CLAIMS

What is claimed is:

1. A method of network bandwidth management, comprising: configuring packets at a node for transmission in an upstream direction, wherein each of the packets is within a flow of packets and is associated with a quality of service (QoS) level based on a service level agreement (SLA); transmitting the packets within the flow of packets at a QoS level above the QoS level based on the SLA if available network bandwidth permits; receiving feedback from a parent node of the node, wherein the node is a neighbor node of the parent node and has a higher rank than the parent node, wherein the feedback restricts the flow of packets to the QoS level based on the SLA, and wherein the feedback is based at least in part on: examination of network congestion; and recognition that the network congestion has exceeded a threshold; and transmitting additional packets within the flow of packets according to a bandwidth indicated by the QoS level based on the SLA.

2. The method of claim 1, wherein the parent node sent the feedback based on operations at the parent node comprising: monitoring the network congestion at the parent node; and transmitting the feedback to the node based on the monitored network congestion, wherein the feedback includes instructions to slow the flow of packets.

3. The method of claim 1, wherein transmitting the packets within the flow of packets at the QoS level above the QoS level based on the SLA if the available network bandwidth permits comprises: detecting a reduced level of congestion at the parent node; and providing additional feedback from the parent node to nodes downstream of the parent node, wherein the additional feedback allows increased bandwidth use by the node for transmission in the upstream direction.

4. The method of claim 1, additionally comprising: receiving, at the node, updated QoS levels, sent from a root node, regarding each of a plurality of flows of packets; and changing a relative bandwidth assigned to each of the plurality of flows of packets based on the updated QoS levels.

5. The method of claim 1, wherein the upstream flow of packets is transmitted based on availability of tokens in a token-bucket system, and the tokens are managed by acts comprising: configuring a quantity of tokens based on: the QoS level of the flow of packets; an estimation of available bandwidth at the node; and the received feedback; transmitting the packets based on the availability of the tokens; and consuming tokens based on transmission of the packets.

6. The method of claim 1, wherein the upstream flow of packets are transmitted based on a leaky bucket technique, and wherein the leaky bucket technique is managed by acts comprising: configuring a leaky bucket based on: the QoS level of the flow of packets; an estimation of the network congestion at the node; and the received feedback; and transmitting the packets based on the leaky bucket.

7. The method of claim 1, additionally comprising: identifying packets whose flow label is indicated by the feedback; and recalculating a time-to-send for the identified packets, wherein the time-to send is either set to an earlier time or postponed by the feedback.

8. The method of claim 1, wherein: the feedback received from the parent node is in response to the congestion at the parent node; and the feedback changes relative bandwidths assigned to at least two flows of packets.

9. The method of claim 1, wherein the feedback limits a rate of packet transmission within the flow of packets but does not limit a rate of packet transmission of a second flow of packets.

10. The method of claim 1, wherein: the feedback is based on operations comprising monitoring the network congestion; and comprises instructions to slow the flow of packets.

11. A node in a network, comprising: a radio transceiver, a congestion measurement manager to determine a level of network congestion; a feedback manager, to use the level of network congestion to determine if feedback should be sent to nodes having a higher rank than the node, wherein the feedback manager configures the feedback to change a quality of service (QoS) level of an upstream flow of packets, and wherein the feedback manager generates feedback based on: the level of network congestion; and recognition of whether the upstream flow of packets is using bandwidth according to the QoS level above the QoS level based on SLA; and

a packet manager to receive, using the radio transceiver, the upstream flow of packets according to a bandwidth indicated by the QoS level.

12. The node of claim 11, wherein the feedback manager is additionally configured to: reduce bandwidth used by the upstream flow of packets based in part on feedback from the parent node.

13. The node of claim 11, wherein the feedback manager is additionally configured to: increase bandwidth used by the upstream flow of packets based in part on feedback from the parent node.

14. The node of claim 11, wherein the packet manager is configured to: transmit the upstream flow of packets according to the QoS level based on the SLA if feedback associated with the upstream flow of packets has not been received by the feedback manager; and transmit the upstream flow of packets according to a different QoS level if feedback associated with the upstream flow of packets has been received by the feedback manager.

15. One or more non-transitory computer-readable media storing computer-executable instructions that, when executed, cause one or more processors to perform acts comprising: under control of one or more processors on a node, the processors configured with executable instructions: evaluating congestion in a network; sending feedback to a child node of the node, wherein the feedback: increases bandwidth used by a flow of packets in an upstream direction when the evaluated congestion indicates available bandwidth is more than a first threshold value; or

decreases bandwidth used by the flow of packets in the upstream direction when the evaluated congestion indicates available bandwidth is less than a second threshold value;

monitoring the network congestion at the node using an average value over a time interval; and configuring the feedback to change bandwidth used by each of a plurality of flows of packets in a manner that restricts different ones of the plurality of flows differently and that is based in part on the average value over the time interval; wherein the feedback: originated at a root node in response to the evaluated congestion; and increases bandwidth to some upstream flows and decreases bandwidth to other upstream flows during the monitoring of the network congestion.

16. The one or more non-transitory computer-readable media of claim 15, additionally comprising: recognizing a flow of packets from an application running on the child node; and configuring the feedback to reduce the flow of packets from the application on the child node from a quality of service (QoS) level greater than required a service level agreement (SLA) to a QoS level not greater than required by the SLA.

17. The one or more non-transitory computer-readable media of claim 15, wherein the feedback directs the child node to perform acts comprising:

delaying transmission of packets within the flow of packets; and recalculating a time-to-send for enough packets in the flow of packets to

conform to a quality of service (QoS). level based on a service level agreement (SLA) of the upstream flow of packets.

18. One or more non-transitory computer-readable media storing computer-executable instructions that, when executed, cause one or more processors to perform acts comprising: under control of one or more processors on a node, the processors configured with executable instructions: evaluating congestion in a network; sending feedback to a child node of the node, wherein the feedback: increases bandwidth used by a flow of packets in an upstream direction when the evaluated congestion indicates available bandwidth is more than a first threshold value; or decreases bandwidth used by the flow of packets in the upstream direction when the evaluated congestion indicates available bandwidth is less than a second threshold value; wherein the feedback directs the child node to perform acts comprising: delaying transmission of packets within the flow of packets; and recalculating a time-to-send for enough packets in the flow of packets to conform to a quality of service (QoS) level based on a service level agreement (SLA) of the upstream flow of packets; and wherein the feedback:

originates at a root node in response to the evaluated congestion; and

increases or decreases bandwidth to upstream flows based at least in part on the evaluated congestion.

19. The one or more non-transitory computer-readable media of claim 18, additionally comprising: recognizing a flow of packets from an application running on the child node; and configuring the feedback to reduce the flow of packets from the application on the child node from a quality of service (QoS) level greater than required by the service level agreement (SLA) to a QoS level not greater than required by the SLA.

20. A method of network bandwidth management, comprising: configuring packets at a node for transmission in an upstream direction, wherein each of the packets is within a flow of packets and is associated

with a quality of service (QoS) level based on a service level agreement (SLA);

transmitting the packets within the flow of packets at a QoS level above the QoS level based on the SLA if available network bandwidth permits; receiving feedback from a parent node of the node, the feedback restricting the flow of packets to the QoS level based on the SLA; identifying packets whose flow label is indicated by the feedback; recalculating a time-to-send for the identified packets, wherein the time-to-send is either set to an earlier time or postponed by the feedback; and transmitting additional packets within the flow of packets according to a bandwidth indicated by the QoS level based on the SLA.

CLAIMS

What is claimed is:

1. A method of network bandwidth management, comprising:

configuring packets at a node for transmission in an upstream direction, wherein each of the packets is within a flow of packets and is associated with a quality of service (QoS) level based on a service level agreement (SLA);

transmitting the packets within the flow of packets at a QoS level above the QoS level based on the SLA if available network bandwidth permits;

receiving feedback from a parent node of the node, the feedback restricting the flow of packets to the QoS level based on the SLA; and

transmitting additional packets within the flow of packets according to a bandwidth indicated by the QoS level based on the SLA.

2. The method of claim 1, wherein the parent node sent the feedback based on operations at the parent node comprising:

monitoring network congestion at the parent node; and

transmitting the feedback to the node based on the monitored network congestion, wherein the feedback includes instructions to slow the flow of packets.

3. The method of claim 1, wherein the parent node sent the feedback based on operations at the parent node comprising:

examining network congestion;

recognizing the network congestion has exceeded a threshold; and

transmitting the feedback to neighbor nodes of the parent node, the neighbor nodes having higher rank than the parent node, wherein the feedback returns the flow of packets to the QoS level based on the SLA.

4. The method of claim 1, wherein transmitting the packets within the flow of packets at the QoS level above the QoS level based on the SLA if available network bandwidth permits comprises:

detecting a reduced level of congestion at the parent node; and

providing additional feedback from the parent node to nodes downstream of the parent node, wherein the additional feedback allows increased bandwidth use by the node for transmission in the upstream direction.

5. The method of claim 1, additionally comprising:

receiving, at the node, updated QoS levels, sent from a root node, regarding each of a plurality of flows of packets; and

changing a relative bandwidth assigned to each of the plurality of flows of packets based on the updated QoS levels.

6. The method of claim 1, wherein the upstream flow of packets is transmitted based on availability of tokens in a token-bucket system, and the tokens are managed by acts comprising:

configuring a quantity of tokens based on:

the QoS level of the flow of packets;

an estimation of available bandwidth at the node; and

the received feedback;

transmitting packets based on availability of the tokens; and

consuming tokens based on transmission of the packets.

7. The method of claim 1, wherein the upstream flow of packets are transmitted based on a leaky bucket technique, and wherein the leaky bucket technique is managed by acts comprising:

configuring a leaky bucket based on:

the QoS level of the flow of packets;

an estimation of network congestion at the node; and

the received feedback; and

transmitting packets based the leaky bucket.

8. The method of claim 1, additionally comprising:

identifying packets whose flow label is indicated by the feedback; and

recalculating a time-to-send for the identified packets, wherein the time-to-send is either set to an earlier time or postponed by the feedback.

9. The method of claim 1, wherein:

the feedback received from the parent node is in response to congestion at the parent node; and

the feedback changes relative bandwidths assigned to at least two flows of packets.

10. The method of claim 1, wherein the feedback limits a rate of packet transmission within the flow of packets but does not limit a rate of packet transmission of a second flow of packets.

11. A node in a network, comprising:

a congestion measurement manager to determine a level of network congestion;

a feedback manager, to use the level of network congestion to determine if feedback should be sent to nodes having a higher rank than the node, wherein the feedback is configured to change a quality of service (QoS) level of an upstream flow of packets; and

a packet manager to receive the upstream flow of packets according to a bandwidth indicated by the QoS level.

12. The node of claim 11, wherein the feedback manager is additionally configured to:

reduce bandwidth used by the upstream flow of packets based in part on feedback from the parent node.

13. The node of claim 11, wherein the feedback manager is additionally configured to:

increase bandwidth used by the upstream flow of packets based in part on feedback from the parent node.

14. The node of claim 11, wherein the feedback manager is configured to generate feedback based on:

the level of network congestion; and

recognition of whether the upstream flow of packets is using bandwidth according to the QoS level above the QoS level based on the SLA.

15. The node of claim 11, wherein the packet manager is configured to:

transmit an upstream flow of packets according to a QoS level based on an SLA if feedback associated with the upstream flow of packets has not been received by the feedback manager; and

transmit the upstream flow of packets according to a different QoS level if feedback associated with the upstream flow of packets has been received by the feedback manager.

16. One or more computer-readable media storing computer-executable instructions that, when executed, cause one or more processors to perform acts comprising:

under control of one or more processors on a node, the processors configured with executable instructions:

evaluating congestion in a network;

sending feedback to a child node of the node, wherein the feedback:

increases bandwidth used by a flow of packets in an upstream direction when the evaluated congestion indicates available bandwidth is more than a first threshold value; or

decreases bandwidth used by the flow of packets in the upstream direction when the evaluated congestion indicates available bandwidth is less than a second threshold value.

17. The one or more computer-readable media of claim 16, additionally comprising:

monitoring network congestion at the node using an average value over a time interval; and

configuring the feedback to change bandwidth used by each of a plurality of flows of packets in a manner that restricts each of the plurality of flows differently and that is based in part on the average value over the time interval.

18. The one or more computer-readable media of claim 16, additionally comprising:

recognizing a flow of packets from an application running on the child node; and

configuring the feedback to reduce the flow of packets from the application on the child node from a QoS level higher than a QoS level based on an SLA to the QoS level based on the SLA.

19. The one or more computer-readable media of claim 16, wherein the feedback directs the child node to perform acts comprising:

delaying transmission of packets within the flow of packets; and

recalculating a time-to-send for enough packets in the flow of packets to conform to the QoS level based on the SLA of the upstream flow of packets.

20. The one or more computer-readable media of claim 16, wherein:

the feedback originated at a root node in response to the evaluated congestion; and

the feedback increases bandwidth to some upstream flows and decreases bandwidth to other upstream flows.