INSTITUTE OF COMMUNICATIONS AND CONNECTED SYSTEMS
ADVANCING THE FUTURE TECHNOLOGIES OF A CONNECTED WORLD

6G CHANNEL

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6G RESEARCH VISIONS WEBINAR SERIES:

6G Networking

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Introduction

I was asked to consider this area: *Showcasing how new transport networks and AI can support expected immersive services*

This is an interesting title that covers many areas.

What does it all mean. First we have to consider some questions ....

- What are immersive services, and how do we create them
- How do transport networks evolve to support these
- How do we manage these enhanced services
- What is AI, and what systems are needed to support the new management and the new facilities of AI
- How do all of the elements interact with each other

Just answering these provides a set of challenges that is beyond the scope of one presentation at one event, and requires a lot of detailed research work, development, and standards creation.

Here I will consider what AI can do to help in networks.

Observation on Intelligence

Artificial Intelligence and Machine Learning bring different techniques and approaches to the area of network management. It is important to know and understand the differences between to make the best choice.

- The use of Artificial Intelligence will bring about mechanisms for *reasoning* about normal situations and error states and conditions. Such reasoning, combined with the relevant abstractions and *knowledge representation* will act as a foundation for advanced approaches that provide for the induction of new knowledge as well as the use of explanation systems to highlight what has occurred.

- Machine Learning algorithms can make probabilistic *predictions* based on input *training data* that has been fed into the system. Progress in both computing hardware (such as GPUs, TPUs, and bespoke chip architectures), as well and the performance and accuracy of machine learning methods such as neural networks, has made Machine Learning a realistic approach for use in network management.

Challenges

The are many challenges in Artificial Intelligence and Machine Learning, with diverse open questions on the mechanisms in the areas of:

- How can AI and ML techniques really be used for effective and/or enhanced network management (*we have seen some in recent years*)
- How do the existing technologies of networking, NFV, SDN, services become features and aspects of AI and ML, and how are they managed in this context
- Is it better to adapt existing management components to support AI and ML, or is it better to design new ones with intelligence built-in
- What are the abstractions and knowledge representation / data models needed to ensure that AI is deployable in networks
- How can the use of induction and explanation systems highlight what error situations have occurred.

AI / ML Work Areas

Our motivation for this work is to focus on specific aspects of network management, where Artificial Intelligence and Machine Learning techniques can be utilized for enhancing the management, including:

- Management of next generation systems based on 5G and onto 6G, plus the orchestration of SDN/NFV-based systems (including function placement, network slicing, and service function chaining)

- Abstractions and knowledge representation for network management such as data, information, and semantic models

- Reasoning about normal situations and error conditions, as well as automated actions, for cognitive, pro-active, autonomic, and self-reliable networks

- Monitoring and telemetry sub-systems, for efficient collection, analysis, distribution, and visualisation of big data.

Distributed Intelligence

- A major innovation is by deploying multiple specialist components using different techniques, AI and ML, it becomes possible to design and build a system that uses expert capabilities and self-learning for intelligent management.

- Each component can be specialised but connected and deployed in a distributed way.
    - AI components take higher-level representations and reason
    - ML components take larger simple data sets and learn

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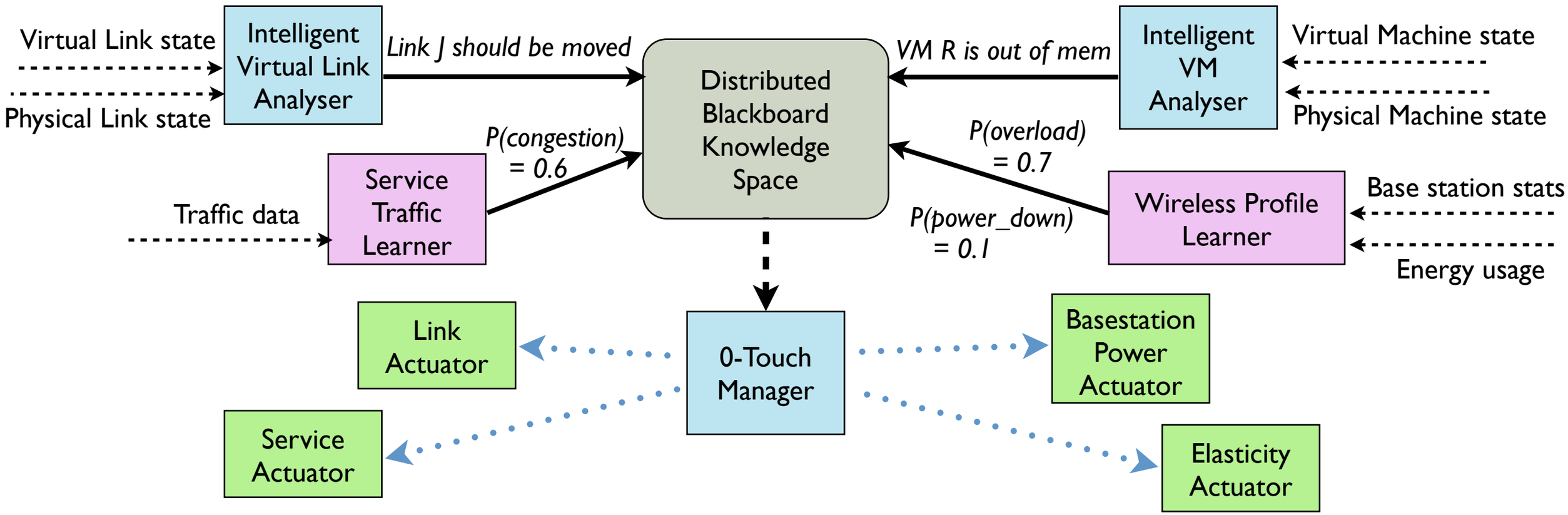

AI / ML Systems Deployment

- From the management perspective, there is a realisation that higher level approaches need to be taken to enable the future networks to accommodate the dynamics, the scale, the reliability, and the adaptability required.

- There is interest in AI, in ML, and in Softwareization and Programmability techniques. They are often presented as different methods.

- However, they are not independent, but are intrinsically linked, as they are need to operate across the same elements in the system, e.g. services, VNFs, routers, links, etc. to provide the immersive services.

- The necessary languages, abstractions, and run-time systems that can be used across these systems are not in place.

- We need more importing of working systems and more commonality and much less reinventing the wheel. We must look at the 60 years of experience the computing world has.

Conclusions

- Intelligence will appear more and more in different layers of networks and for various management aspects. So we need ways to combine all of the intelligent actors so they work together and avoid having a new set of silos.

- New networks and new network paradigms, and new services, will use AI and ML for their operation. Each one may use a different set of components, configured with different parameter values. The one size fits all is not really a suitable option.

- There can be no machine intelligence if there are no representations of the underlying elements to reason about.

- We need flexibility and dynamic control. This is necessary with the rise of SDN, NFV and SFC, plus the targets of AI, ML, automation, and analytics. We must address this in a timely way.

- Clearly these AI / ML elements will be used for some of the new transport networks and the new immersive services that will be available to us in the future.