Researchers develop intelligent segment routing scheme for network management

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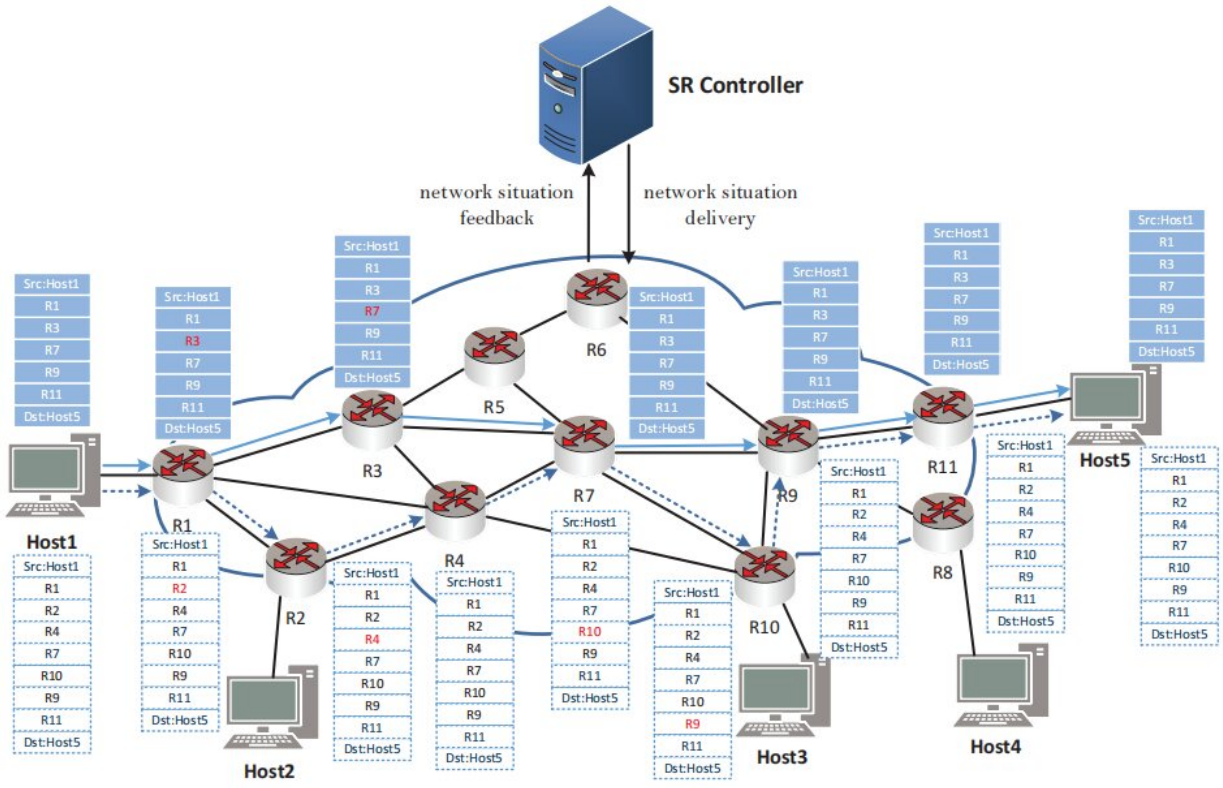


Case study illustrates the date transmission mechanism of diversion routing. Credit: Big Data Mining and Analytics, Tsinghua University Press

Traffic engineering has attracted much research attention, especially in recent years as networks grow in size and complexity. Network operators increasingly need better ways to manage the massive amounts of data

flowing through their networks. A team of researchers has proposed an intelligent routing scheme for traffic engineering that achieves load balancing with limited control overheads.

Their research is published in the journal *Big Data Mining and Analytics*.

Traditionally, researchers have studied traffic engineering related to traditional internet protocol (IP) networks with a focus on IP routing protocols, routing optimization problems, and overlaying in an IP network. With the arrival of the software-defined network, researchers began to focus more on traffic engineering issues, including traffic splitting and protocol design.

In software-defined networks, the network can be centrally controlled using software applications. Software-defined networks allowed researchers to achieve more efficient network management, solving some of the massive traffic engineering issues that are difficult to manage in traditional networks.

Yet even with software-defined networks, researchers struggled with scalability issues. So researchers turned their attention to segment routing. Segment routing is a technique that allows researchers to simplify traffic engineering across network domains by organizing collections of information called packets.

Researchers realized that by combining segment routing with software-defined networks, they could be capable of solving some of the challenges in the software-defined network. However, there were still some unresolved issues because segment routing brings with it control overheads, meaning additional packet headers have to be inserted. The overheads greatly reduce a large network's efficiency when the segment headers become too long.

"Segment routing has been a novel architecture for traffic engineering, but it also brings control overheads and reduces forwarding efficiency. So we focused on how to optimize the link load balancing performance with limited control overhead based on segment routing," said Laizhong Cui, a professor with the College of Computer Science and Software Engineering at Shenzhen University.

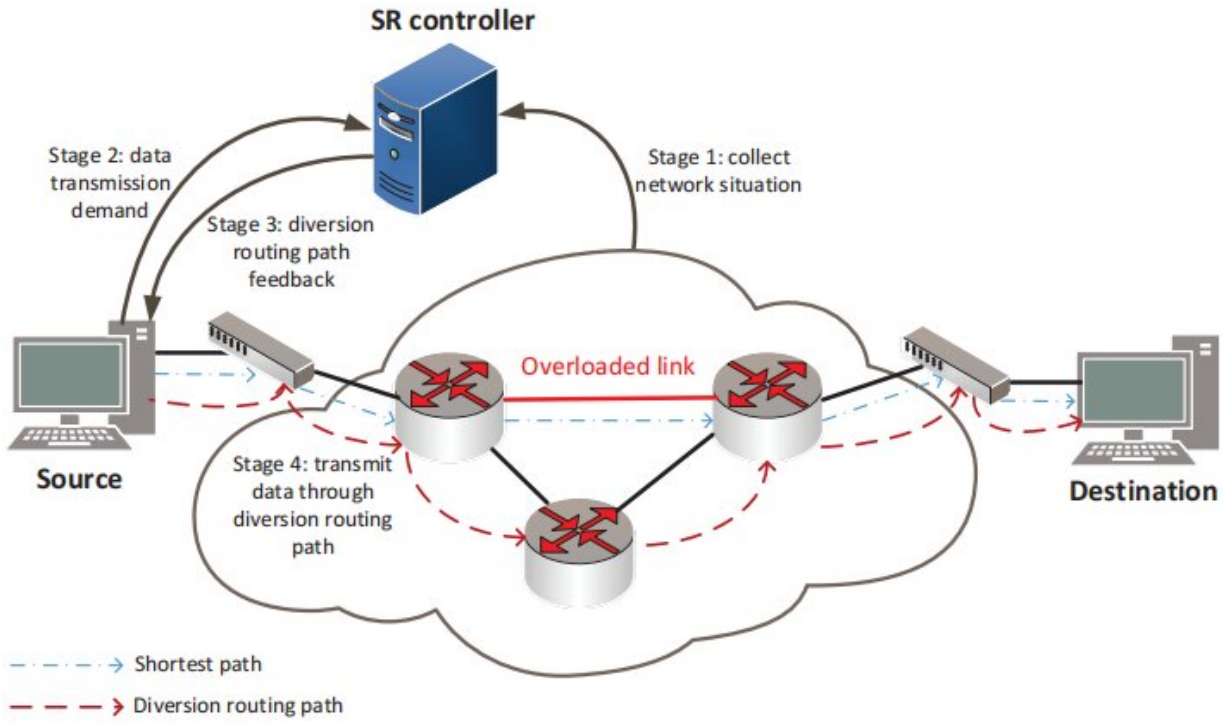


Diagram shows the total architecture of the intelligent routing scheme for traffic engineering. Credit: Big Data Mining and Analytics, Tsinghua University Press

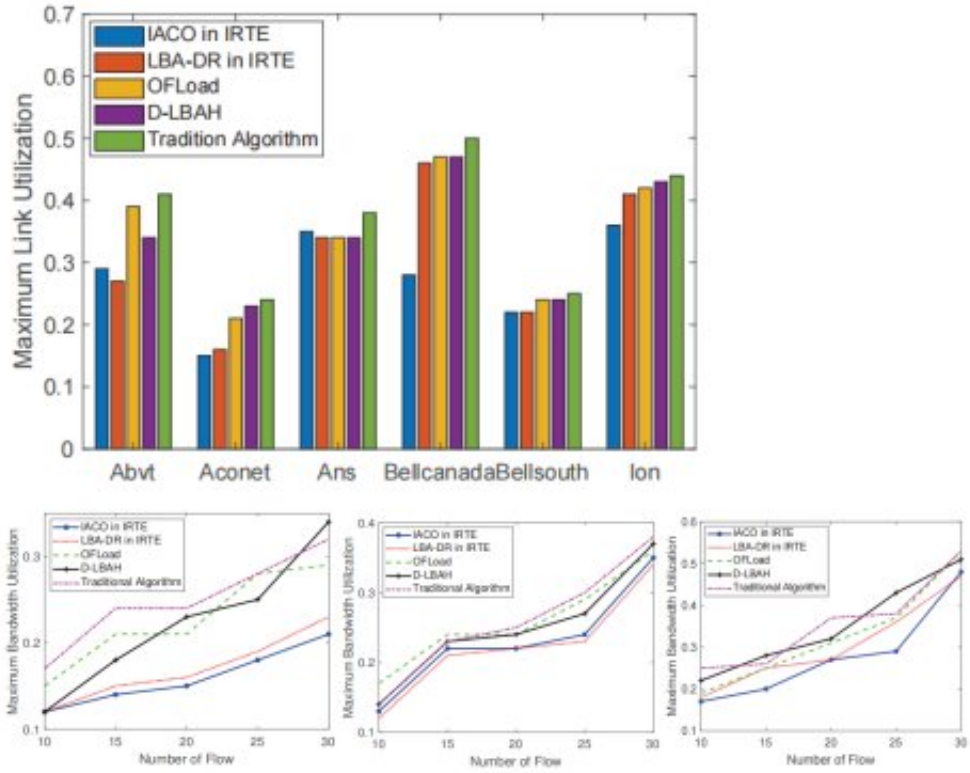
To overcome these challenges, the research team proposed an intelligent routing scheme for traffic engineering. This allows for load balancing with limited control overheads. The team started by formulating the problem as a mapping problem that maps different flows to key

diversion points. Next they proved the problem is nondeterministic polynomial hard, a way of defining the problem in computational complexity theory.

Then to solve the problem, they developed an improved ant colony optimization algorithm. Ant colony optimization is a technique that uses probability in solving network optimization problems. They also designed a second algorithm, a load balancing algorithm, and they analyzed its theoretical performance.

"We proposed two algorithms to realize our load balancing target and avoid forwarding overload. The theory of ant colony optimization and linear programming provided ideas and directions for the algorithms," said Laizhong Cui.

The team evaluated their intelligent routing scheme for traffic engineering in different real-world topologies. Topology describes how the elements of networks are arranged and connected. The team's results show that their algorithms outperform traditional algorithms. With their intelligent routing scheme for traffic engineering, the maximum bandwidth is 24.6 percent lower than that of traditional algorithms, when evaluated on the Bell Canada network topology.



Graph showing load balancing performance of maximum bandwidth for algorithms in six selected topologies. Credit: Big Data Mining and Analytics, Tsinghua University Press

Looking ahead to future research, the team is preparing to test and optimize their algorithms in a real network environment. They also plan to further develop their scheme by adding the method of artificial intelligence in software-defined wide area networks. "Our ultimate goal is to develop and apply our solutions to most network architectures to improve network transmission performance," said Cui.

More information: Shu Yang et al, Intelligent Segment Routing: Toward Load Balancing with Limited Control Overheads, *Big Data Mining and Analytics* (2022). DOI: 10.26599/BDMA.2022.9020018

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