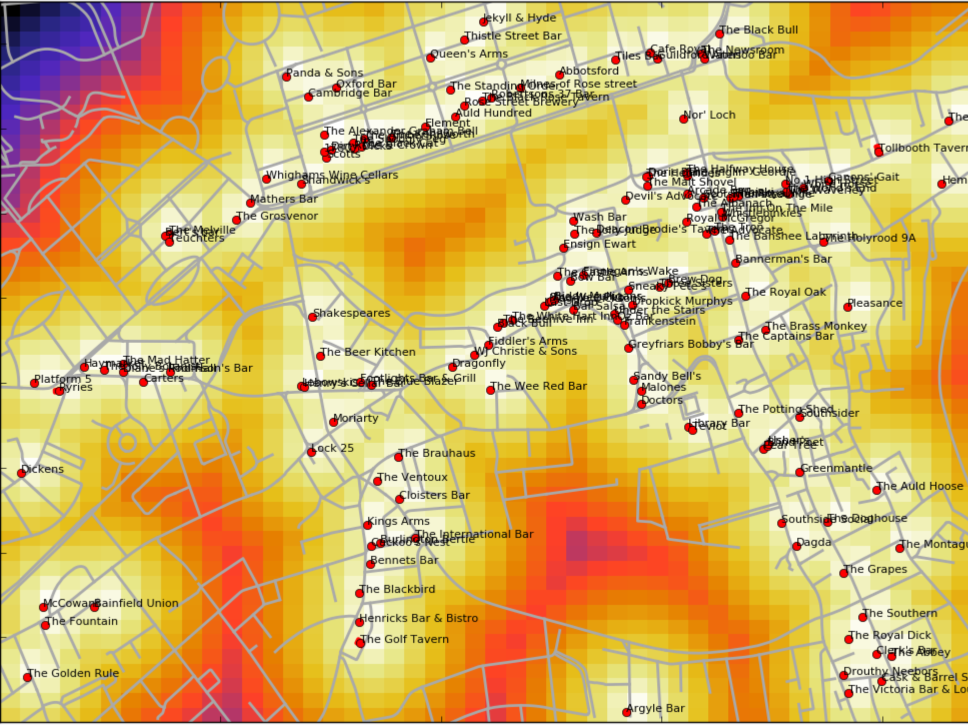
- Perceived *usefulness* of technology to individuals:

$$u = \alpha p + \beta s + \gamma m$$

- p, s, m: personal benefit, social-network and mainstream influence,



- Interventions can be modelled and compared


Jekyll & Hyde
Thistle Street Bar
Queen's Arms
The Black Bull
Panda & Sons
Oxford Bar
Cambridge Bar
Abbotsford
Auld Hundred
Element
Nor' Loch
Tollbooth Tavern
Whighams Wine Cellars
Mathers Bar
The Grosvenor
Devil's Advocate
The Malt Shovel
The Halfway House
Wash Bar
Ensign Ewart
Bannerman's Bar
The Holyrood 9A
The Royal Oak
Pleasance
Dropkick Murphys
Frankenstein
The Brass Monkey
The Captains Bar
Greyfriars Bobby's Bar
Shakespeares
The Beer Kitchen
Fiddler's Arms
WJ Christie & Sons
Dragonfly
The Mad Hatter
Platform 5
Ryries
Carters
The Wee Red Bar
Sandy Bell's
Malones
Doctors
The Potting Shed
Southsider
Moriarty
Lock 25
The Brauhaus
Dickens
Greenmantle
The Auld Hoose
The Ventoux
Cloisters Bar
Kings Arms
The International Bar
Bennets Bar
Dagda
The Grapes
The Blackbird
McCowan
Bainfield Union
The Fountain
Henricks Bar & Bistro
The Golf Tavern
The Southern
The Royal Dick
The Abbey
The Golden Rule
Drouthy Neebors
The Victoria Bar & Lo
Argyle Bar

Thanks for listening

time to network in the city. . .