5G is More Than Faster Mobile Broadband

...Much More

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Wireless Cellular Data History

- 2G-Limited analog data support 9.6 Kbps

- 3G support for data 384 Kbps
  - Slow amp up and rollout of data services
  - 2008, first mobile device web browser released

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Wireless Cellular Data History

- 4G networks dominated by video and image traffic

  o Initially real world speeds of 5 Mbps using LTE and 600 Mbps using LTE-A

  o Wireless became the preferred access method for the Internet

  o Social networking become the killer app

  o Video dominates Internet traffic

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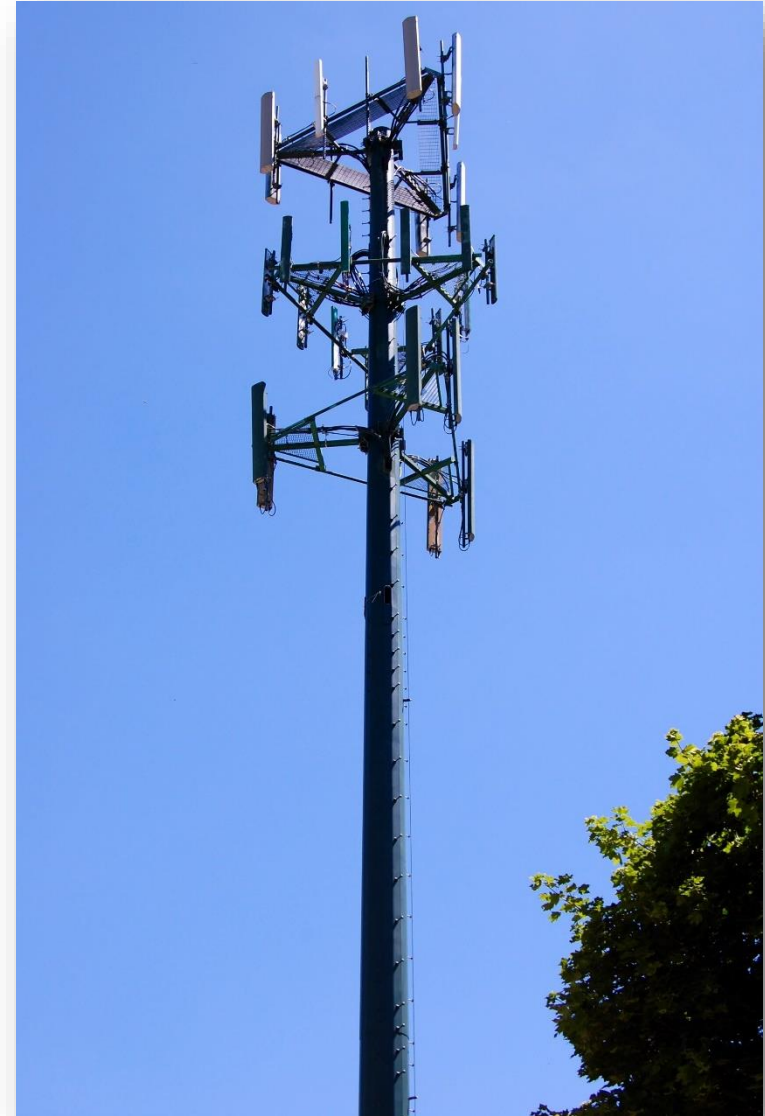
What is it?

- Spectrum for mobile cellular and fixed wireless

- Includes licensed and unlicensed spectrum

- Frequency ranges with the most space and therefore greatest bandwidth are above 28 GHz

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Spectrum Allocated by FCC in July 14 Order

- 7 GHz of unlicensed spectrum in 64-71 GHz band

- 3.85 GHz of licensed spectrum in 28, 37 and 39 GHz bands

- 600 MHz of shared access spectrum in 37-37.6 GHz bands

Use of high frequencies allow for a large amount bandwidth but requires small cell radiuses

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Future Actions under consideration by the FCC

- 150 MHz in the 3.5 GHz band

- Repurpose of the 2.5 GHz BRS/EBS band

- 650 MHz in the 3.7-4.2 GHz band

- 450 MHz in the 3.1-3.55 GHz band

Lower spectrum Band may be more suitable for Rural Deployments of 5G

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5G Network Goals

- Designed to support real time applications requiring:

    - Higher bandwidths

        - 10 Gigabit per second throughput per cell

    - Low latency response times

        - 1 millisecond in comparison to today's 50-100 millisecond response times

    - Support for 100's of billions of intelligent devices and sensors

    - Use of high frequency RF bands to avoid congestion

5G Network Goals

- Opens up bandwidth that appears to be capable of serving 50+ Mbps to several thousand devices

- Gigabit service to many subscribers in an area

- Less than 1 ms latency

- Claims of providing a viable alternative to FTTP-5GTTP

- Available by 2020 and beyond

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5G Network Goals

Initially targeted to fixed wireless applications and machine-to-machine communications, not personal devices

5G is going to look more like a super Wi-Fi than a traditional mobile cellular network.

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5G How?

- Multiple Input, Multiple Output antenna system
  - Current MIMO supports 4x4 and 8x8 systems
  - 5G supports 16, 64 and 128 way MIMO
- More RF spectrum
  - Using higher RF bandwidths
  - 28, 35, 40 and 61 GHz spectrums for 5G
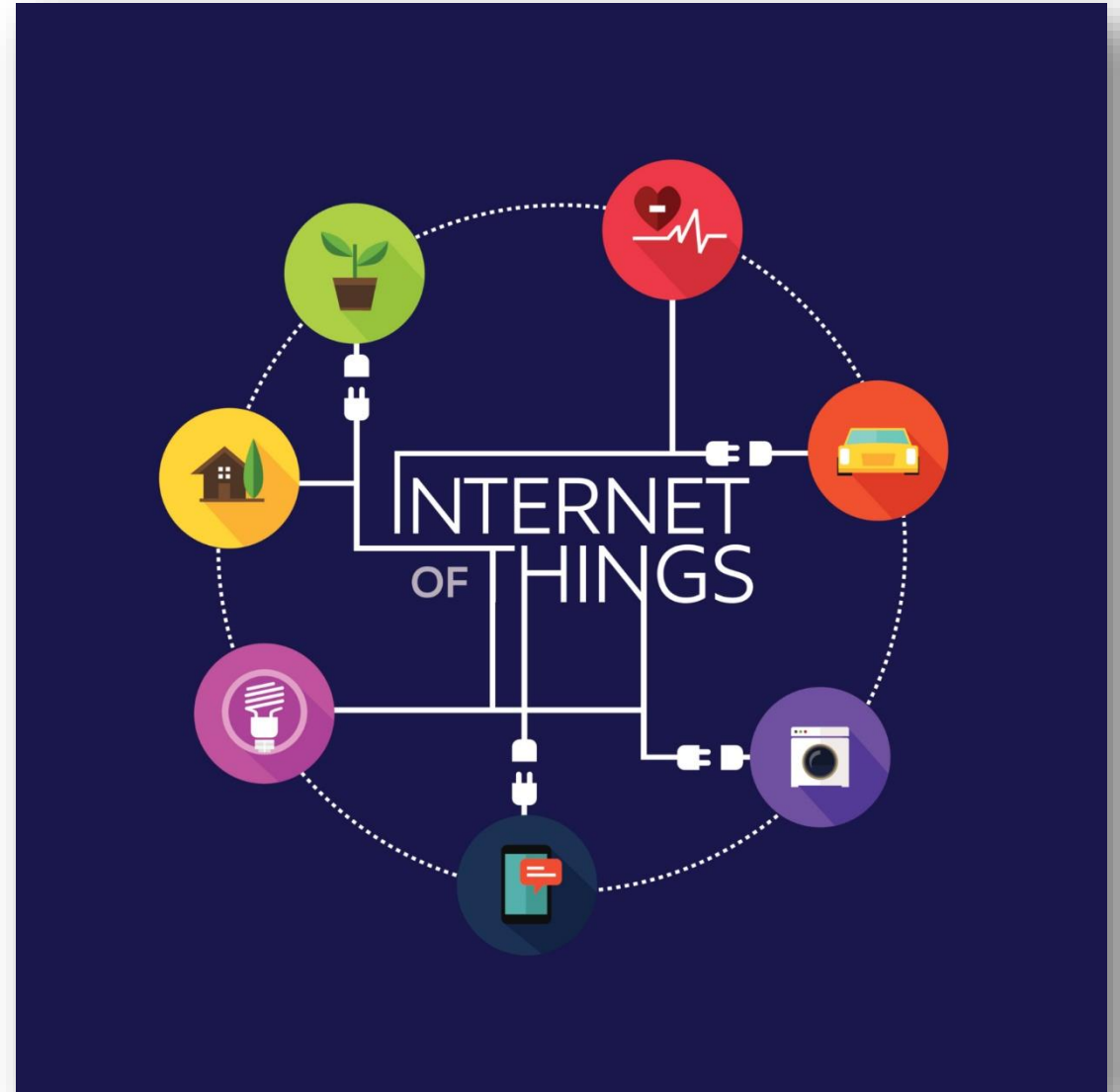 - Smaller cell serving area radius

5G How?

- Substantial blocks of unlicensed spectrum are included in the standards

- 5G may also take advantage of bi-directional simultaneous transmission and reception on the same frequency

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5G Why?

- Smart cities
- Smart vehicles
- Smart homes
- Smart agriculture
- Last mile broadband

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Smart Communities

Better civic services and more engaged citizens

Smart Cities

- Public amenities and infrastructure connecting and harmonizing

- E-Health
  - Continuous patient monitoring

- IoT making remote actions seem local
  - Real time user centric network

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Smart Homes

o Security

o Energy efficiency

o Home automation

o Machine-to-machine

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SMART VEHICLES

Reducing accidents, congestion, and eventually self-driving cars

RIDE

Smart Vehicles

- Not just self-driving cars
  - Traffic management
    - Adjust Speed and Route to decrease overall travel time
  - Vehicle-to-vehicle
    - Rear end collision avoidance
  - Self-driving vehicles
    - Semis
    - Local delivery
  - Trucking
  - Autonomous robotics

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IoT-Sensors Everywhere

- Autonomous vehicle-talk to each other directly car-to-car in addition to network

- Trucking

- Drones as sensors
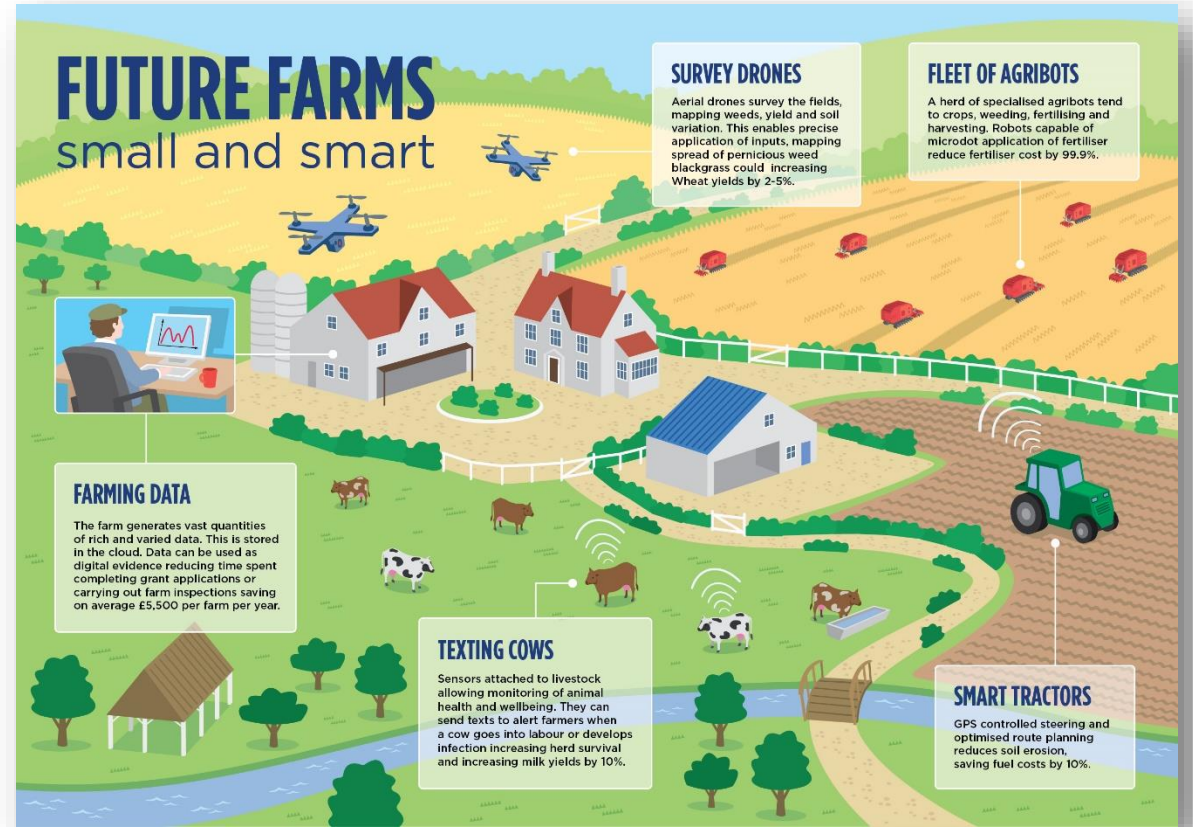
- Last mile drop bypass for broadband services

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SMART FARMS

Better crop yields and healthier livestock means more profitability

Smart Agriculture

- IoT
  - Machine-to-machine communications
  - Sensors everywhere
- Fiber to the cow
- Weather monitoring
- Livestock and field monitoring

FUTURE FARMS
small and smart

SURVEY DRONES
Aerial drones survey the fields, mapping weeds, yield and soil variation. This enables precise application of inputs, mapping spread of pernicious weed blackgrass could increasing Wheat yields by 2-5%.

FLEET OF AGRIBOTS
A herd of specialised agribots tend to crops, weeding, fertilising and harvesting. Robots capable of microdot application of fertiliser reduce fertiliser cost by 99.9%.

FARMING DATA
The farm generates vast quantities of rich and varied data. This is stored in the cloud. Data can be used as digital evidence reducing time spent completing grant applications or carrying out farm inspections saving on average £5,500 per farm per year.

TEXTING COWS
Sensors attached to livestock allowing monitoring of animal health and wellbeing. They can send texts to alert farmers when a cow goes into labour or develops infection increasing herd survival and increasing milk yields by 10%.

SMART TRACTORS
GPS controlled steering and optimised route planning reduces soil erosion, saving fuel costs by 10%.

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Last Mile Broadband

- Fiber to the wireless access Point/wireless to the home
  - 5G wireless to complete the last mile connection to the home (i.e. drop)
  - Eliminates the cost of the drop and house wiring
    - 30-50% of the FTTP implementation cost
 - May use wireless radios for back haul

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Last Mile Broadband

- AT&T AirGig
  - Allows the use of existing power transmission lines to act as waveguides for 5G RF signals to provide broadband services to customers

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5G Opportunities for Rural Carriers

- ## Antenna sites

  - o The increase in number of antennas required to provide coverage will multiply
    - o 100's of antennas required instead of 10's for 4G coverage

- ## Fiber backhaul

  - o Low latency requirements will limit the use of Ethernet based services but may increase the need for dark fiber or optical wavelength based services.
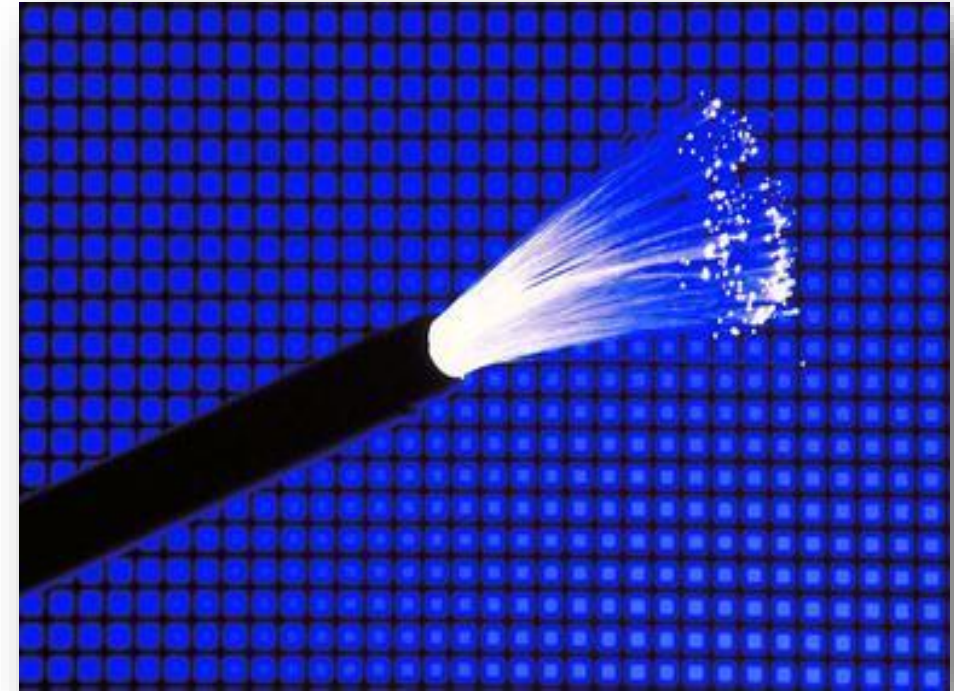
# Two Sides to the 5G Coin for Rural Carriers

5G could make it easier for a WISP to come in and overbuild a small town and adjacent subdivisions.

On the other side, 5G will allow a small local provider to edge-out into holding company territory and pick up customers without the expense of going FTTH.

5G Opportunities for Rural Carriers

- Edge computing
  - Movement of computing requirements from a centralized location in the cloud to the network edge will require additional investment in small scale data centers at local locations
  - 1 millisecond response times limit max allowable distance of fiber cable to 150 miles or less

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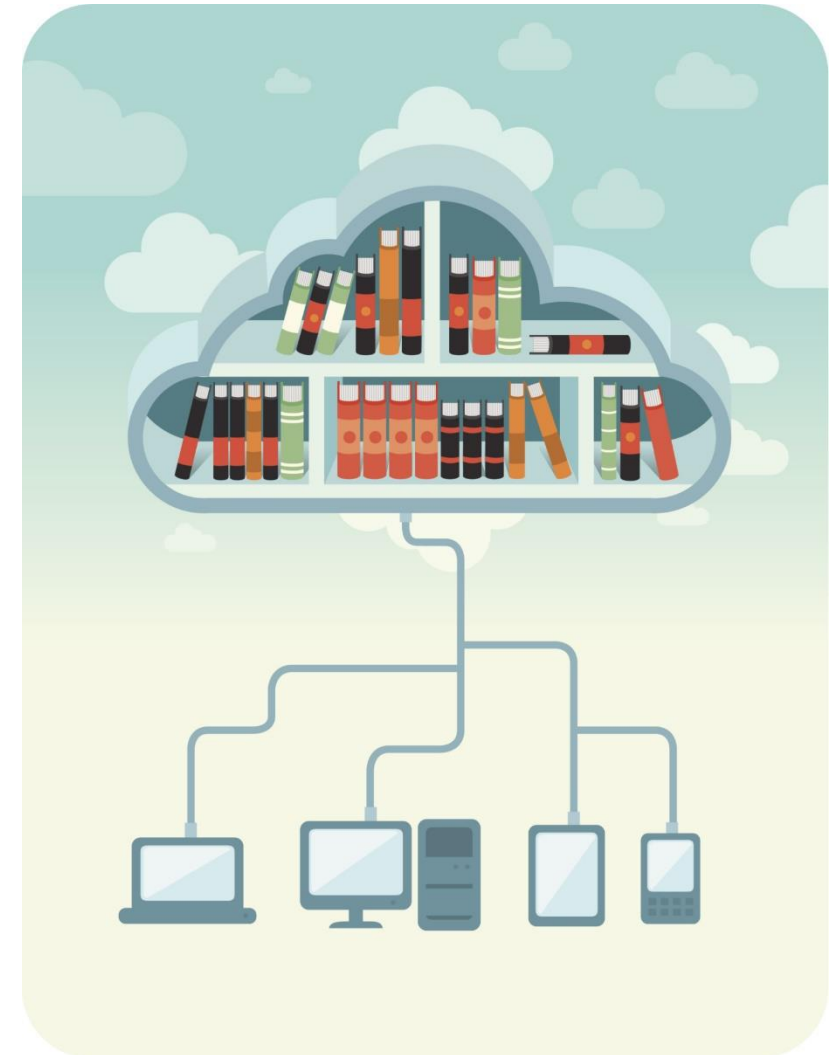
5G Roll-Out Timeline

- **2016:** Standards work

- **2017:** Experimental trials

- **2018:** 4.5G Roll-out using existing 4G radios to support new 5G applications and technologies

- **2020:** Initial 5G rollout

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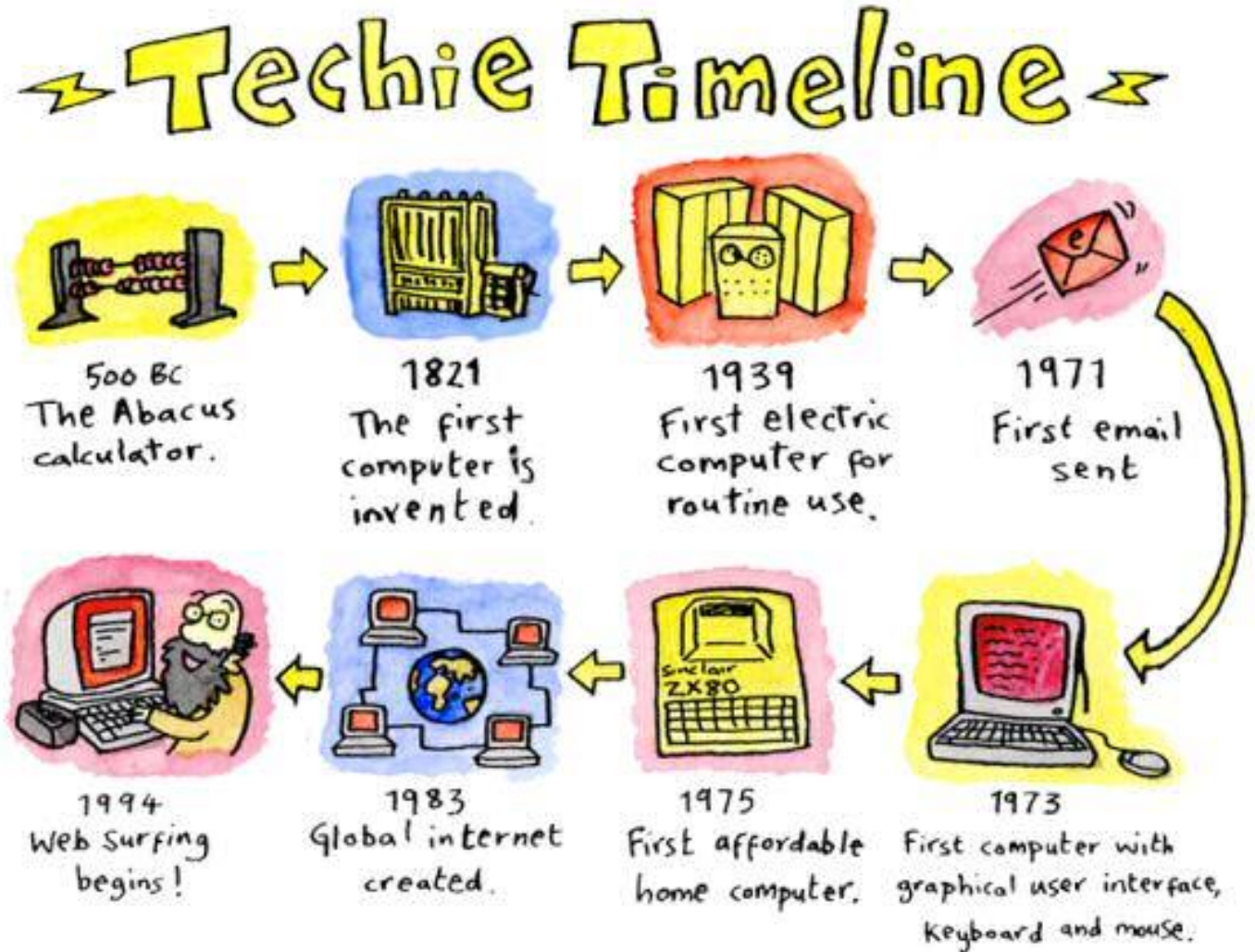
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