[2450 words / 17 mins]

Developing Opportunities for Transnational Cyberinfrastructure Collaborations
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Thank you very much Beth. I am very pleased to have this opportunity to speak at this sixth conference of CENTRA. I was very active in the international networking and cyber infrastructure community up until I became Indiana University president in 2007 so I have not worked in this area for some years, though the broader international engagement of the university was one of my top priorities during my 14 years as president.

However, this invitation to speak at your opening event gave me the opportunity to think first about the ways in which the state of world has changed from the days I was more active in it, and then given this changed state, to consider what appear to be some of the opportunities that present themselves today. I will begin this by recounting some of the very early initiatives in this area in which I was engaged.

Science has always been to a greater or lesser degree, international and global. The impact on it of politics and religion has at times been intrusive and stifling, even in some areas to this day. But nearly always, the search for understanding of the world and the universe and the transmittal and dissemination of the knowledge gained, has survived these strictures and challenges, which have at times been severe, and continued to advance - sometimes with the greatest of caution and hesitancy; sometimes with remarkable speed and progress.

In the last little more than 50 years or so, this progress was massively accelerated with the advent of the Internet.

No longer was the full global development of science rate-limited by postal services, the speed of journal publication, telephone, and expensive travel. With the Internet it gradually became almost instantaneous. First it became possible to transmit and disseminate new scientific results and discoveries as soon as these were made to scientists everywhere who had access to the Internet (which rapidly became most of them). Initially this was within individual countries, but then, increasingly, globally as international Internet connectivity grew. This in turn allowed these results and discoveries to be scrutinized in close to real-time, causing a major increase in the rate of scientific progress and geographically distributed collaboration. Then as bandwidth and international connectivity grew, it became possible to build true globally accessible distributed databases; remotely access, operate and manage scientific instruments ranging from sensor arrays to telescopes; mount sophisticated real-time virtual collaborations; and much, much more. And all of this continues to grow and expand today with remarkable innovation and speed, with progress continually happening.

The international connections that I just mentioned were seen as key to the development of a truly global scientific community. This was recognized early by some scientists and researchers around the world. As national Internet networks in those countries were established and became stable, these scientists and researchers began to explore how to establish connectivity beyond their countries to support and expand regional and then global scientific collaborations.

My first major involvement in such efforts began at a meeting in Japan in March, 1996, when together with Professor Kilnam Chon of KAIST in Korea we co-founded the Asia Pacific Advanced Network known as APAN whose founding members were scientific organizations involved in research and education networking in Australia, Japan, Korea, and Singapore. The objectives that were adopted at this meeting basically remain the objectives of APAN to this day. They are to quote:

1. to coordinate and promote network technology developments and advances in network-based applications and services.
2. to coordinate the development of an advanced networking environment for research and education communities in the Asia-Pacific region.
3. to encourage and promote global cooperation to help achieve the above.

APAN has been by any measure a great success and now has 17 members including nearly every major research and education networking organization in Asia and members from 5 of the 10 ASEAN countries. I gave the (virtual) keynote address to celebrate APAN's 50th Conference that was held in Hong Kong in August, 2020, and used it to give a detailed history of the founding of APAN and its future challenges[1].

In 1997 I moved to the United States to take up the position of Vice President for Information Technology at Indiana University where I have remained ever since. Fortuitously this coincided with the release by the National Science Foundation late that year, of a solicitation to establish the program then called HPIIS – the High-Performance International Internet Services program – one of a number of truly visionary programs the NSF established from the early 1990s in Internet connectivity and technology. The goal of HPIIS was, in conjunction with international partners:

> "… to link the U.S. and international research and education communities and to assist other countries in connecting to the global Internet."

Indiana University and APAN with Japan as the primary partner, submitted a proposal to this program on which I was the PI called TransPAC to establish a direct high performance connection between the US and Japan which would then connect into other APAN member networks in Asia. This was successful and commenced in August, 1998, and was funded until 2005 for a total from the NSF of around $20 million. After this Jim Williams, from whom you will hear later in this conference took over as PI and it

[1] See https://universitychancellor.iu.edu/speeches/select-speeches/2020/08-04-apan-keynote-address.html

was successfully re-funded four times and continues to this day (though with many orders of magnitude greater bandwidth). Proposals also grew out of these efforts for successfully funded international connections to Europe and Africa.

This coincided with a remarkable burst of growth at Indiana University with the establishment also in 1998 of the Global Network Operations Center called the GlobalNOC, to manage and operate the Internet2 network and these international network connections. It grew rapidly and today under the superb leadership of Dave Jent, operates 23 networks nationally and globally, with $12 million of external funding and 140 network engineers. A year later in 1999 what is now called the Pervasive Technology Institute was established, whose able director today is Professor Plale, with an initial $30 million award from the Lilly Endowment to pursue research in networked technologies.

I recount all this to show the direct lineage from the earliest days of international networking as exemplified in the goals of APAN and HPIIS, right up to organizations like CENTRA whose name is itself an acronym for “Collaborations to Enable Transnational Cyberinfrastructure Applications” which is defined as:

> “… a partnership and evolving framework for collaborations amongst research centers, institutes and laboratories across the world.”

The roughly 20 year period between the beginning of serious efforts to establish robust and stable international connectivity such as APAN and HPIIS (and of course many more) and the founding of CENTRA, were times of enormous optimism and enthusiasm for the promise the Internet held not just for science and research, but more broadly for societies around the world, as the Internet exploded, massive economic growth took place in previous underdeveloped countries, and free trade and the world economy became increasingly globalized driven by free trade.

But gradually this period of optimism began to decline, and a more sober and apprehensive mood developed in the face of escalating use of the Internet for cybercrime and cyberterrorism, intellectual property theft, large-scale state-sponsored disinformation efforts aimed at weakening the political strength of democratic societies, and the destruction of whole industries causing extensive social disruption through job loss and economic decline.

This coincided with a period that saw the rise in authoritarianism and the retreat of democracy according to the respected source Freedom House, the decline of free trade and globalization, rising global geopolitical tensions and even war in Europe on a scale not seen since 1945, and the grim realization that the future is likely to be haunted by the very real specters of deadly pandemics and catastrophic environmental change.

And then there is the ambiguous promise of AI – a technology that finally seems to have arrived and be real – but ambiguous because on the one hand it holds extraordinary promise for dramatic new scientific discovery and understanding, like the extraordinary identification of the 3-D structure of all 200 million known proteins, but at the same time threatens another maybe even more destructive round of social dislocation through massive job loss, further undermining of social coherence and even greater intrusion into privacy and freedom through greatly improved surveillance technologies. Concern about these possibilities is reflected in the speed with which governments and politicians around the world have sought to regulate and control AI.

So, in the face of this rather bleak picture, where are there positive opportunities for international collaborations of the kind CENTRA represents? To see these, one needs to look at what is happening in the United States and in particular the massive rebuilding of the American economy that is taking place in response to many of the challenges I have just listed in order to improve American competitiveness, innovation and industrial productivity. In a recent Economist editorial this is summarized as follows:

> "In the past two years Congress has passed three bills, on infrastructure, semiconductor chips and greenery, that will make $2trn available to reshape the economy. The idea is that, with government action, America can reindustrialise itself, bolster national security, revive left-behind places, cheer up blue-collar workers and dramatically reduce its carbon emissions all at the same time. It is the country's most ambitious and *dirigiste* industrial policy for many decades."[2]

Other countries of course are making major investments in these sorts of areas and restructuring various aspects of their own economies. But the sheer scale of this government investment in the United States - $2 trillion which is about the annual GDP of Canada – means that its impact will not just be in this country, but both directly and certainly indirectly, world-wide. And of course this must also be compounded with the fact that the US is the world's largest economy and the world's most technologically advanced country.

To understand this impact let us have a closer look at the three bills mentioned before in the Economist leader.

The Infrastructure Investment and Jobs Act approved in November 2021, approves a massive sum of $1.2 trillion to repair, modernize, expand and enhance America's infrastructure relating to roads, bridges, power infrastructure, passenger and freight rail, broadband access, domestic water infrastructure, public transit, airports, water and soil remediation, port infrastructure, and many other areas.

The CHIPS and Science Act approved in August 2022, approves $280 billion for semiconductor research, development, and production, and strengthening supply chains in this area, and for research and development in science, technology, and the workforce and areas of advanced technology such as nanotechnology, clean energy, quantum computing, and AI.

[2] The Economist, February 2, 2023.

The Inflation Reduction Act passed later in the same month, approves $437 billion for investments in renewable and clean fuels and energy generation, electrification, environmental conservation, and wider adoption of electric vehicles, as well as many other areas related to addressing climate change and reducing America's carbon footprint as well as research and development in these areas.

This represents the largest US government investment in technology and science since the Space Race in the early 1960 and the impact of this is already world-wide and this will only increase, as happened with the Space Race. On a personal note I well remember the dismal state of science laboratories in my high school in my home country of Australia at this time when the then Australian government, spurred by the huge investment taking place in science and technology in the United States driven by the Space Race, decided on a crash program to build brand new science laboratories in high schools throughout the nation so Australia would not be left completely behind in terms of a scientifically literate and competent workforce.

Some of this funding will go directly to research, development and workforce education and training. But indirectly its effect is likely to much greater since effectively addressing many of the issues on which these bills are focussed will take major new innovations and discoveries in both university, government and corporate research laboratories. This in turn will stimulate and catalyze similar work across the world as the solutions of many of these problems transcend national boundaries.

And it is in this context and in these areas that the research and collaborative opportunities are likely to arise and abound for new and existing international collaborations like CENTRA. There is an enormous gap of course between the developments I have described at this very high level and with the identification of specifics. But they provide a roadmap at the highest level of the areas and problems to which funding will go and hence where the opportunities will be and thus provide a

guide to help universities, research labs, and international collaborations of all kinds to develop their future strategic directions.

Let me add a final point. The shock of shortages of all kinds combined with the realization of possible future shortages of products and materials seen as being strategic, brought on by the COVID pandemic and the rising geopolitical tensions, especially in the Asia Pacific, have had a profound impact on the belief in unitary supply chains. There is now intense activity globally to diversify supply chains and to establish new supply chains that are resilient, reliable and responsive. The concept of off-shoring is being replaced with, to use the terrible neologism, “friend-shoring”, where a desirable or even necessary characteristic of a supplier is that they be in friendly or at least neutral countries and where this relationship is projected to remain stable.

From this it follows that such new supply chains will be developed with countries that have been in a sense “neglected” or “overlooked” previously and that this will expand to the development or enhancement of new types of relationships and collaborative possibilities in the research and education fields. And this also, points to new opportunities for future collaborations and research directions for CENTRA.

Let me conclude where I began by noting again the international and global nature of science and research. None of what I have just described in anyway diminishes my belief in the vital importance of international cooperation and collaboration between all countries. But science is neutral, it is neither good nor bad in a moral sense. Rather it is human beings who use or misuse it according to one’s perspective, and this must ultimately have an impact on our choice of those with whom we chose to work.

Thank you.