Challenges for Network to Support Future Scientific Applications

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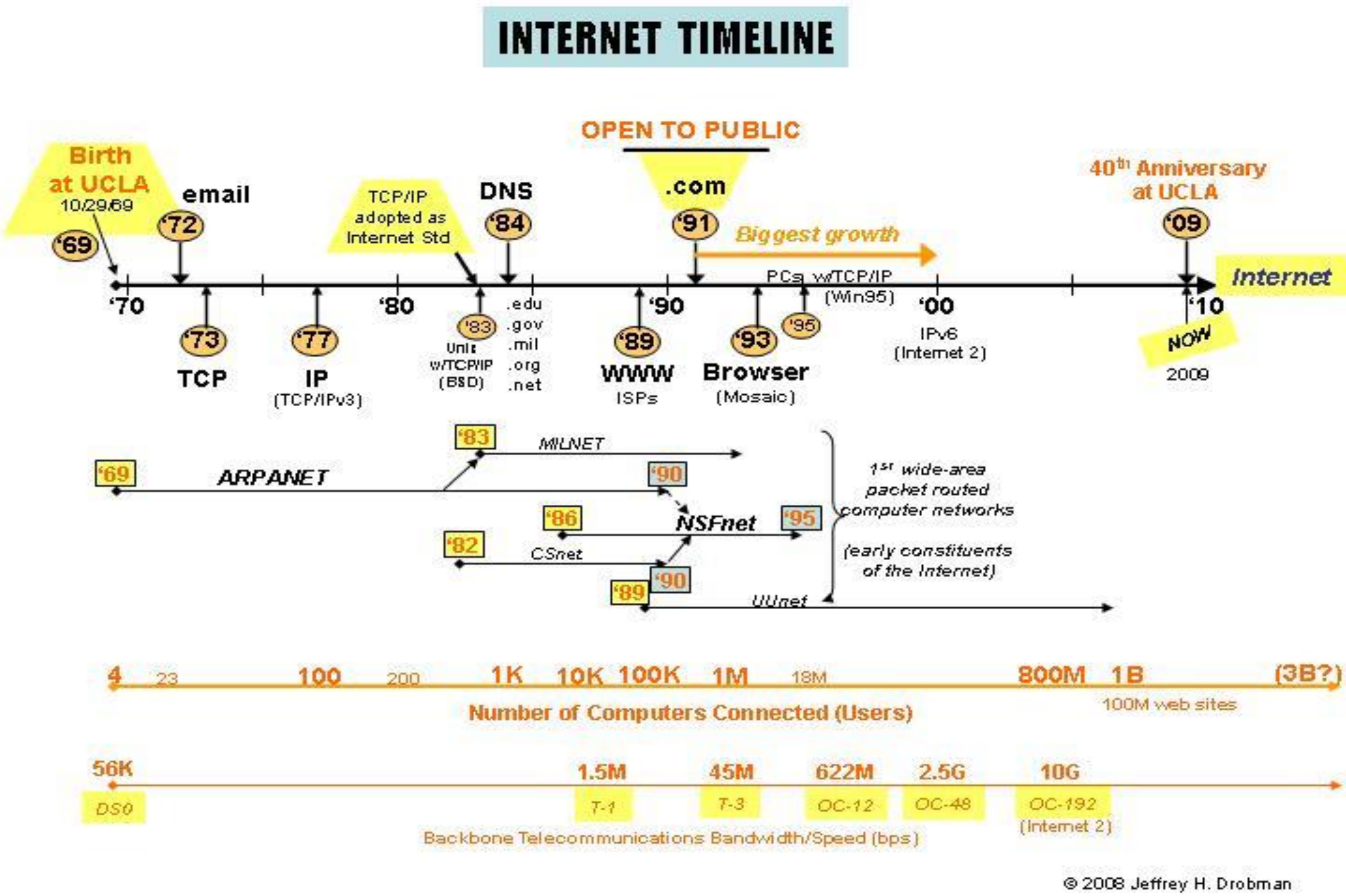
Outlines

- Overview
- Future Scientific Applications
- Requirement & Challenges
- Conclusion

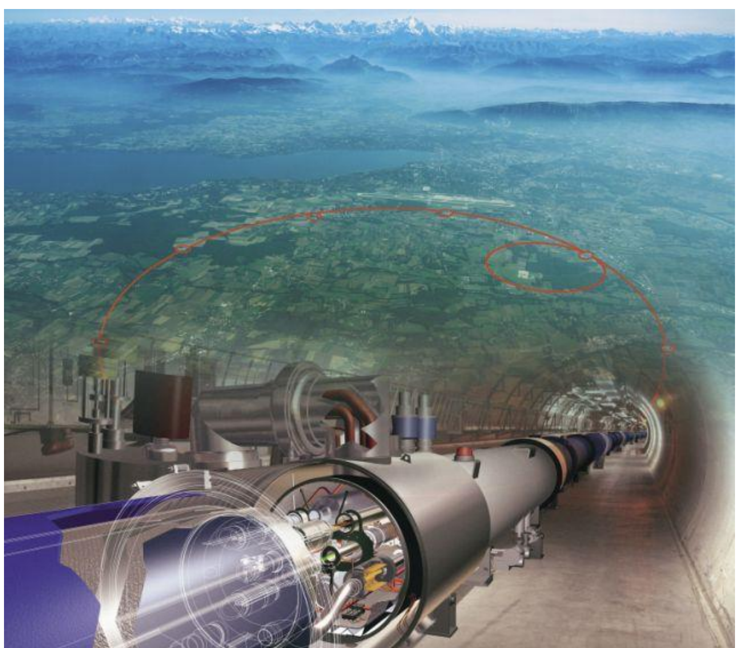
Internet History

- Internet was invented for scientific applications



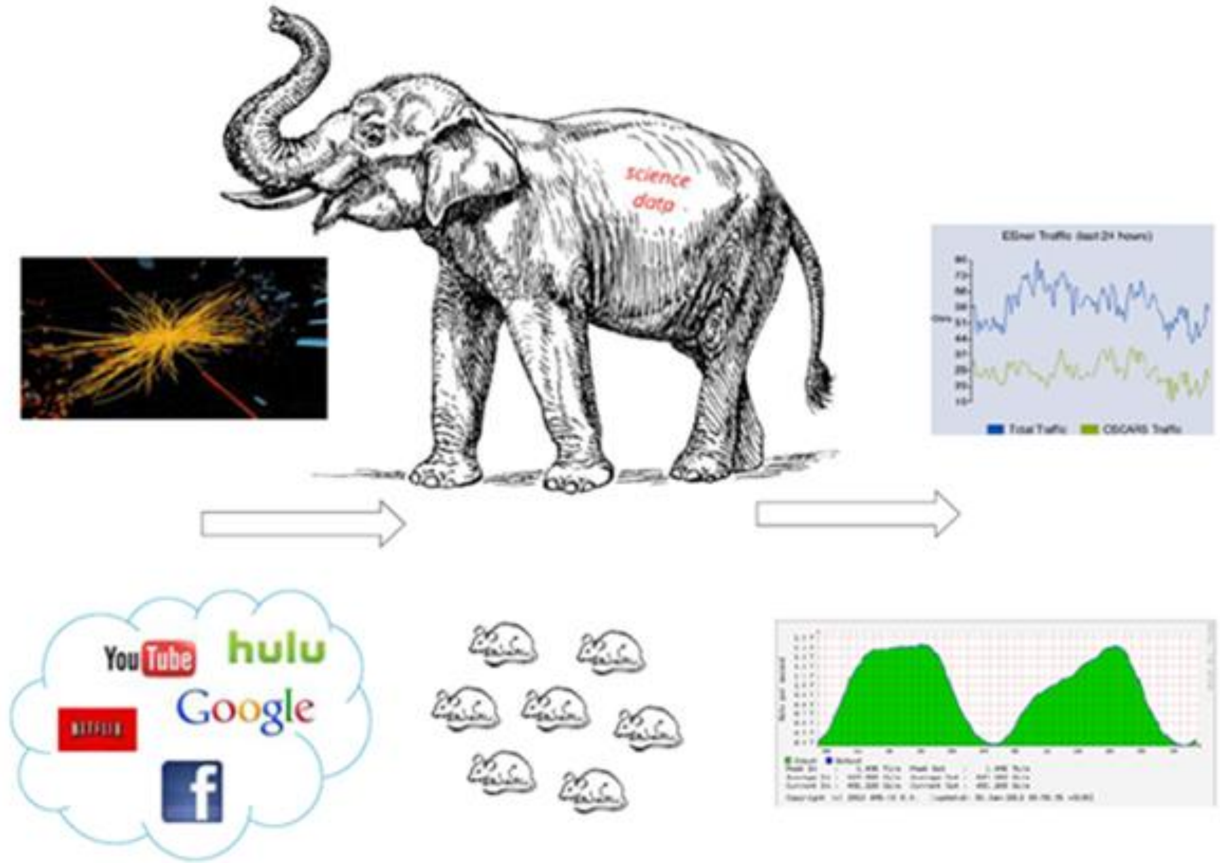
Internet History

- WWW is invented by Physicist at CERN, which is motivated by the requirement of physicists



Internet History

- Usually, requirements from scientists lead the requirements from common users



----from ESnet website

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Future Scientific Applications

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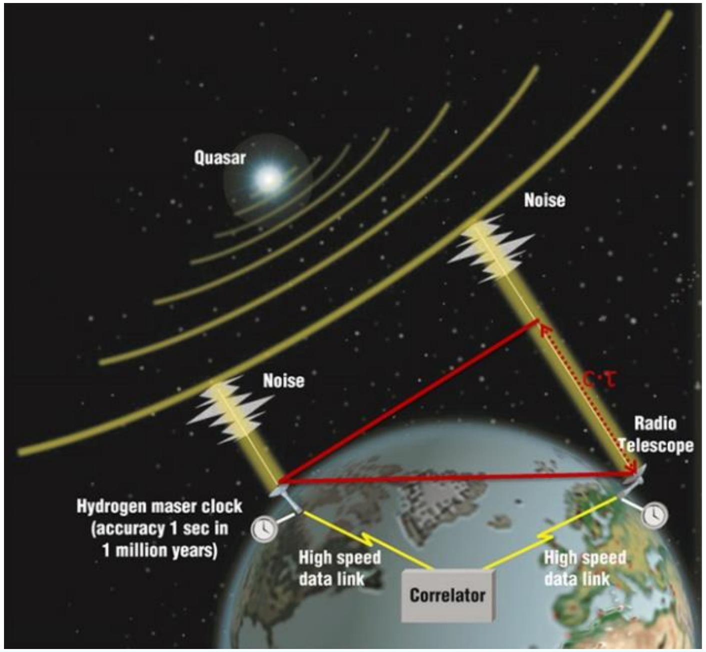
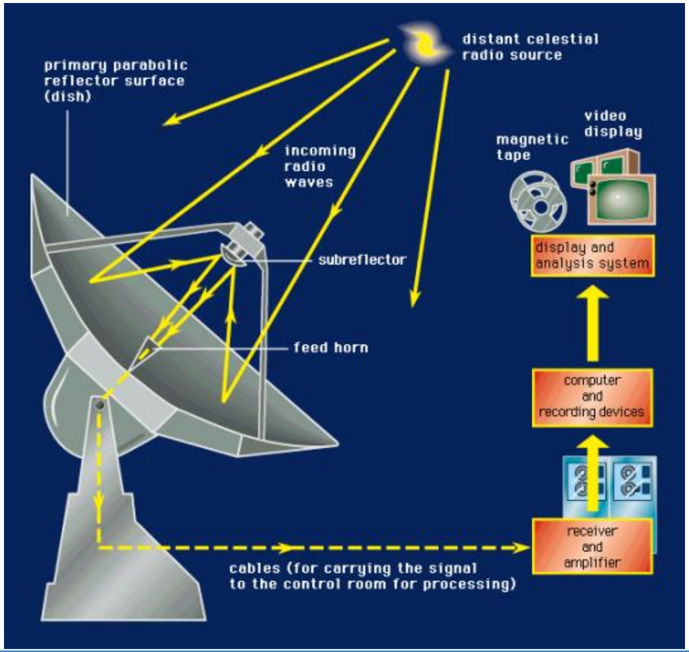
- VLBI
- SKA
- FAST
- LHC
- ITER
- Meteorology
- …

E-VLBI

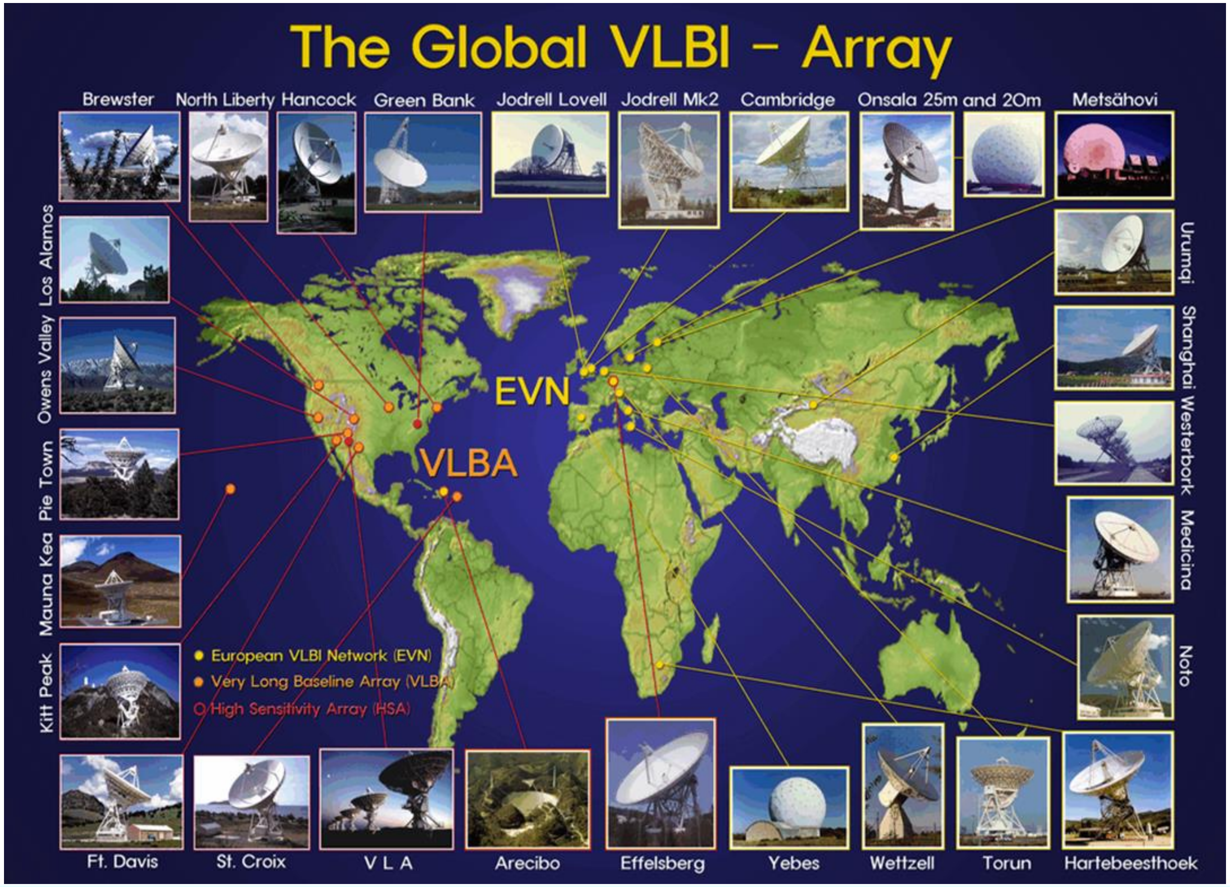
- VLBI: Very Long Baseline Interferometry
- Astronomists use VLBI to observe the sky.
- A typical E-VLBI system consists multiple distributed networked telescopes and a central correlator.
- Each telescope generates constant-rate massive data, which need to be transferred to the correlator in real-time





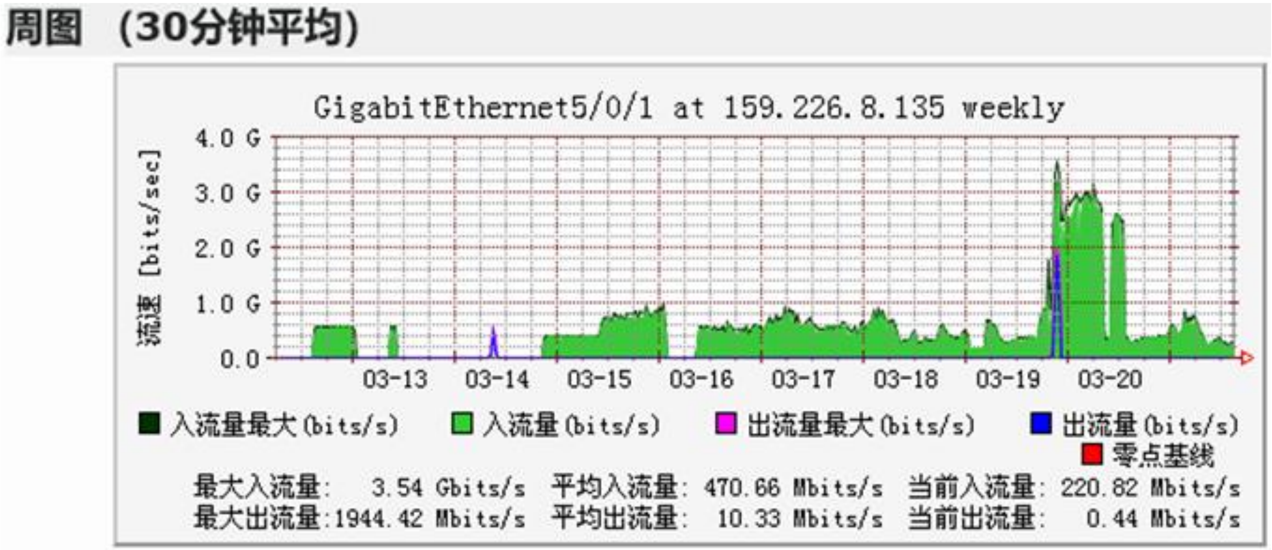
E-VLBI

- Global E-VLBI Array
- China CVN， Korea KVN，Japan VERA，Russia QUASAR, Australia LBA …



E-VLBI

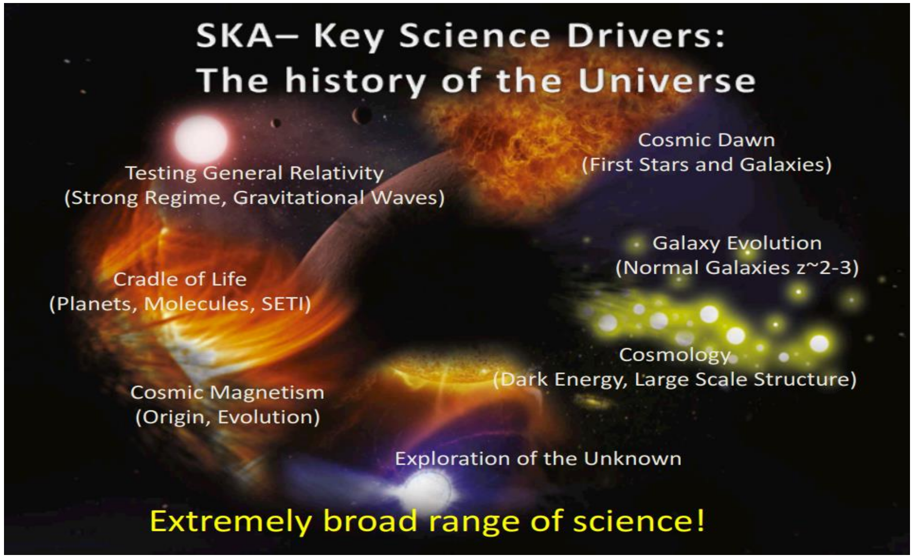
- Current rate requirement:
  - 256Mbps~16Gbps per site real time transfer
- In the future:
  - **128Gbps** and beyond
- The bigger data rate is available, the more accurate observation can be done.

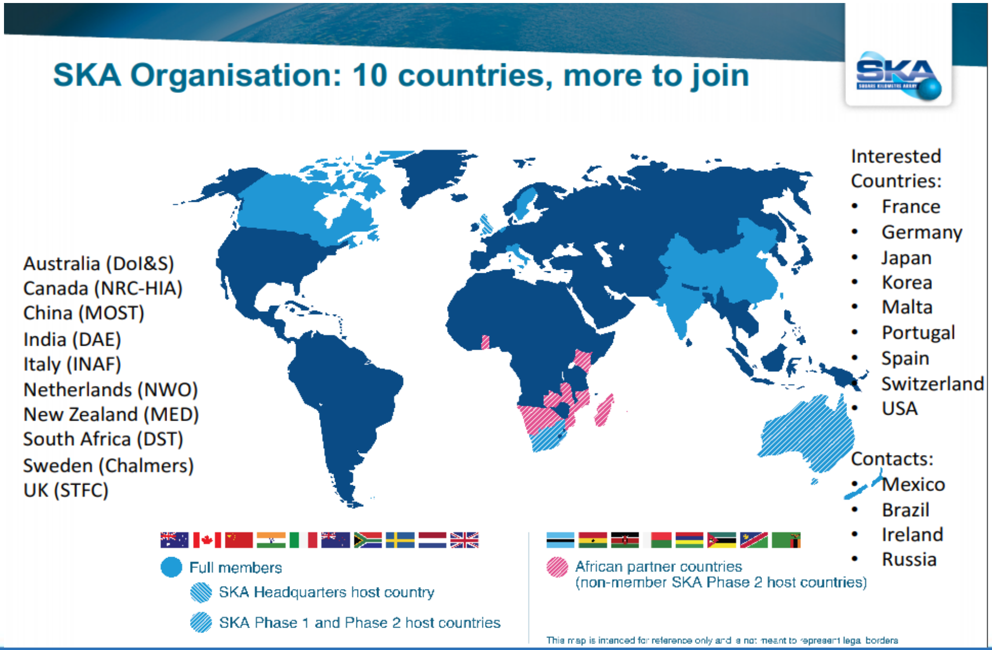


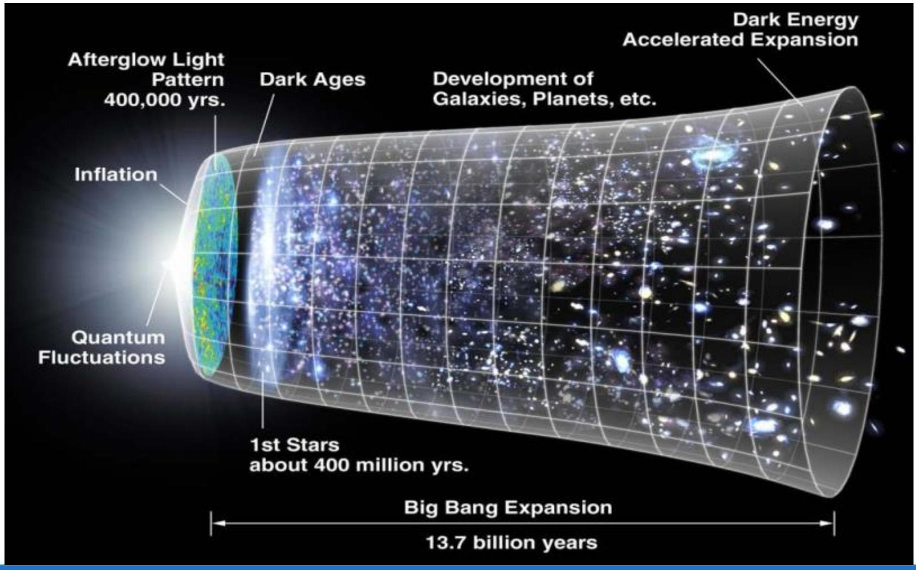
SKA - Square Kilometer Array

SKA

Will be one of the great physics machines of 21st Century and, when complete, one of the world's engineering marvels







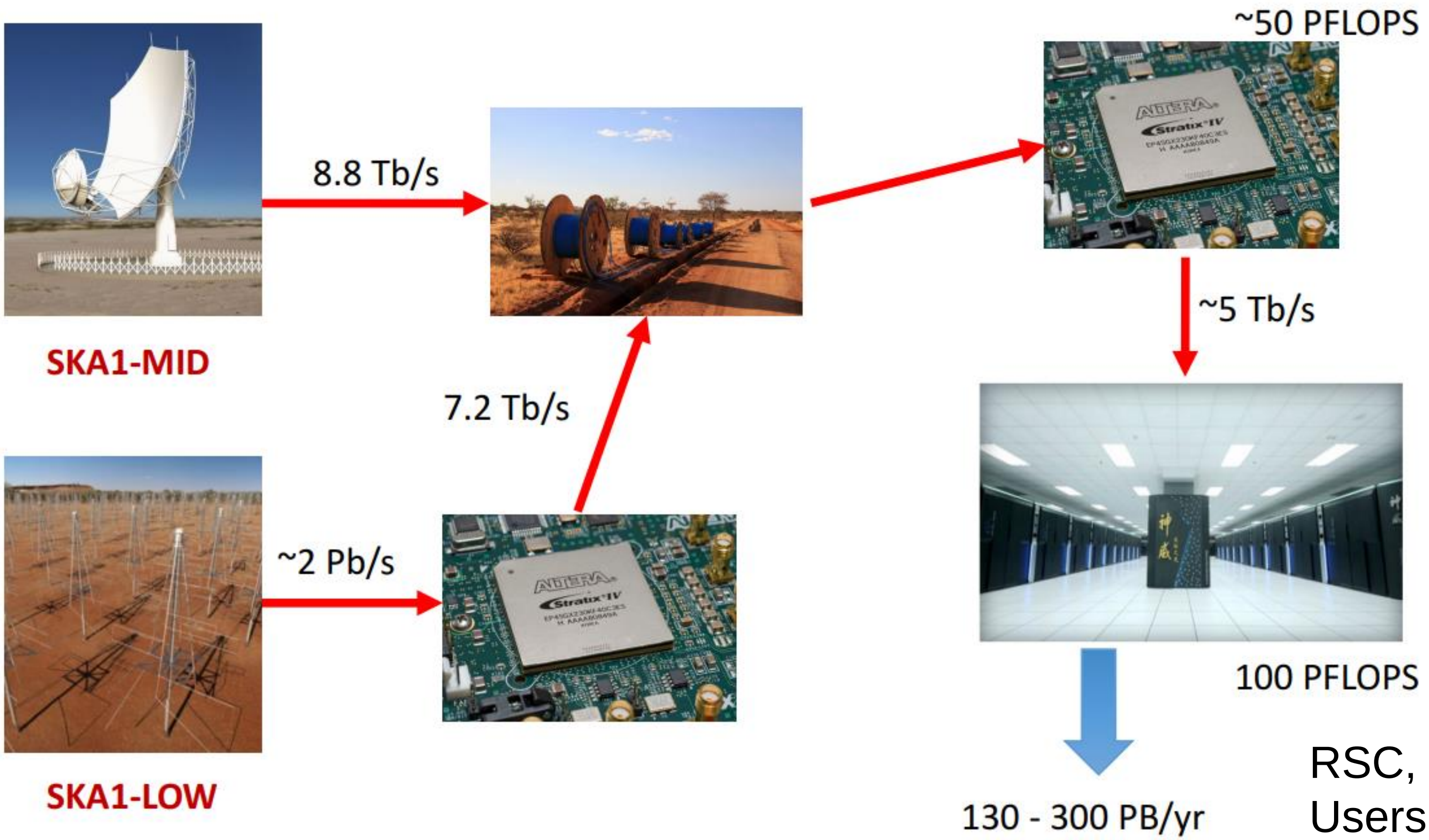
SKA

- Headquarter：UK
- Telescope Array：Australia, South Africa
- 2018-2023， SKA1 construction phase
- 2023-2030, SKA2 construction phase
- From 2020, starts the science research

Founding Members Sign SKA Observatory Treaty

SKA - a Software Defined Telescope

- **SKA is a software telescope**
  - Very flexible and potentially easy to reconfigure



SKA - a Software Defined Telescope

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SKA: driving innovation

Element	SKA1 scale	SKA2 scale
Dishes, feeds, receivers	~200	~2500
Aperture arrays	~130,000	~1,000,000
Signal transport	~1 Pb/s	~10 Pb/s
Signal processing	~exa-MACs	~exa-MACs
High performance computing	~100s tera-flops	~exa-flops
Data storage	Exa-byte capacity	Exa-byte
Power requirements	~10MW	~50MW

Key innovation: Software engineering and algorithm development.

Exa = 10^{18}, or 1 followed by 18 zeroes;
requires increase in compute capability by factor 1000

FAST

- FAST：Five-hundred-meter （500m） Aperture Spherical radio Telescope
- FAST is the largest single dish radio telescope in the world.
- It is managed by the National Astronomical Observatories of Chinese Academy of Sciences (NAOC)

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FAST Data Requirement at the early stage

- **Simple mode**
  - Pulsar and FRB seek (7x24h), 50us, 4k channel, 4pol, 8bits, 19 beam => **6GB/s** ~ 520TB/day **~ 200PB/year**

- **Complex mode**
  - 19 beams orginal base band data: 1Gsps *2pol*19*8bits = **38GB/s ~ 1ExaByte/year**

FAST in 20 years

- FAST Data Volume
  - 2017-2027　　100PB
  - 2027-2037　　1EB,　3EB,　10EB
  - 2027-2037　　100EB

Others

- LHC
- ITER
- Meteorology
- Gene
- …

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Requirement & Challenges

- **Extra-High network bandwidth**
- Currently, typical 100Gbps,
  - eg., e-VLBI:128Gbps/site
- In the near future, →Tbps→…
  - Eg., SKA: 8.8Tbps

Requirement & Challenges

- **High Reliability**
- >99.9%
- Eg., ITER experiment requires 99.999% network reliability (each experiment runs 8~16hours/day, 5~7 days/week, the network fault time has to be less than 1minute during the experiment)
- LHC experiment requires the network >99.95% reliability

Requirement & Challenges

- **End-to-end QoS guarantee and Dynamical on-demand bandwidth provisioning**
- Massive scientific data usually need to be transferred between multiple sites cross multiple network domains
- Different experiments have different running time, from several minutes to many days or even long term.

Requirement & Challenges

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- **Determined Delay Gurantee**
- For many experiments, data are gathered at the same time with the experiments, and need to be processed at the remote processing center in real-time through network transfer.
- Eg., when running an e-VLBI experiment, data from distributed multiple telescopes are continually gathered, and have to be synchronously transferred to the data process center. It’s only meaningful if all the data from multiple sites are converged and correlatedly processed.

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Conclusion

- Requirements from scientific applications lead the development of new network technologies
- Future scientific applications have great requirements for network performance, such as:
  - Bandwidth
  - Reliability
  - QoS
  - Dynamical on-demand provision
  - Determined delay

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Thanks!

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