Module Introduction

Data Structures

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What are Data Structures & Algorithms?

- Data structures describe how data are organised in a computer.
- This organisation allows for the efficient processing (storage, search, retrieval, manipulation, etc.) of the data using appropriate algorithms in order to make it useful.
- Different types of data require different types of data structures for different types of applications. How that data is going to be used will determine what algorithms to use to effectively process it.
  - "Horses for courses." No one data structure or algorithm is always best or suitable for every application.
  - The choice of data structures, and the algorithms to process them, are among the most fundamental decisions in an application's development.

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- Different data structures:
  - Have different space requirements for any given data.
  - Have different levels of algorithmic efficiency for given operations applied to the data (sorting, searching, retrieval, insertion, etc.).
- We always want to save (memory) space and/or (processing) time by choosing appropriate data structures and algorithms.
  - Sometimes we have to trade space for time, and vice versa. Which is more important depends on the application.

What is a “Structure”?

- A structure is something that, essentially, has an ostensible shape and form.
- We humans see and use structure everywhere!
  - Its how we make sense of the complexity and chaos in the world.
  - The structure we perceive helps us to organise things in order to process them.
    - What this processing involves depends on the nature of the structure and its actual use or application.
      - Examples: adding, removing, inserting, reading/observing, aggregating, searching, etc.

What Do You See?

- Consider the following photographs / images.
- Can you see any structures or patterns?
  - Name the structures and any components / concepts you see.
  - The key point is that structures emerge that explain, describe and simplify the situation.

Q. How would we?

- Add (or Insert)
- Remove
- Search
- Aggregate (e.g. Count)
- Organise further?

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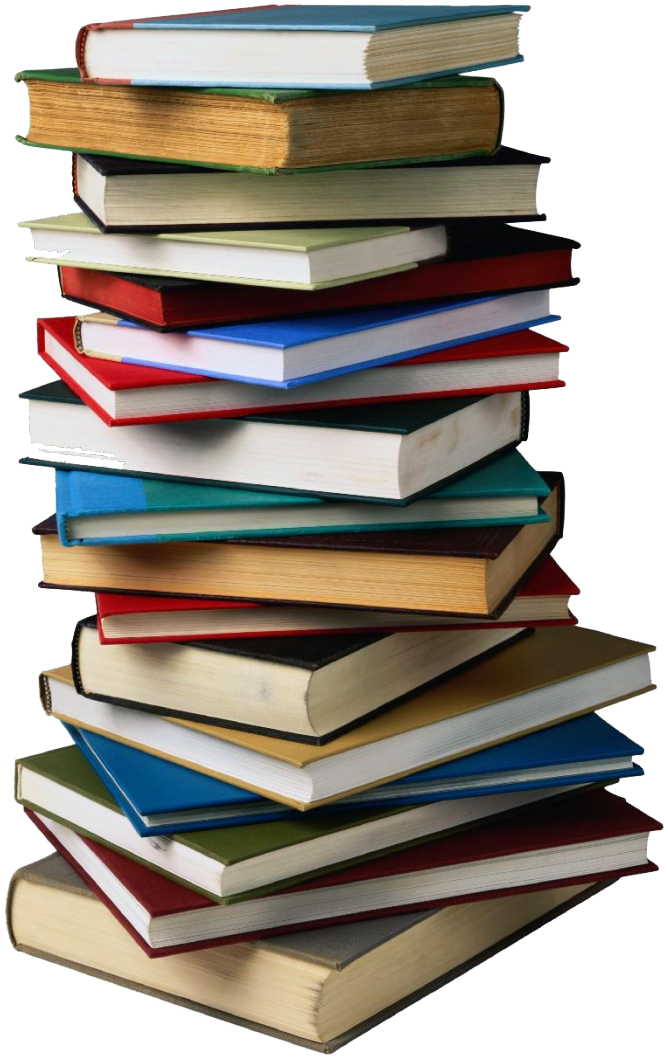

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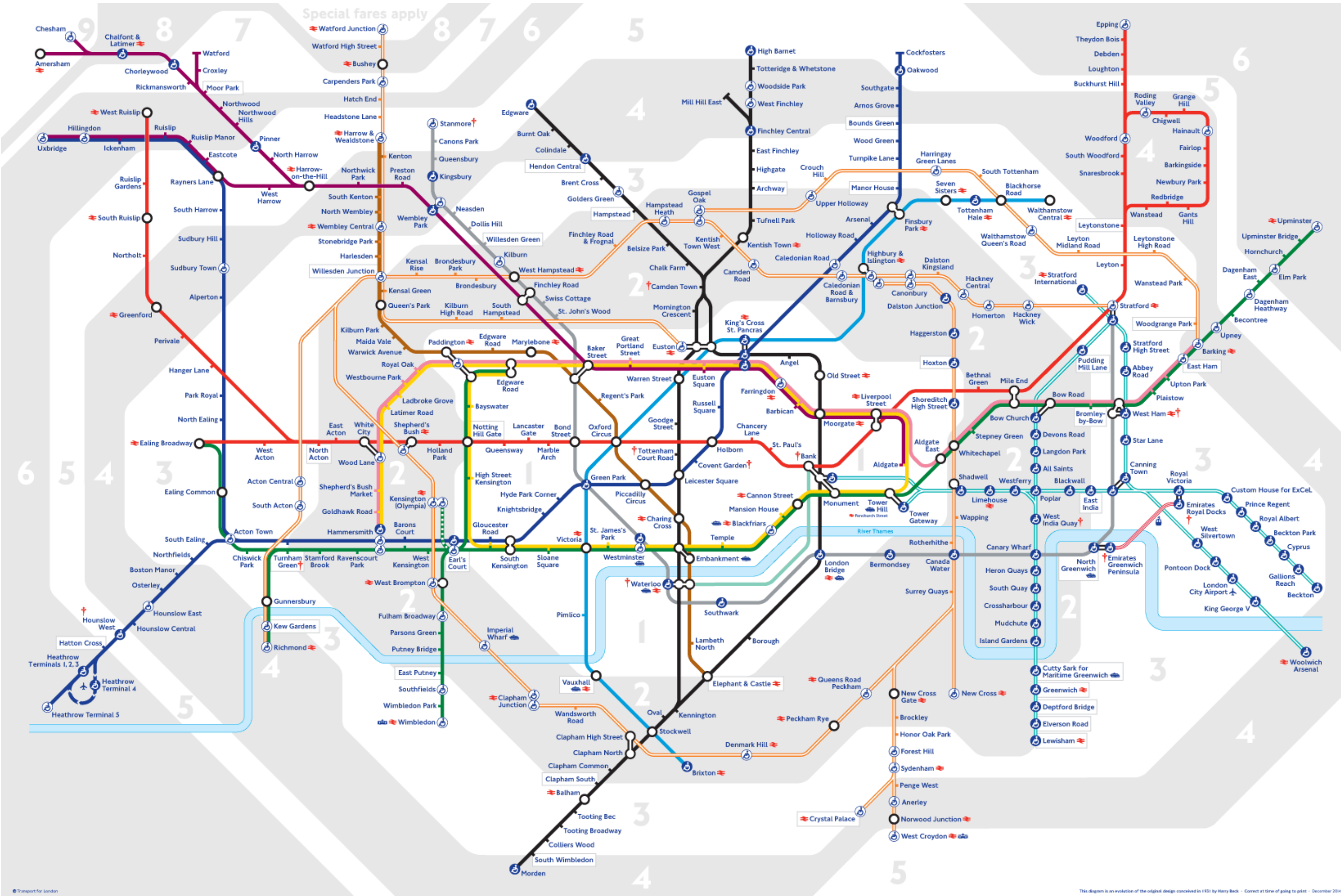
Special fares apply
Chesham
Amersham
Chalfont & Latimer
Chorleywood
Rickmansworth
Watford
Croxley
Moor Park
Northwood
Northwood Hills
Pinner
North Harrow
Harrow-on-the-Hill
West Harrow
Watford Junction
Watford High Street
Bushey
Carpenders Park
Hatch End
Headstone Lane
Harrow & Wealdstone
Kenton
Northwick Park
Preston Road
Wembley Park
South Kenton
North Wembley
Wembley Central
Stonebridge Park
Harlesden
Willesden Junction
Kensal Green
Queen's Park
Kilburn Park
Maida Vale
Warwick Avenue
Stanmore
Canons Park
Queensbury
Kingsbury
Neasden
Dollis Hill
Willesden Green
Kilburn
West Hampstead
Finchley Road
Swiss Cottage
St. John's Wood
Edgware
Burnt Oak
Colindale
Hendon Central
Brent Cross
Golders Green
Hampstead
Belsize Park
Chalk Farm
Camden Town
Mornington Crescent
High Barnet
Totteridge & Whetstone
Woodside Park
West Finchley
Mill Hill East
Finchley Central
East Finchley
Highgate
Archway
Tufnell Park
Kentish Town
Cockfosters
Oakwood
Southgate
Arnos Grove
Bounds Green
Wood Green
Turnpike Lane
Manor House
Finsbury Park
Arsenal
Holloway Road
Caledonian Road
Highbury & Islington
Epping
Theydon Bois
Debden
Loughton
Buckhurst Hill
Woodford
South Woodford
Snaresbrook
Leytonstone
Leyton
Stratford
Roding Valley
Chigwell
Grange Hill
Hainault
Fairlop
Barkingside
Newbury Park
Gants Hill
Redbridge
Wanstead
West Ruislip
Ruislip
Ruislip Manor
Eastcote
Rayners Lane
Uxbridge
Hillingdon
Ickenham
Ruislip Gardens
South Ruislip
Northolt
Greenford
Perivale
Hanger Lane
Park Royal
North Ealing
Ealing Broadway
Ealing Common
South Harrow
Sudbury Hill
Sudbury Town
Alperton
West Acton
North Acton
East Acton
White City
Shepherd's Bush
Holland Park
Notting Hill Gate
Queensway
Lancaster Gate
Marble Arch
Bond Street
Oxford Circus
Tottenham Court Road
Holborn
Chancery Lane
St. Paul's
Bank
Liverpool Street
Bethnal Green
Mile End
Acton Central
South Acton
Acton Town
Chiswick Park
Turnham Green
Stamford Brook
Ravenscourt Park
Hammersmith
Barons Court
West Kensington
Earl's Court
Gloucester Road
South Kensington
Sloane Square
Victoria
St. James's Park
Westminster
Embankment
Temple
Blackfriars
Mansion House
Cannon Street
Monument
Tower Hill
Aldgate
Aldgate East
Whitechapel
Paddington
Edgware Road
Marylebone
Baker Street
Great Portland Street
Euston Square
Euston
King's Cross St. Pancras
Angel
Old Street
Moorgate
Barbican
Farringdon
Russell Square
Goodge Street
Warren Street
Regent's Park
Green Park
Piccadilly Circus
Leicester Square
Covent Garden
Charing Cross
Hyde Park Corner
Knightsbridge
High Street Kensington
Kensington (Olympia)
Waterloo
Southwark
Lambeth North
Borough
London Bridge
Elephant & Castle
Kennington
Oval
Stockwell
Vauxhall
Pimlico
Brixton
Clapham North
Clapham Common
Clapham South
Balham
Tooting Bec
Tooting Broadway
Colliers Wood
South Wimbledon
Morden
Gunnersbury
Kew Gardens
Richmond
Fulham Broadway
Parsons Green
Putney Bridge
East Putney
Southfields
Wimbledon Park
Wimbledon
West Brompton
Imperial Wharf
Clapham Junction
Northfields
Boston Manor
Osterley
Hounslow East
Hounslow Central
Hounslow West
Hatton Cross
Heathrow Terminals 1, 2, 3
Heathrow Terminal 4
Heathrow Terminal 5
South Ealing
Canary Wharf
Canada Water
Rotherhithe
Bermondsey
Surrey Quays
Wapping
Shadwell
Limehouse
Westferry
Poplar
Blackwall
East India
Canning Town
West Ham
Plaistow
Upton Park
East Ham
Barking
Upney
Becontree
Dagenham Heathway
Dagenham East
Elm Park
Hornchurch
Upminster Bridge
Upminster
Bow Road
Bromley-by-Bow
Bow Church
Devons Road
Langdon Park
All Saints
Stepney Green
Star Lane
Abbey Road
Stratford High Street
Pudding Mill Lane
Heron Quays
South Quay
Crossharbour
Mudchute
Island Gardens
Cutty Sark for Maritime Greenwich
Greenwich
Deptford Bridge
Elverson Road
Lewisham
North Greenwich
Emirates Greenwich Peninsula
Emirates Royal Docks
Royal Victoria
Custom House for ExCeL
Prince Regent
Royal Albert
Beckton Park
Cyprus
Gallions Reach
Beckton
Pontoon Dock
London City Airport
King George V
West Silvertown
Woolwich Arsenal
Tottenham Hale
Blackhorse Road
Walthamstow Central
South Tottenham
Seven Sisters
Harringay Green Lanes
Walthamstow Queen's Road
Leyton Midland Road
Leytonstone High Road
Wanstead Park
Woodgrange Park
Hackney Central
Hackney Wick
Homerton
Dalston Kingsland
Dalston Junction
Canonbury
Haggerston
Hoxton
Shoreditch High Street
Upper Holloway
Crouch Hill
Gospel Oak
Hampstead Heath
Kentish Town West
Camden Road
Caledonian Road & Barnsbury
Finchley Road & Frognal
Brondesbury
Brondesbury Park
Kensal Rise
South Hampstead
Kilburn High Road
Westbourne Park
Royal Oak
Ladbroke Grove
Latimer Road
Wood Lane
Bayswater
Shepherd's Bush Market
Goldhawk Road
Stratford International
New Cross
New Cross Gate
Brockley
Honor Oak Park
Forest Hill
Sydenham
Penge West
Anerley
Norwood Junction
West Croydon
Crystal Palace
Queens Road Peckham
Peckham Rye
Denmark Hill
Clapham High Street
Wandsworth Road
River Thames

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- For data structures the same principle applies: identify a structure/form/shape that logically organises a "bunch of data" in a useful and efficient way.
  - So it is easy to read, delete, add to, search, etc. the data as appropriate.
- Data structures include: lists, queues, stacks, rings, sets, bags, maps, trees, graphs, etc.
- Abstract data types (ADTs) can also be used to describe basically anything!
  - Examples: Skydiver, Person, Box, Book, Tin, Flock, FlockFormation, Drawer, EatingUtensil, Basket, ClothingItem, Wardrobe, WardrobeRail, Family, Alien, Spaceship, Engine, City, Building, TubeStation, etc. etc.

Who Knew I Knew?

- You have already been using some data structures, and related concepts, in your Year 1 programming modules, including:
  - Arrays (and ArrayLists?)
  - Classes / ADTs
- Although you will have only seen these in pretty rudimentary form, they are widely used to form the basis of more complex data structures too.
- It is therefore important to reconsider these concepts from a data structures perspective to understand their relevant characteristics, and also their strengths and weaknesses in this regard.