A Cognitive Routing System for the Internet

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By combining the networking and the machine learning research fields, a cognitive routing system fundamentally revisits the control capabilities of the IP/networking layer. Indeed, no satisfactory solution is currently available or even exists to address altogether the challenges experienced by the Internet and its evolution:

– Operational challenges: manageability/diagnosability, and availability caused by a performance drop due to an increasingly complex and growing Internet infrastructure, for which existing solutions are no longer adequate. In particular, availability problems result from the decreasing routing system quality (in part., its stability, its robustness, and its convergence properties);
– New challenges: security is only supported weakly by the current Internet infrastructure. On the other hand, accountability (part of the initial Internet design objectives) has never been really met by the current Internet infrastructure, e.g., traceback and other congestion control techniques are not widely deployed to identify misbehaving users and traffic sources. As the Internet grows, the routing system scalability progressively results into major cost concerns for both vendors and Internet Service Providers (ISP).

A cognitive routing system using semi-supervised, on-line, and distributed machine learning techniques would provide for a routing system that can meet the Future Internet challenges in terms of manageability, availability, security, and accountability. This system, implemented by means of a distributed and loosely coupled cognitive engine, coexists and sits next to the existing routing engine of current IP networking equipment.

The most notable use of learning paradigm applied to networking is the unified Knowledge Plane (KP), introduced in by D.Clark [Clark03][1]. The driving idea of the KP is to augment the network control system with a higher-level structure that addresses issues of "knowing what is going on" in the network. The goal is to build a new generation of network that can *i)* drive its own deployment and configuration *ii)* diagnose its own problems *iii)* make defensible decisions about how to resolve them. The KP, by sitting on top of the current control system, is intended to break the boundaries of the control and management system. The KP, that embodies cognitive tools and learning, is a separate structure that creates, reconciles and maintains the many aspects of a high-level view, and then provides services and advices as needed to other network elements. The core foundation of the KP is its ability to integrate behavioral models and reasoning processes into a networked environment. Compared to the KP approach, we believe that a cognitive routing system should

– be modularized instead of relying on a unified approach for practical development and deployment reasons;
– rely on a relative view of the network environment from the routing perspective rather than relying on a global view that would result in scaling issues;
– be built taking into account the inherent properties and capabilities of the routing system instead of being constructed as a uniform and ubiquitous two-dimensional structure that does not account for the specialization of the routing functionality (e.g. intra- vs inter-domain);
– be realized by means of distributed, on-line, semi-supervised learning techniques instead of supervised, off-line and centralized learning leading to e.g. limited predictive value.

To evaluate the benefits of machine learning techniques in addressing the abovementioned Internet challenges, representative use cases will be experimented. Nevertheless, applying machine learning to networking environments requires to address a set of problems that have not been resolved up to now, in particular, with the purpose of obtaining a methodology for the cognitive routing system and engine. The resulting research problems will be outlined during the talk.

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[1] [Clark03] D. D. Clark, C. Partridge, J. C. Raming, and J. T. Wroclawski. A Knowledge Plane for the Internet. In Proc. ACM SIGCOMM. August 2003.