Chapter 47
Self-Driving Networks

Kireeti Kompella
Juniper Networks, USA

ABSTRACT

This chapter presents a new vision of network operations, the self-driving network, that takes automation to the next level. This is not a description of existing work; rather, it is a challenge to dramatically rethink how we manage networks (or rather, how we do not manage networks). It draws upon an analogy with the development of self-driving cars and presents motivations for this effort. It then describes the technologies needed to implement this and an overall architecture of the system. As this endeavor will cause a major shift in network management, the chapter offers an evolutionary path to the end goal. Some of the consequences and human impacts of such a system are touched upon. The chapter concludes with some research topics and a final message. Key takeaways are that machine learning and feedback loops are fundamental to the solution; a key outcome is to build systems that are adaptive and predictive, for the benefit of users.

PROBLEM STATEMENT

Network operations, from configuration to service provisioning and management to capacity planning and other activities, tend to be fairly manual, with some automation scripts thrown in to take care of common situations such as upgrading devices, and some robots to detect service degradation. Increasingly, though, there are attempts to increase automation in networks – for example, event-driven automation, where the appropriate responses to a number of foreseen network events are captured in scripts that "fire" when an event is observed. There are also areas (e.g., Self-Organizing Networks, Autonomic Networks, and Zero-Touch Provisioning) where the goal is to eliminate the need for human operation. However, these are limited to a small set of functions in specific areas of networking. Nonetheless, interest in these and similar efforts is the genesis of this book; moreover, they are a necessary step in the evolution towards "self-driving" networks.

DOI: 10.4018/978-1-6684-3694-3.ch047

One may think that incremental progress in automation is a fine path forward. The author feels otherwise. Consider the development of automobiles. The invention of the automobile, and especially its mass manufacture, was a complete disruption in transportation. Since then, automation has been increasingly deployed, to the great benefit of drivers and passengers – increased safety and convenience, and a wider cross-section of drivers. But that was all incremental. Fast forward to today, where we stand on the brink of another revolution: self-driving cars. The impact of this is still being explored. Over the next five years, expect major upheavals in legislation, urban planning, and insurance. Automation was an absolute necessity for self-driving cars, but it was far from sufficient; the fundamental advance is the elimination of the human element from driving. We took a bold leap in driving; we need a similarly bold leap in networking.

The problem statement before us is the similar complete elimination of humans from all aspects of network operation, in all areas of networking. The motivations for doing so are described below. In the author's opinion, humans are needed at the front end of any change, in specifying what the change should accomplish as a very high-level, declarative statement of intent; and at the back end, conducting post-mortems of the actual (machine-led) operation, with a view towards improvement. Everything in between should (and eventually will) be done by machines equipped with the necessary intelligence to do so. In this chapter, the author shows how. Once Self-Driving Networks are realized, one may be able to remove humans both from the front end and back end of changes: infer required changes, implement the changes and ensure that the intended result was indeed accomplished.

INTRODUCTION

Advances in autonomous systems[1] are all around us. As processors become more powerful and more energy efficient; as data becomes more ubiquitous and purposeful; and as software gets more sophisticated; our ability to hand over control to machines increases. In a very real sense, this is the logical conclusion of automation, the progression being: do things manually; find (sub-)tasks that are repetitive and automate them; and eventually, give the whole job over to a machine. This process requires considerable technological progress, as well as human considerations. Both of these will be explored in this chapter. A useful intermediate stage between automation and full autonomy is "augmentation," where man and machine cooperatively operate a system; this will be discussed as well.

The very visible face of autonomous systems today is the self-driving car. Here again, we have gone from a very manual approach, where humans control every aspect of driving, to automating various driving functions; and from this, to creating fully autonomous vehicles. Efforts to automate driving functions have been sprinkled throughout the car's 130-year history; efforts to build self-driving cars are much more recent. A significant trigger in the latter came from the Defense Advanced Research Projects Agency's Grand Challenge to build an autonomous ground vehicle, held in 2004. Fifteen teams participated, albeit unsuccessfully; the following year, though, 5 teams were successful. This journey since has been long, but finally appears quite near technological success; now, human considerations dominate. The author will draw on this analogy in the discussion of self-driving networks; there are valuable lessons to learn in so doing, while bearing in mind that no analogy is perfect.

Of course, the autonomous system the author focuses on in this chapter is a network, what he likes to call a "self-driving network[2]" (and abbreviated as SDN2). Here, "network" refers to both the connectivity infrastructure (Layer 1 to Layer 4) as well as the service infrastructure (VPN, VoIP, BNG, IPTV, etc.).