ISGC 2018
(Taipei, Taiwan)

Singapore Smart Nation Initiatives Using HPC

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President, SingAREN Network
Board Member, APAN Committee

Super Computing - Key to Economic Growth and Prosperity

- Cloud Computing, IoT, data mining, data analytics, blockchain, cyber-security, supercomputing, are now perceived as essential to the wealth, security, growth, and economic prosperity of nations.

- Super Computing simulation and analysis have become a source of discovery. Genomics and personalized medicine as well as Cloud Computing require ultra high security and reliability, fast data replication and disaster recovery.

- Exascale computing is seen as the next Frontier with the USA, Europe, Japan and China allocating each in excess of one billion US$ to be the first to reach this milestone by the early 2020's.

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Singapore

Physical Land Area: **718 sq km**

Population: **5.5 million**
    3.9 million (70.8%)
    Singapore Residents

Literacy Rate: **96.7%** (Aged 15 & above)
    76.4% of those aged 25-34 years
    have tertiary qualifications

2014 GDP S$390.1bn (US$307.9bn)
    Real Growth :   2.9%
    Per Capita GDP: S$71,318
                  (US$56,284)

Independent since 9 August 1965

ASIA

SINGAPORE

Sources: Singapore in Brief 2015, Department of Statistics

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Resource Centre

Singapore's lead government agency for economic oriented R&D

Annual Outputs (FY2011 – 2015)

>1,700
Industry projects a year
5 Industry projects a day

| 55% MNCs |
| 38% SMEs |
| 7% LLEs |

>200
Licenses a year
4 Licenses a week

>2,800
Papers published a year

>14
Start-Ups a year

>270
Patents filed a year

1
RSE spun out to industry a day*
*average number of Research Scientists and Engineers (RSE) per working day in a calendar year

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A*STAR Computational Resource Centre

Scope:

– serve A*STAR users

– exploration of novel technologies and architectures

Many unique systems:

– Cumulus (IBM), Cirrus (IBM), Aurora (SGI), Fuji (Fujitsu), Axle (HP), Cray

Large range of architectures:

– Intel x86, IBM Power, NVIDIA Tesla, AMD FirePro, Intel Xeon Phi, Micron Automata

Involvement in exploration projects:

– InfiniCortex – InfiniBand ring around the world

– Intel Center of Excellence

– IBM OpenPower Foundation member *(4 x IBM Power 8 servers)*

– Micron Automata Center of Excellence *(2 x Automata boards)*

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National Supercomputing Centre (NSCC)

~1 PFLOP System

- **1,288 nodes** *(dual socket, 12 cores/CPU E5-2690v3)*
- **128 GB** *DDR4 RAM/ node*
- **10 Large memory nodes** *(1x6TB, 4x2TB, 5x1TB)*

13PB Storage

- **HSM Tiered, 3 Tiers**
- **I/O 500 GB/s flash** *burst buffer*
- **10x Infinite Memory Engines** *(IME)*

EDR Interconnect

- **EDR (100Gbps) Fat Tree** *within cluster*
- **InfiniBand connection** *to remote login nodes at stakeholder campuses (NUS/NTU/GIS) at 40/80/500 Gbps throughput*

Sample of NSCC applications

Numerical Ocean Basin

TECHNOLOGY CENTRE FOR OFFSHORE AND MARINE, SINGAPORE (TCOMS)

A state-of-the-art Ocean Basin facility is being developed by TCOMS@NUS in Singapore, comprising a deep tank equipped with wave and current generation systems to simulate ocean environment. NSCC partners TCOMS to provide the computational power required for the numerical modeling of waves and current flows of test models and experiments for marine and offshore structures.

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Collaborative Project
Technology Centre for Offshore and Marine Singapore (TCOMS)

COUPLED EXPERIMENTAL - NUMERICAL WAVE FLUME TEST
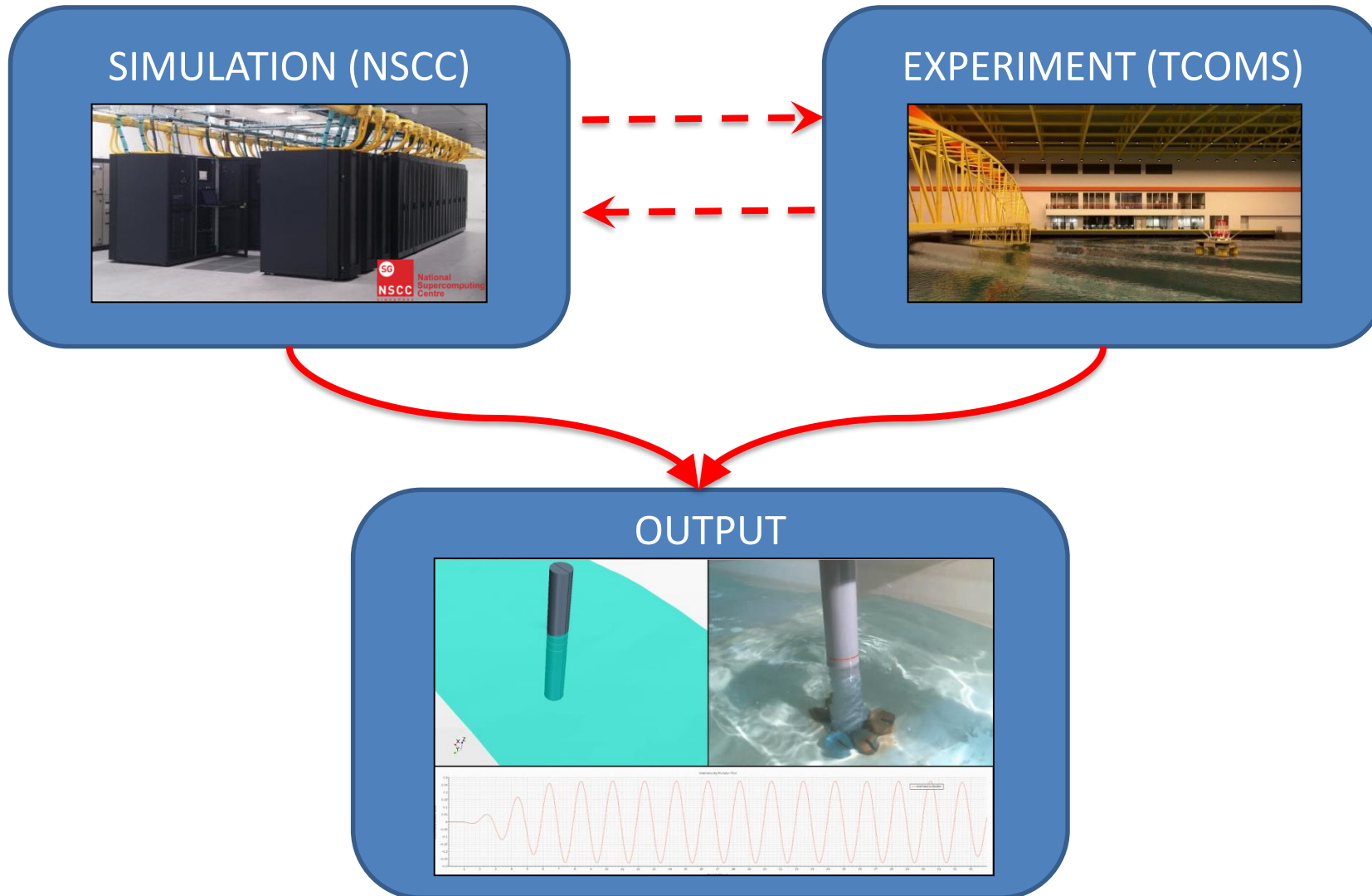
NSCC applications

**GenomeAsia 100K Consortium**

GENOME@NANYANG TECHNOLOGICAL UNIVERSITY

The GenomeAsia100K initiative aims to sequence 100,000 genomes from North, South and East Asia populations, with the goal of accelerating precision medicine and clinical application for Asian patients by leveraging new information and understanding from the collected genomics data.

Collaborating with NTU acting as host to the initiative to utilise NSCC's infrastructure to undertake the computational analysis of massive datasets for accelerating downstream analysis and experiments leading to new knowledge and insights in Genome science.

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Collaborative Project
(NTU-NSCC-GenomeAsia 100K consortium)

- **Aim**: To sequence 100,000 genomes from various South, North & East Asia populations
- **Goal:** To accelerate precision medicine and clinical applications for Asian patients
- **NTU** acts as the host and **NSCC** provides the HPC resources
- **68TB** of genome data from USA and Korea aggregated and hosted on NSCC platform
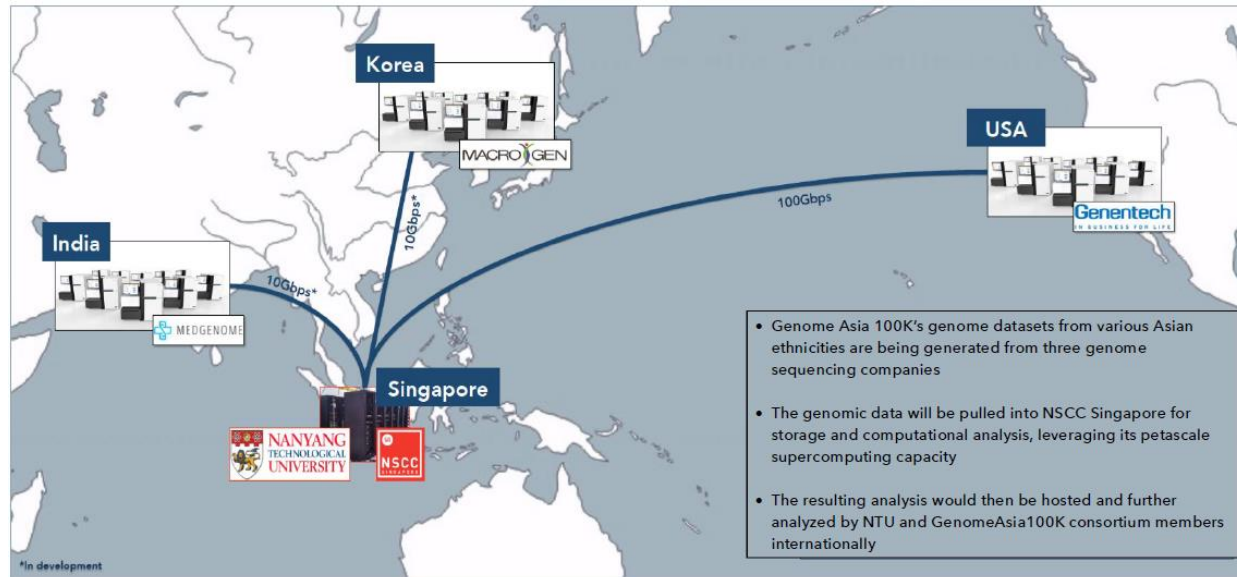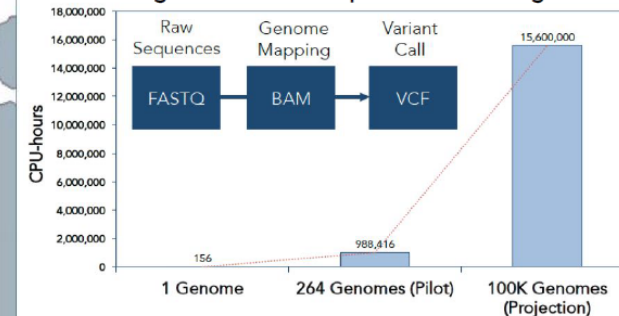
- Using **NSCC HPC resources**, total compute time to process genome data for **100,000 genomes will only take up 1.1% of the 4-year project**, thus providing more time for novel downstream analysis and experiments

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NSCC applications

National Precision Medicine Initiative

Led by Prof. Patrick Tan (Deputy Director, Biomedical Research Council of A*STAR and NSCC Steering Committee member) the NPMI will be a key partner and user of NSCC's supercomputing, advanced networking, visualisation and data wormhole highspeed connectivity to globally located healthcare information resources.

Some new Developments

Platform for Deep Learning

STRATEGIC PARTNERSHIP WITH NVIDIA:
Towards a Deep Learning platform leveraging on Theano, Caffe, TensorFlow and Torch on our 128 Tesla K40 GPU nodes.

Data Wormhole

High bandwidth, low latency, transcontinental data transfer gateway in collaboration with International Centre of Advanced Internet Research (iCAIR), University of California San Diego (UCSD) to support our participation in the Global Research Platform, an extension of the Pacific Research Platform.

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Collaborative Project
(Data "Wormhole")

DATA "WORMHOLE"

NCMIR

Facilitating Data Intensive Collaboration Between NSCC and the National Center for Microscopy and Imaging Research (NCMIR) at UC San Diego

SG
NSCC
SINGAPORE
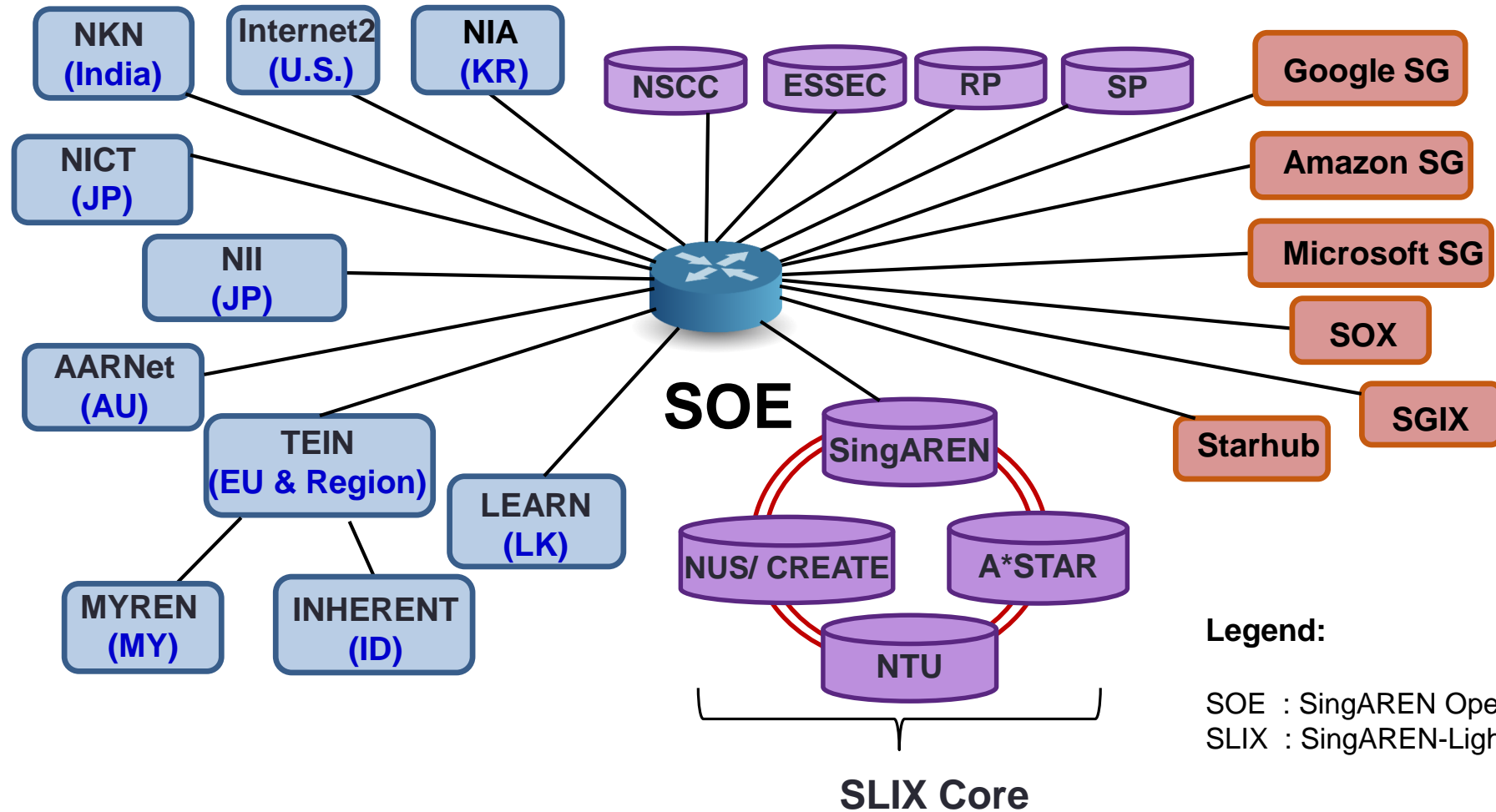National Supercomputing Centre

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Collaborative Project
IMDA-NTU-NSCC (Green Data Centre)

- Development of an interactive 3D visualization of the thermal profile of high performance server clusters in NSCC

- Ability to monitor the thermal dynamics of servers and spot outliers or anomalies

- Eventual aim is to improve the energy efficiency at NSCC's data centre
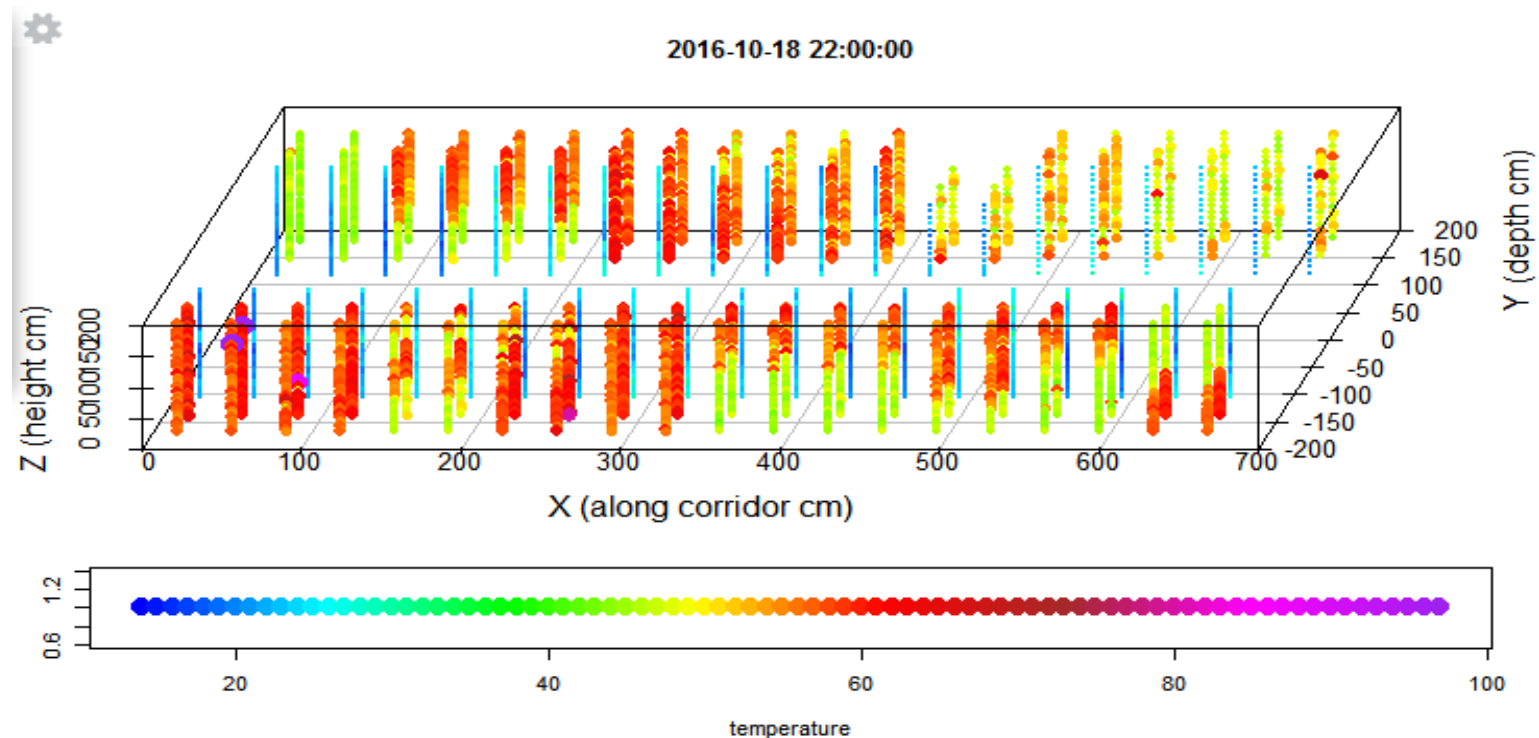
SingAREN Network Infrastructure

NKN (India)
Internet2 (U.S.)
NIA (KR)
NICT (JP)
NII (JP)
AARNet (AU)
TEIN (EU & Region)
LEARN (LK)
MYREN (MY)
INHERENT (ID)

NSCC
ESSEC
RP
SP

Google SG
Amazon SG
Microsoft SG
SOX
SGIX
Starhub

SOE

SingAREN
NUS/ CREATE
A*STAR
NTU

SLIX Core

Legend:

SOE : SingAREN Open Exchange
SLIX : SingAREN-Lightwave Internet Exchange

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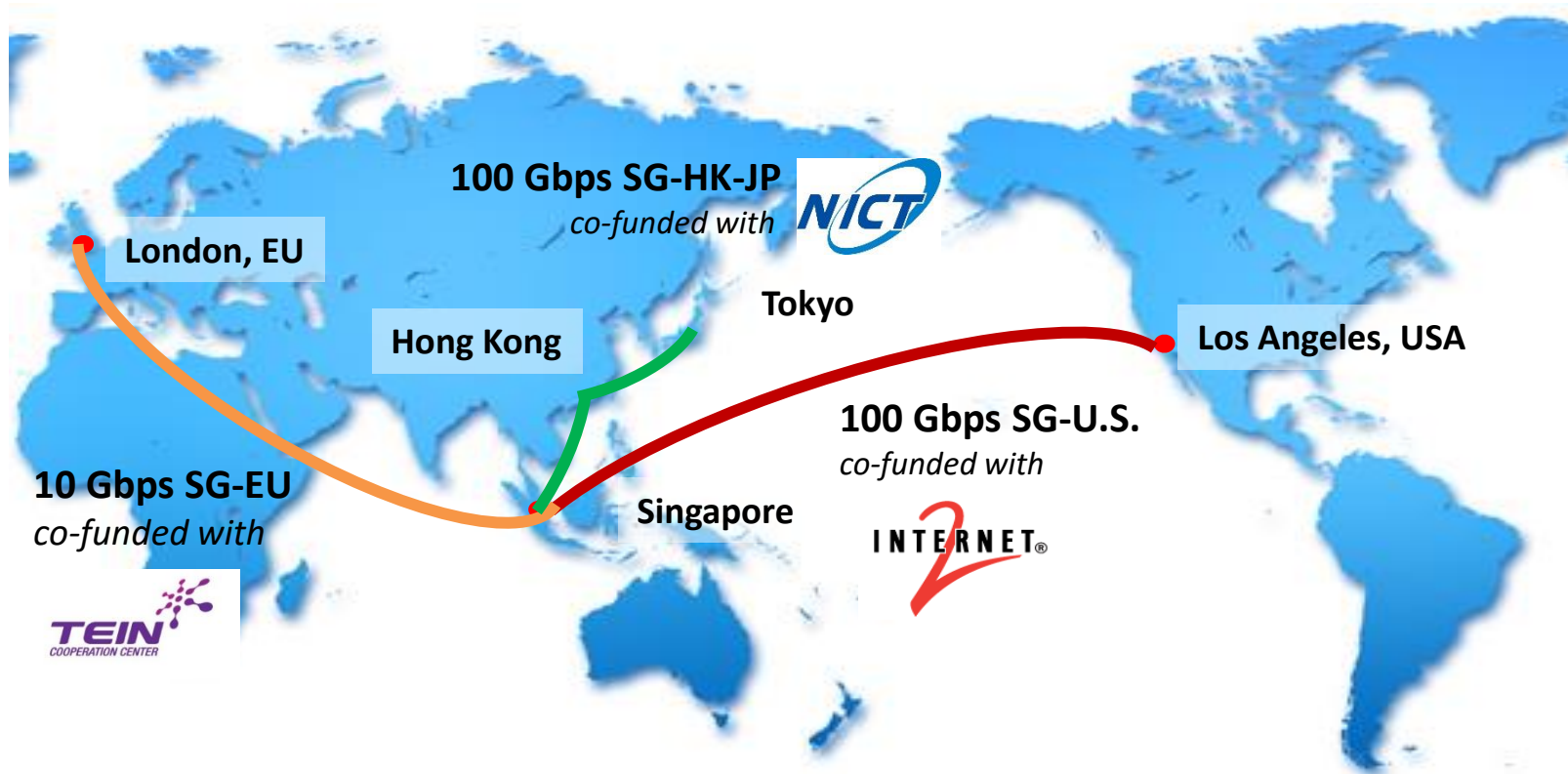
'Maximize my effective throughput between my storage and my compute'

Fusionopolis and Biopolis are 2km apart

A*CRC Datacenter I

Level 17 at Fusionopolis

Matrix Building at Biopolis

Tests started with Mellanox METRO-X early 2013. Today the sites are connected with nx40gbps connections running native InfiniBand and reaching approx. 98.4% of maximum theoretical possible throughput. Dark fibre running at 400Gbps, soon 1Tbps using Infinera connects the two sites.

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InfiniCortex at SC 2017

largest spanning InfiniBand network: ring-around-the-world with up to 100Gbps sections (Singapore-USA)

UAlberta (Edmonton)

PSNC (Poznań)

URCA (Reims)

SBU (New York)

GA TECH (Atlanta)

SC15 (Austin)
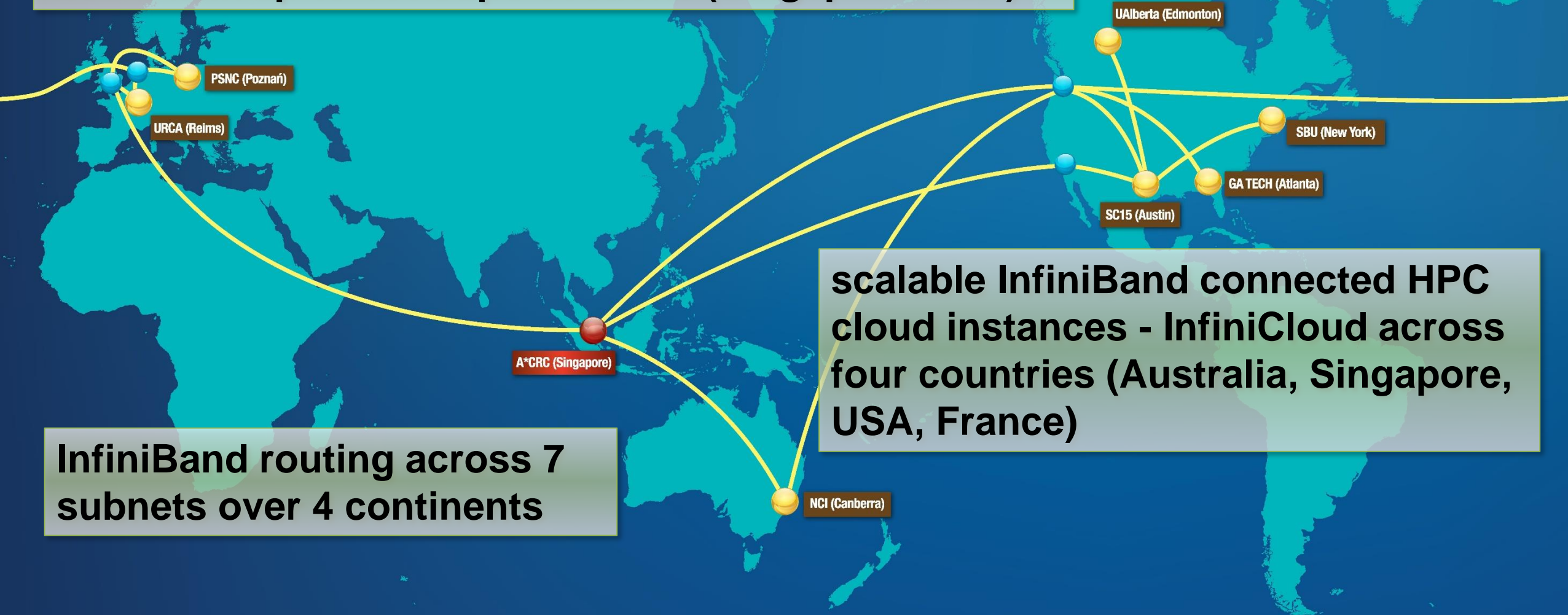
A*CRC (Singapore)

scalable InfiniBand connected HPC cloud instances - InfiniCloud across four countries (Australia, Singapore, USA, France)

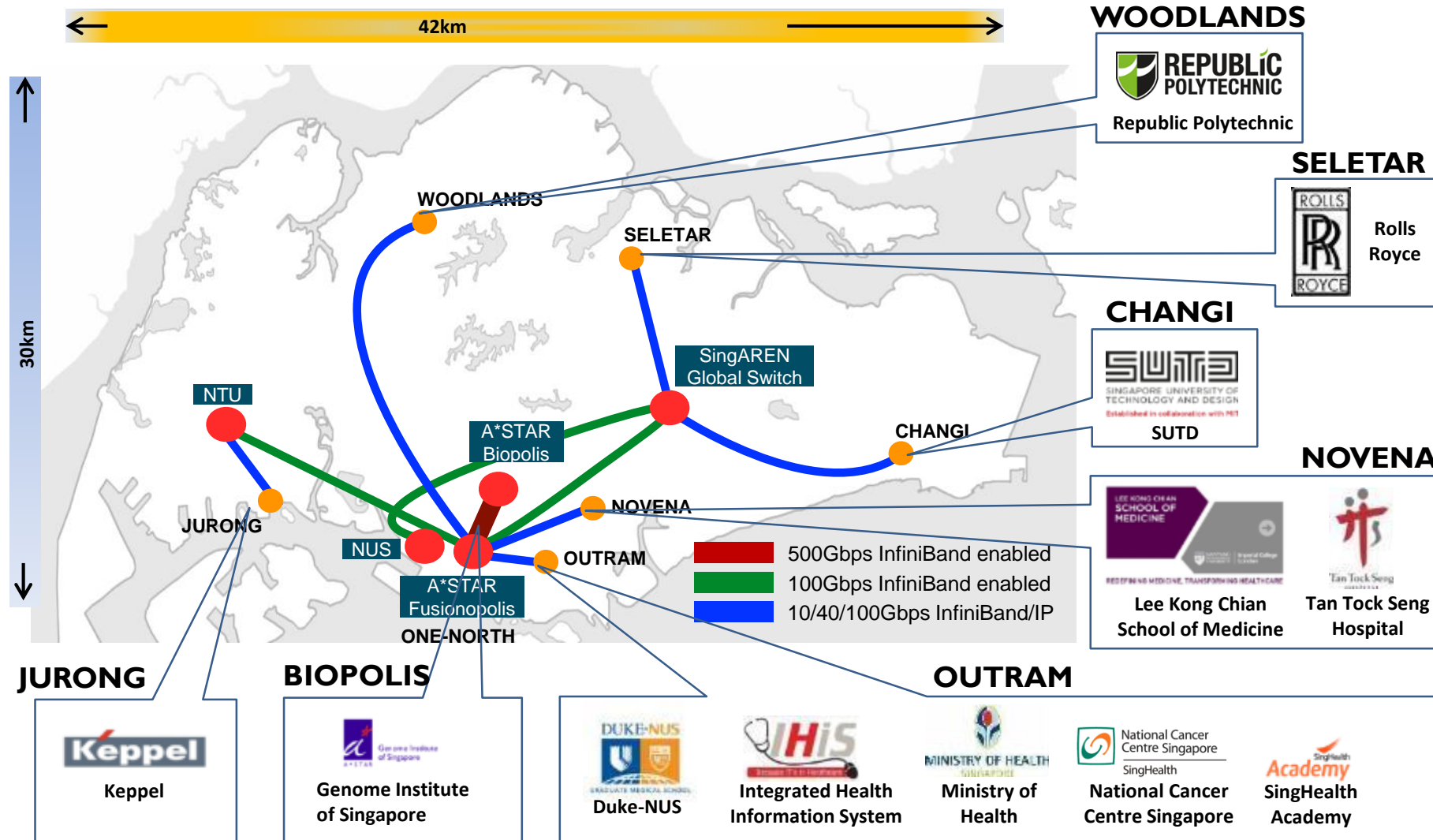InfiniBand routing across 7 subnets over 4 continents
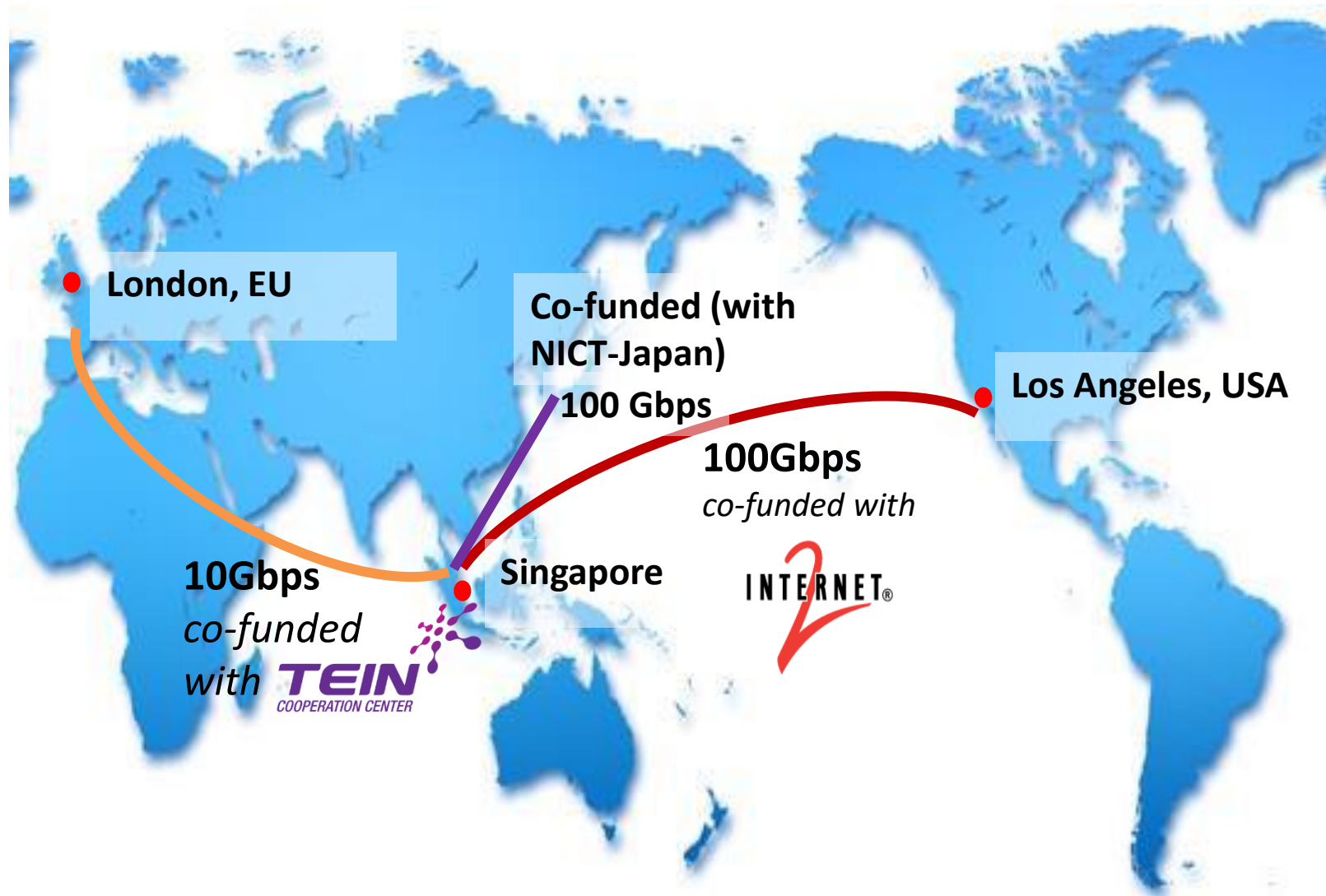
NCI (Canberra)

InfiniCloud at ISC 2017 Frankfurt, Germany

Data Transfer Test (dsync)

1 TB in 24 minutes

Singapore/Canberra
10Gbs (~30,000km)

Canberra/Singapore
1Gbs (~6000km)
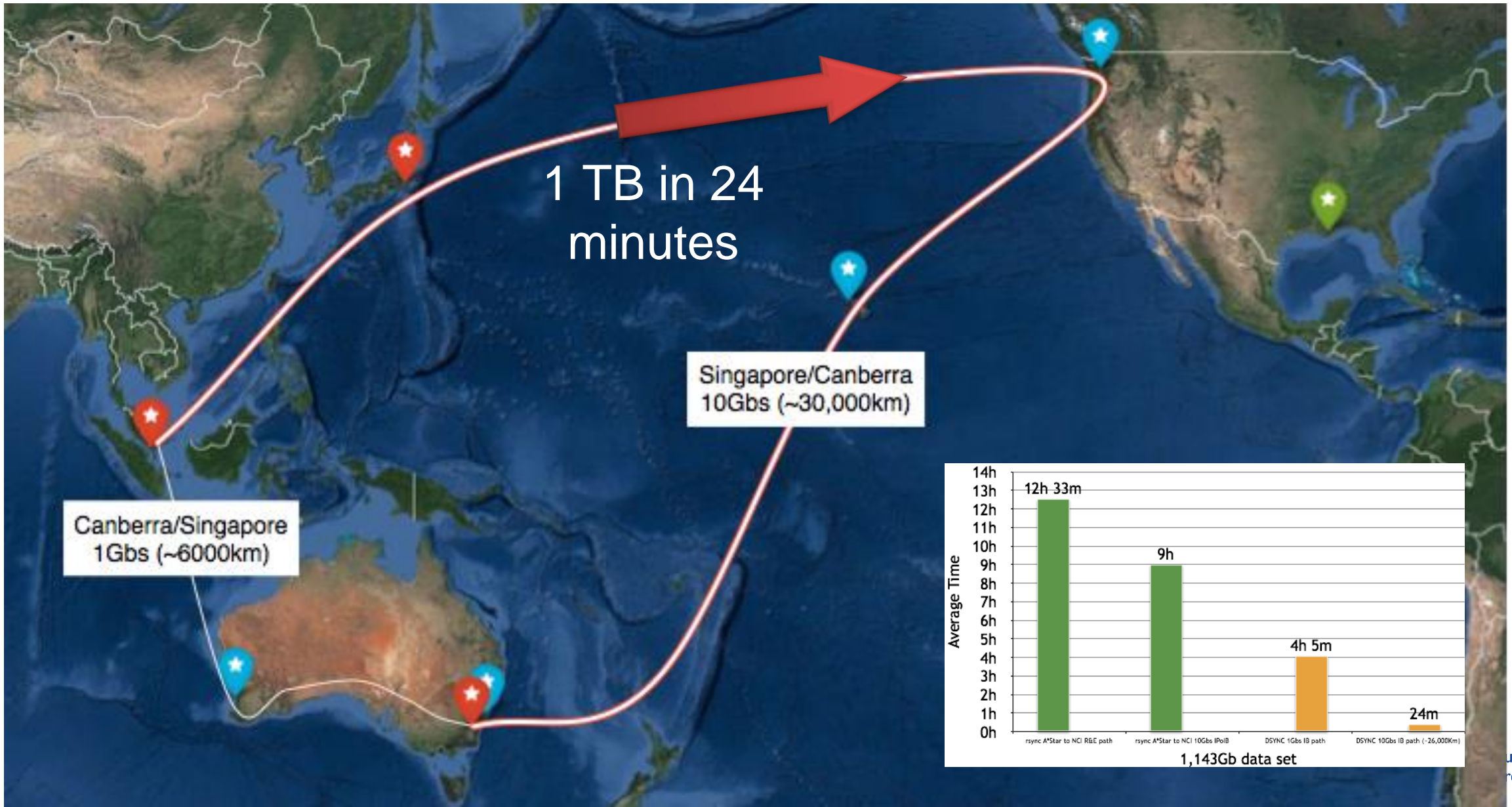
S'pore InfiniBand Connectivity and Fabric

Singapore Intercontinental Connectivity

London, EU

Co-funded (with NICT-Japan)
100 Gbps

Los Angeles, USA

100Gbps
co-funded with

INTERNET2

10Gbps
*co-funded
with* TEIN
COOPERATION CENTER

Singapore

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Strategic Projects

Domain Areas

LIFE SCIENCES

Accelerate biomedical discoveries through **high performance applications in genomics**, thus improving the effectiveness of clinical treatments and personalised medicine.

[Image courtesy of insideHPC]

CLIMATE MODELLING

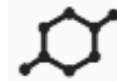Contribute to atmospheric science and **improves the accuracy of weather forecasts** by broadening the range of parameters included in the simulations.
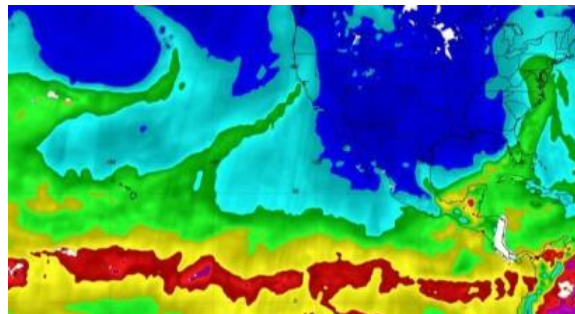
[Image courtesy of NASA]

MANUFACTURING

Enhance modeling, simulation and analysis to **speed up the design cycle for a faster time-to-market** for new and advanced products.
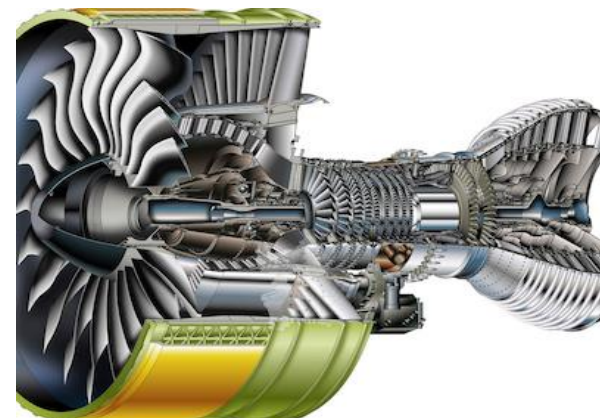
[Image courtesy of EnterpriseTech & Airbus]

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Domain Areas

COMPUTATIONAL FINANCE

Perform high performance **computational modelling** of **market conditions, pricing model, risk models**, and contingencies to allow financial institutions to **accurately meet real-time goals**.

[Image courtesy of MIR Labs]

DIGITAL MEDIA PRODUCTION

Accelerate **rendering with high realism**, reduces time to market for producers and increases the quality of production for users.

[Image courtesy of Omens Studios]
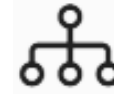
DATA CENTRE & NETWORKING

Offer an unprecedented high performance network testbed coupled with **high performance data analytics for quasi-real-time intrusion detection** and cybersecurity optimisation

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Strategic Focus

- To provide HPC resources for National R&D projects (RIE2020 / Science & Technology Research - $19B)

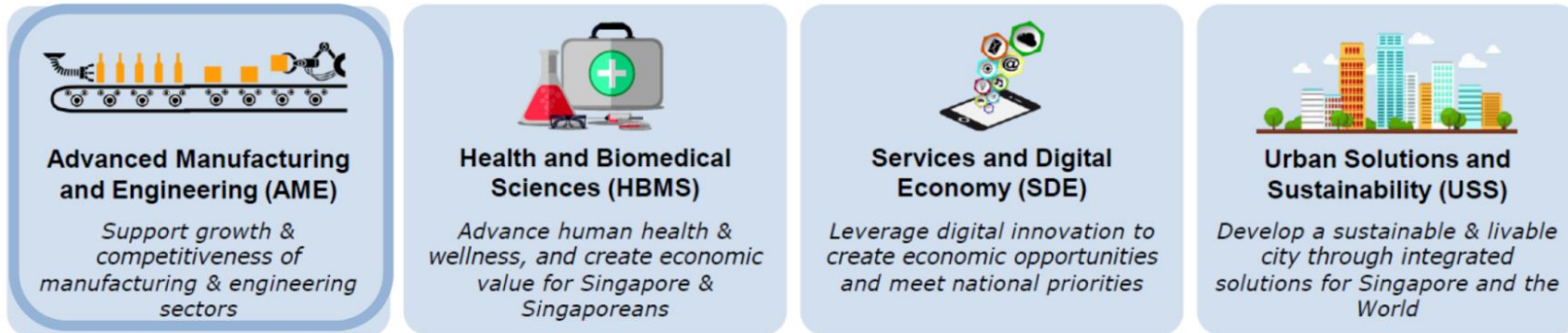- To identify within these domains, those which HPC can have maximum impact

Advanced Manufacturing and Engineering (AME)
Support growth & competitiveness of manufacturing & engineering sectors

Health and Biomedical Sciences (HBMS)
Advance human health & wellness, and create economic value for Singapore & Singaporeans

Services and Digital Economy (SDE)
Leverage digital innovation to create economic opportunities and meet national priorities

Urban Solutions and Sustainability (USS)
Develop a sustainable & livable city through integrated solutions for Singapore and the World

CROSS CUTTING PROGRAMMES (HORIZONTALS)

Academic Research — Build up a significant base of capabilities and a pipeline of ideas that can drive the next phase of growth

Manpower — Build a strong research and innovation community

Innovation & Enterprise — Build a strong core of innovative enterprises that drive value creation and economic competitiveness

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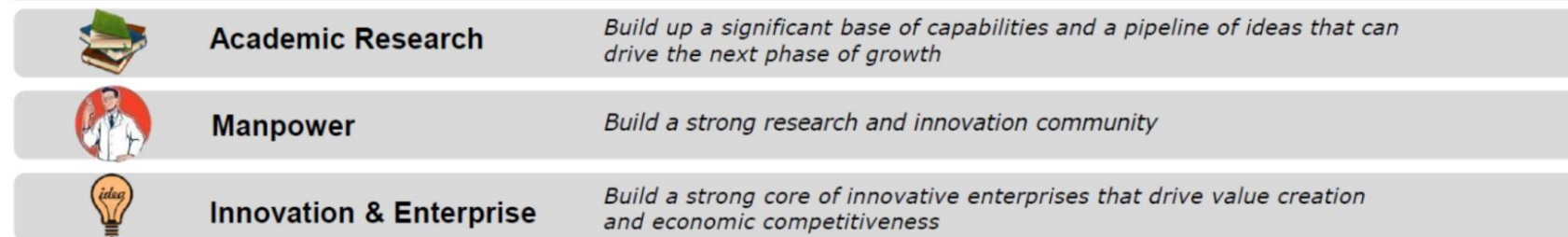
Outreach &
Manpower Capability Development

Outreach

Conduct Regular Training Workshops

Workshops

- Introductory
- Optimisation Techniques
- Parallel Profiling & Debugging
- Advanced Job Mgmt.

A*STAR

NTU

NUS

Local & Overseas Conference Participation

APAN42 HONG KONG
1 – 5 Aug 2016
Hong Kong

INCOB 2016 SINGAPORE
21–23 Sep 2016
Singapore

InnovFest UnBound
18 May 2016
Singapore

SC16 Salt Lake City, Utah
13 – 18 Nov 2016
Salt Lake City, Utah, USA

ISC High Performance The HPC Event.
20 – 22 Jun 2016
Frankfurt, Germany

GPU TECHNOLOGY CONFERENCE
4 – 5 Oct 2016
Melbourne, Australia

Roadshows / Collaborations / Industrial Engagement

MOU with Industry (Mar 2016)

HealthSeq   CloudSeq   Keppel Data Centres
RafflesHospital   NUH   nvidia   ViSHU@

Industrial/Government Engagements

syngenta   SILICON CLOUD INTERNATIONAL   SingAREN
URBAN REDEVELOPMENT AUTHORITY   CAD-IT Consultants   OMENS STUDIOS
INFOCOMM MEDIA DEVELOPMENT AUTHORITY   Global Gene Corp   SJ SURBANA JURONG
1degreenorth   ROLLS ROYCE   Keppel Offshore & Marine

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Launch of the First 100G International R&E Network in Asia, 1 Dec 2017
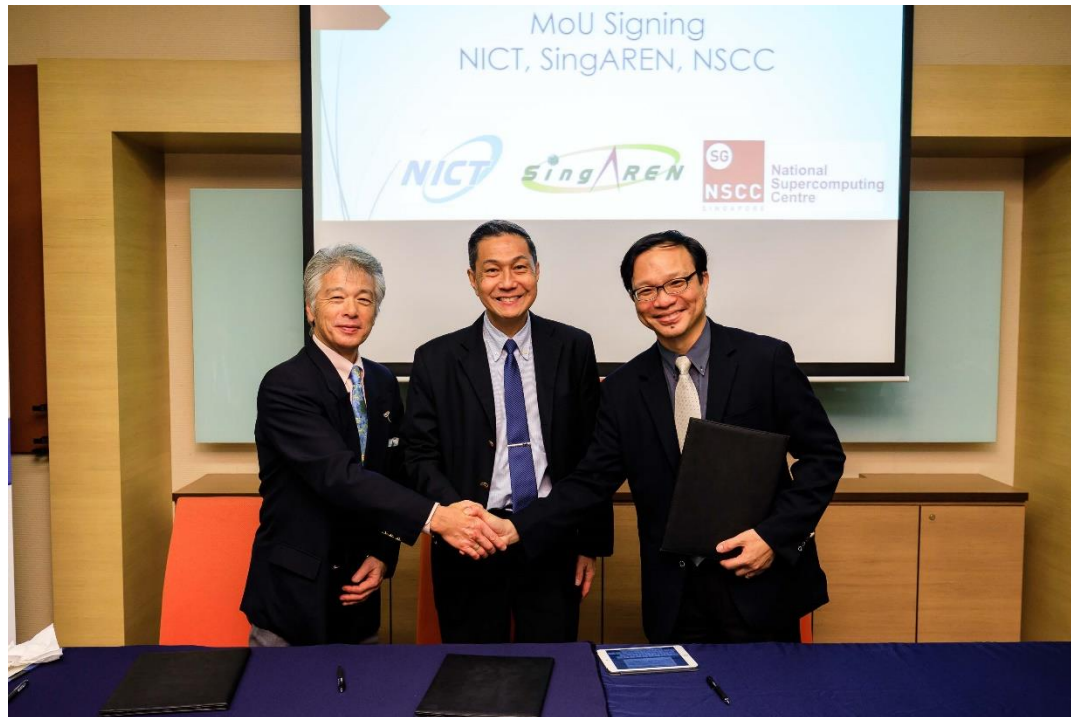
MoU signing for collaboration through the 100G Singapore-Japan Link:
NICT, SingAREN and NSCC.

Asia Pacific Ring (APR) MoU signing:
WIDE, SingAREN, NII, NICT, Internet2, Pacific Wave and TransPAC

Thank you!