FRAMEWORK FOR TRAFFIC ENGINEERING IN SOFTWARE DEFINED NETWORKING

~~CROSS-REFERENCE TO RELATED APPLICATIONS~~

~~This application claims the benefit of priority to US Patent Application Serial Number 14/097,930 entitled "A Framework for Traffic Engineering in Software Defined Networking" filed on December 5, 2013, the contents of which are expressly incorporated herein by reference.~~

TECHNICAL FIELD

The present invention relates to a system and method for software defined networking, and, in particular embodiments, to a system and method for traffic engineering in software defined networking.

BACKGROUND

Software defined networking , SDN, decouples traffic management (i.e., the control plane) from traffic forwarding (i.e., the data plane). In the control plane, SDN manages the network resources (e.g., how to use them) and the control network traffic flows (e.g., where to send them) jointly by a central SDN controller. Traffic flows have diversified Quality of Experience (QoE) and Quality of Service (QoS) requirements (e.g., rate, delay, delay jitter, outage, buffering time, etc.), depending on their nature (e.g., video) and/or application (e.g., video conferencing or downloading, etc.). The SDN controller has the responsibility to engineer traffic, that is, to plan routes for traffic flows and allocate resources (e.g., capacity, spectrum, power, etc.) along the routes, jointly so that their Quality of Experience/Service (QoE/S) requirements are met efficiently and effectively. This is normally an optimization problem.

SUMMARY

In accordance with an embodiment, a method in a network component for traffic engineering (TE) in a software defined network (SDN) includes receiving TE information from a first core network component in a core network, a radio access network (RAN) component, wherein the RAN is communicatively coupled to the core network, and wherein the TE information includes a TE objective; and determining a TE decision between at least

The antenna circuit 570 and antenna element 575 may allow the processing unit 501 to communicate with remote units via a network. In an embodiment, the antenna circuit 570 and antenna element 575 provide access to a wireless wide area network (WAN) and/or to a cellular network, such as Long Term Evolution (LTE), Code Division Multiple Access (CDMA), Wideband CDMA (WCDMA), and Global System for Mobile Communications (GSM) networks. In some embodiments, the antenna circuit 570 and antenna element 575 may also provide Bluetooth and/or WiFi connection to other devices.

The processing unit 501 may also include one or more network interfaces 550, which may comprise wired links, such as an Ethernet cable or the like, and/or wireless links to access nodes or different networks. The network interface 501 allows the processing unit 501 to communicate with remote units via the networks 580. For example, the network interface 550 may provide wireless communication via one or more transmitters/transmit antennas and one or more receivers/receive antennas. In an embodiment, the processing unit 501 is coupled to a local-area network or a wide-area network for data processing and communications with remote devices, such as other processing units, the Internet, remote storage facilities, or the like.

Although the description has been described in detail, it should be understood that various changes, substitutions and alterations can be made without departing from the spirit and scope of this disclosure as defined by the appended claims. Moreover, the scope of the disclosure is not intended to be limited to the particular embodiments described herein, as one of ordinary skill in the art will readily appreciate from this disclosure that processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, may perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

WHAT IS CLAIMED IS:

1. A method in a network component for traffic engineering, TE, in a software defined network, SDN, the method comprising:

receiving TE information from a first core network component in a core network, a radio access network, RAN, component, wherein the RAN is communicatively coupled to the core network, and wherein the TE information includes a TE objective; and

determining a TE decision between at least one UE and a second core network component in the core network according to the TE information and the TE objective, wherein the TE decision comprises information for at least one end-to-end path solution between the at least one UE and the second core network wherein the path traverses the core network and the RAN.

2. The method of claim 1, wherein the TE information comprises spectral efficiency, SE, values over radio links.

3. The method of claim 1, further comprising determining a feasibility result indicating whether a current TE problem defined by the TE information is feasible.

4. The method of claim 1, wherein the determining a TE decision between the UE and a second core network component is performed in response to a triggering event.

5. The method of claim 4, wherein the triggering event comprises at least one of a network topology change, a network parameter change, a service requirement change, and a service quality of experience or quality of service performance degradation event.

6. The method of claim 5, wherein the network topology change comprises a node addition or removal.

7. The method of claim 5, wherein the network parameter change comprises at least one of a radio resource availability change, a link capacity change, a buffer size change, an operating cost change, and a link SE change.

8. The method of claim 5, wherein the service requirement change comprises at least one of a source addition, destination addition, a source removal, a destination removal, a logical link quality of experience requirement change, and a logical link quality of service requirement change.

9. The method of claim 1, wherein the TE decision comprises at least one of an end-to-end path, a per route resource allocation, a per route rate allocation, links used for end-to-end routing, per link resource allocation, and per link rate allocation.

10. The method of claim 1, further comprising adjusting a path computation algorithm according to a change in traffic engineering configuration parameter.

11. The method of claim 1, wherein the traffic engineering information comprise at least one of quality of experience requirements between sources and destinations and quality of service requirements between sources and destinations.

12. The method of claim 1, wherein the traffic engineering information comprise at least one of a rate requirement and a delay requirement.

13. The method of claim 1, wherein the traffic engineering information comprises at least one of quality of experience feedback and quality of service feedback.

14. The method of claim 1, wherein the traffic engineering information comprises network parameters.

15. The method of claim 14, wherein the network parameters comprise at least one of link capacity, buffer size, radio resources at RAN nodes, per node operating cost, and per link operating cost.

16. A network component configured for traffic engineering, TE, in a software defined network, SDN, the network component comprising:

a processor; and

a computer readable storage medium storing programming for execution by the processor, the programming including instructions to:

receive TE information from a first core network component in a core network, a radio access network, RAN, component, wherein the RAN is communicably coupled to the core network, and wherein the TE information includes a TE objective; and

determine a TE decision between at least one UE and a second core network component in the core network according to the TE information and the TE objective, wherein the TE decision comprises information for at least one end-to-end path

solution between the at least one UE and the second core network wherein the path traverses the core network and the RAN.

17. The network component of claim 16, wherein the TE information comprises spectral efficiency, SE, values over radio links.

18. The network component of claim 16, wherein the programming further comprises instructions to determine a feasibility result indicating whether a current TE problem defined by the TE information is feasible.

19. The network component of claim 16, wherein the instructions to determine a TE decision between the at least one UE and a second core network component is performed in response to a triggering event.

20. The network component of claim 19, wherein the triggering event comprises at least one of a network topology change, a network parameter change, a service requirement change, and a service quality of experience or quality of service performance degradation event.

21. The network component of claim 20, wherein the network topology change comprises a node addition or removal.

22. The network component of claim 20, wherein the network parameter change comprises at least one of a radio resource availability change, a link capacity change, a buffer size change, an operating cost change, and a link SE change.

23. The network component of claim 20, wherein the service requirement change comprises at least one of a source addition, destination addition, a source removal, a destination removal, a logical link quality of experience requirement change, and a logical link quality of service requirement change.

24. The network component of claim 16, wherein the TE decision comprises at least one of an end-to-end path, a per route resource allocation, a per route rate allocation, links used for end-to-end routing, per link resource allocation, and per link rate allocation.

25. The network component of claim 16, wherein the programming further comprises instructions to adjust a path computation algorithm according to a change in a traffic engineering configuration parameter.

26. The network component of claim 16, wherein the TE information comprise at least one of quality of experience requirements between sources and destinations and quality of service requirements between sources and destinations.

27. The network component of claim 16, wherein the TE information comprise at least one of a rate requirement and a delay requirement.

28. The network component of claim 16, wherein the TE information comprises at least one of quality of experience feedback and quality of service feedback.

29. The network component of claim 16, wherein the TE information comprises network parameters.

30. The network component of claim 29, wherein the network parameters comprise at least one of link capacity, buffer size, radio resources at RAN nodes, per node operating cost, and per link operating cost.

31. A traffic engineering, TE, component in a software defined network, SDN, comprising:

an first interface connected to at least one control/management component to receive TE information about a wireline network and a radio access network, RAN, and to receive TE configuration information;

a second interface configured to receive a triggering event from one of the wireline network and the RAN; and

a TE decision component connected to the first and second interfaces configured to determine a unified TE determination in response to the triggering event according to the TE information and TE configuration information, wherein the unified TE determination comprises a path selection between a source and destination for a plurality of source-destination pairs in the RAN and the wireline network and a rate allocation over selected paths for the plurality of source-destination pairs in the RAN and the wireline network.

32. The TE component of claim 31, wherein the first interface is further configured to receive service requirements, wherein the service requirements include quality of experience and quality of service requirements between sources and destinations.

33. The TE component of claim 32, wherein the first interface is further configured to receive quality of experience and quality of service feedback.

34. The TE component of claim 31, wherein the triggering event comprises at least one of a network topology change, a network parameter change, a service requirement change, and a service quality of experience or quality of service performance degradation event.

The antenna circuit 570 and antenna element 575 may allow the processing unit 501 to communicate with remote units via a network. In an embodiment, the antenna circuit 570 and antenna element 575 provide access to a wireless wide area network (WAN) and/or to a cellular network, such as Long Term Evolution (LTE), Code Division Multiple Access (CDMA), Wideband CDMA (WCDMA), and Global System for Mobile Communications (GSM) networks. In some embodiments, the antenna circuit 570 and antenna element 575 may also provide Bluetooth and/or WiFi connection to other devices.

The processing unit 501 may also include one or more network interfaces 550, which may comprise wired links, such as an Ethernet cable or the like, and/or wireless links to access nodes or different networks. The network interface 501 allows the processing unit 501 to communicate with remote units via the networks 580. For example, the network interface 550 may provide wireless communication via one or more transmitters/transmit antennas and one or more receivers/receive antennas. In an embodiment, the processing unit 501 is coupled to a local-area network or a wide-area network for data processing and communications with remote devices, such as other processing units, the Internet, remote storage facilities, or the like.

One embodiment provides a method in a network component for traffic engineering, TE, in a software defined network, SDN, the method comprising: receiving TE information from a first core network component in a core network, a radio access network, RAN, component, wherein the RAN is communicatively coupled to the core network, and wherein the TE information includes a TE objective; and determining a TE decision between at least one UE and a second core network component in the core network according to the TE information and the TE objective, wherein the TE decision comprises information for at least one end-to-end path solution between the at least one UE and the second core network wherein the path traverses the core network and the RAN.

Wherein the TE information comprises spectral efficiency, SE, values over radio links.

The method further comprising determining a feasibility result indicating whether a current TE problem defined by the TE information is feasible.

Wherein the determining a TE decision between the UE and a second core network component is performed in response to a triggering event.

Wherein the triggering event comprises at least one of a network topology change, a network parameter change, a service requirement change, and a service quality of experience or quality of service performance degradation event.

Wherein the network topology change comprises a node addition or removal.

Wherein the network parameter change comprises at least one of a radio resource availability change, a link capacity change, a buffer size change, an operating cost change, and a link SE change.

Wherein the service requirement change comprises at least one of a source addition, destination addition, a source removal, a destination removal, a logical link quality of experience requirement change, and a logical link quality of service requirement change.

Wherein the TE decision comprises at least one of an end-to-end path, a per route resource allocation, a per route rate allocation, links used for end-to-end routing, per link resource allocation, and per link rate allocation.

The method further comprising adjusting a path computation algorithm according to a change in traffic engineering configuration parameter.

Wherein the traffic engineering information comprise at least one of quality of experience requirements between sources and destinations and quality of service requirements between sources and destinations.

Wherein the traffic engineering information comprise at least one of a rate requirement and a delay requirement.

Wherein the traffic engineering information comprises at least one of quality of experience feedback and quality of service feedback.

Wherein the traffic engineering information comprises network parameters.

Wherein the network parameters comprise at least one of link capacity, buffer size, radio resources at RAN nodes, per node operating cost, and per link operating cost.

One embodiment provides a network component configured for traffic engineering, TE, in a software defined network, SDN, the network component comprising: a processor;

and a computer readable storage medium storing programming for execution by the processor, the programming including instructions to: receive TE information from a first core network component in a core network, a radio access network, RAN, component, wherein the RAN is communicably coupled to the core network, and wherein the TE information includes a TE objective; and determine a TE decision between at least one UE and a second core network component in the core network according to the TE information and the TE objective, wherein the TE decision comprises information for at least one end-to-end path solution between the at least one UE and the second core network wherein the path traverses the core network and the RAN.

Wherein the TE information comprises spectral efficiency, SE, values over radio links.

Wherein the programming further comprises instructions to determine a feasibility result indicating whether a current TE problem defined by the TE information is feasible.

Wherein the instructions to determine a TE decision between the at least one UE and a second core network component is performed in response to a triggering event.

Wherein the triggering event comprises at least one of a network topology change, a network parameter change, a service requirement change, and a service quality of experience or quality of service performance degradation event.

Wherein the network topology change comprises a node addition or removal.

Wherein the network parameter change comprises at least one of a radio resource availability change, a link capacity change, a buffer size change, an operating cost change, and a link SE change.

Wherein the service requirement change comprises at least one of a source addition, destination addition, a source removal, a destination removal, a logical link quality of experience requirement change, and a logical link quality of service requirement change.

Wherein the TE decision comprises at least one of an end-to-end path, a per route resource allocation, a per route rate allocation, links used for end-to-end routing, per link resource allocation, and per link rate allocation.

Wherein the programming further comprises instructions to adjust a path computation algorithm according to a change in a traffic engineering configuration parameter.

Wherein the TE information comprise at least one of quality of experience requirements between sources and destinations and quality of service requirements between sources and destinations.

Wherein the TE information comprise at least one of a rate requirement and a delay requirement.

Wherein the TE information comprises at least one of quality of experience feedback and quality of service feedback.

Wherein the TE information comprises network parameters.

Wherein the network parameters comprise at least one of link capacity, buffer size, radio resources at RAN nodes, per node operating cost, and per link operating cost.

One embodiment provides a traffic engineering, TE, component in a software defined network, SDN, comprising: an first interface connected to at least one control/management component to receive TE information about a wireline network and a radio access network, RAN, and to receive TE configuration information; a second interface configured to receive a triggering event from one of the wireline network and the RAN; and a TE decision component connected to the first and second interfaces configured to determine a unified TE determination in response to the triggering event according to the TE information and TE configuration information, wherein the unified TE determination comprises a path selection between a source and destination for a plurality of source-destination pairs in the RAN and the wireline network and a rate allocation over selected paths for the plurality of source-destination pairs in the RAN and the wireline network.

Wherein the first interface is further configured to receive service requirements, wherein the service requirements include quality of experience and quality of service requirements between sources and destinations.

Wherein the first interface is further configured to receive quality of experience and quality of service feedback.

Wherein the triggering event comprises at least one of a network topology change, a network parameter change, a service requirement change, and a service quality of experience or quality of service performance degradation event.

Although the description has been described in detail, it should be understood that various changes, substitutions and alterations can be made without departing from the spirit and scope of this disclosure as defined by the appended claims. Moreover, the scope of the disclosure is not intended to be limited to the particular embodiments described herein, as one of ordinary skill in the art will readily appreciate from this disclosure that processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, may perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

WHAT IS CLAIMED IS:

1. A method for traffic engineering (TE) in a software defined network (SDN), the method comprising:

receiving, by a TE component, a first TE information from a core network component in a core network;

receiving, by the TE component, a second TE information from a radio access network (RAN) component in a RAN; and

transmitting, by the TE component, a TE decision to at least one node in the SDN,

wherein the TE decision is determined according to the first TE information and the second TE information, and the TE decision comprises at least one end-to-end path solutions based on a flow-path format or flow-link format.

2. The method of claim 1, wherein the flow-path format comprises at least one path between a source and destination for a plurality of source destination pairs in the SDN and a rate allocation over the at least one path for the plurality of source destination pairs; the flow-link format comprises per link resource allocation for a plurality of source destination pairs in the SDN.

3. The method of claim 1, further comprising:

receiving, by the TE component, a TE configuration selected by an network operator; and

determining, by the TE component, the TE decision based on the first TE information and the second TE information and the TE configuration.

4. The method of claim 3, wherein the TE configuration comprises a TE objective for controlling network resources assigned to different services.

5. The method of claim 3, further comprising:

receiving, by the TE component, a service requirement; and

determining, by the TE component, the TE decision based on the first TE information and the second TE information, the TE configuration and the service requirement.

6. The method of claim 5, wherein the service requirement comprises at least one of quality of experience requirements between sources and destinations and quality of service requirements between sources and destinations; or at least one of quality of experience feedback and quality of service feedback.

7. The method of claim 1, further comprising:

receiving, by the TE component, a TE triggering event comprising at least one of a one-time time out event, a periodic time out event, an input change event, and a service quality of experience (QoE) and quality of service (QoS) performance degradation event; and

determining, by the TE component, the TE decision in response to receiving the TE triggering event.

8. The method of claim 7, wherein the input change event comprises one of a network topology change, a network parameter change, a service requirement change, and a service quality of experience or quality of service performance degradation event.

9. The method of claim 1, wherein the first TE information and the second TE information comprise network topology information and network parameter.

10. The method of claim 9, wherein the network parameter in the second TE information further comprises spectral efficiency (SE) values for radio links.

11. The method of claim 1, further comprises:

determining, by the TE component, routing path candidate from a maximum number of candidate routing paths for each logical link.

12. The method of claim 1, further comprising:

transmitting, by the TE component, a feasibility result indicating whether a current TE problem defined by the TE information is feasible.

13. The method of claim 1, wherein the TE decision comprises at least one of an end-to-end path, a per route resource allocation, a per route rate allocation, links used for end-to-end routing, per link resource allocation, and per link rate allocation.

14. A traffic engineering (TE) component in a software defined network (SDN), comprising:

a first interface configured to receive a first TE information from a core network component in a core network and a second TE information from a radio access network (RAN) component in a RAN; and

a second interface configured to transmit a TE decision to at least one node in the SDN,

wherein the TE decision determined according to the first TE information and the second TE information, and the TE decision comprising at least one end-to-end path solutions according to a flow-path format or a flow-link format.

15. The TE component of claim 14, wherein the flow-path format comprises at least one path between a source and destination for a plurality of source destination pairs in the SDN and a rate allocation over the at least one path for the plurality of source destination pairs; the flow-link format comprises per link resource allocation for a plurality of source destination pairs in the SDN.

16. The TE component of claim 14, wherein the first interface is further configured to receive a TE configuration selected by a network operator, wherein the TE decision determined according to the first TE information and the second TE information and the TE configuration.

17. The TE component of claim 16, wherein the first interface is further configured to receive a service requirement, wherein the TE decision determined according to the first TE information and the second TE information, the TE configuration and the service requirement.

18. The TE component of claim 14, wherein the TE component further comprises a third interface, wherein the third interface configured to receive a TE triggering event, wherein TE triggering event comprises at least one of a one-time time out event, a periodic time out event, an input change event, and a service quality of experience (QoE) and a quality of service (QoS) performance degradation event.

19. The TE component of claim 14, wherein the second interface is further configured to transmit a feasibility result, wherein the feasibility result is used to indicate whether a current TE problem defined by the TE information is feasible.

20. A method for traffic engineering (TE) in a software defined network (SDN), the method comprising:

transmitting, by a radio access network (RAN) component in a RAN, a second TE information to a TE component; and

receiving, by the RAN component, a data packet from a source node; wherein the data packet carrying a data header generated based on a TE decision,

wherein the TE decision determined according to a first TE information generating from a core network component in a core network and the second TE information, and the TE decision comprising at least one end-to-end path solutions based on a flow-path format or flow-link format.

21. The method of claim 20, wherein the data header comprises a path ID indicating at least one path between a source and destination for a plurality of source destination pairs in the SDN and a rate allocation over the at least one path for the plurality of source destination pairs; or the data header comprises a flow ID indicating per link resource allocation for a plurality of source destination pairs in the SDN.

22. The method of claim 20, wherein the TE decision is determined according to the first TE information, the second TE information and a TE configuration, wherein the TE configuration comprises a TE objective for controlling network resources assigned to different services.

23. The method of claim 22, wherein the TE decision is determined according to the first TE information, the second TE information , the TE configuration and a service requirement, wherein the service requirement comprises at least one of quality of experience requirements between sources and destinations and quality of service requirements between sources and destinations; or at least one of quality of experience feedback and quality of service feedback.

24. A radio access network (RAN) component in a RAN, comprising:

a transmitter configured to transmit a second TE information to a traffic engineering (TE) TE component in a software defined network (SDN); and

a receiver configured to receive a data packet from a source node; wherein the data packet carrying a data header generated based on a TE decision,

wherein the TE decision determined according to a first TE information generating from a core network component in a core network and the second TE information, and the TE decision comprising at least one end-to-end path solutions based on a flow-path format or a flow-link format.

25. The RAN component of claim 24, wherein the data header comprises a path ID indicating at least one path between a source and destination for a plurality of source destination pairs in the SDN and a rate allocation over the at least one path for the plurality of source destination pairs; or the data header comprises a flow ID indicating per link resource allocation for a plurality of source destination pairs in the SDN.

26. The RAN component of claim 25, wherein the TE decision is determined according to the first TE information, the second TE information, the TE configuration and a service requirement, wherein the service requirement comprises at least one of quality of experience requirements between sources and destinations and quality of service requirements between sources and destinations; or at least one of quality of experience feedback and quality of service feedback.

27. The RAN component of claim 24, wherein the TE decision is determined according to the first TE information, the second TE information and a TE configuration, wherein the TE configuration comprises a TE objective for controlling network resources assigned to different services.