ETH zürich

Prof. Laurent Vanbever
Networked Systems Group

BGP is Turing Complete!—Let's visualize it!

Bachelor thesis proposal

In [3], we showed that the Border Gateway Protocol (BGP) is Turing Complete, assuming an infinitely-large Internet. Concretely, it means that one can make BGP routers "compute" any algorithm. And, yes, it also means that, technically, one can implement BGP. . . in BGP.

To proof this, we built, using BGP configurations: (i) all the logic gates (OR, AND, NOT); (ii) a 1-bit memory; and (iii) a clock. By composing these pieces together one can be arbitrary combinatorial circuits which take BGP routes as inputs and outputs. In these circuits, we encode 0 (resp. 1) by the absence of a route at given input (resp. output) routers. The 1-bit memory and the clock leverages well-known "wrong" BGP configurations in which BGP routers can converge to 2 distinct states (which we use to "store" a 0 or a 1), or oscillate perpetually [4].

The goal of this thesis is to build a framework to "visualize BGP computing". The framework would consist of at least two pieces. The first piece is a BGP circuit synthesizer which, given an description of a computation (e.g., addition of two unsigned n -bit binary numbers), generates the corresponding BGP circuit and encode it in a way that can run in a simulation environment such as [1]. Technically, this step will require to design of the basic components of digital circuits (e.g., half adders, full adders, flip-flops) out of BGP routers. Depending on the progress, one could go all the way to implementing a full Arithmetic and Logic Unit (ALU).

The second piece is a visualization engine which, given the execution trace of the synthesized circuit, automatically produces a visualization of it in the form of a 2D-animation (e.g. a large SVG figure produced with [2]). Ideally, the visualization engine would also produce a static view of the corresponding BGP circuit which could be displayed e.g. on a website.

Pre-requisites This thesis is best-suited for a student with:

- An interest for formal reasoning, complexity theory, and digital circuit designs;
- A strong interest and appreciation for aesthetics. You do not need to be a designer or artist, but you need at least be able to distinguish good design from bad design.
- A good knowledge of BGP. Ideally, you have followed "Communication Networks" (or equivalent) and performed well in the routing project.
- Good programming skills (in any language), with possibly an interest in web technologies.

Contact

- Prof. Laurent Vanbever, lvanbever@ethz.ch
- Tibor Schneider, sctibor@ethz.ch

References

[1] The C-BGP routing solver. https://github.com/lvanbever/cbgp.

[2] SVG tiler. https://github.com/gedemaine/svgtiler.

[3] M. Chiesa, L. Cittadini, G. Di Battista, L. Vanbever, and S. Vissicchio. Using routers to build logic circuits: How powerful is bgp? In *2013 21st IEEE International Conference on Network Protocols (ICNP)*, pages 1–10. IEEE, 2013.

[4] T. G. Griffin and G. Wilfong. An analysis of bgp convergence properties. *ACM SIGCOMM Computer Communication Review*, 29(4):277–288, 1999.