ns-3 training

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Outline

> TCP
  – tcp-variants-comparison.cc example
  – Connection of TCP trace sources at runtime
  – PCAP tracing
  – Flow Monitor tracing and processing

> Flow Monitor
  – PyViz demonstration

> Bake and DCE (included in another presentation)
History of ns-3 TCP

• Until ns-3.10
  – it was a port of TCP model from GTNetS (Georgia Tech Network Simulator)

• For ns-3.10
  – it was substantially rewritten by Adriam Tam in 2011

• For ns-3.25
  – the module was refactored as a part of GSoC 2015 project by Natale Patriciello
  – one of the major changes involved how congestion control algorithms are implemented (more details to follow)
  – other notable change was about automating the tests
  – Target is to align the implementation with that of Linux
Congestion control algorithms

- NewReno *(default)*
- Westwood, Westwood+
- Hybla
- HighSpeed
- Vegas
- Scalable
- Veno
- Binary Increase Congestion Control (BIC)
- Yet another HighSpeed TCP (YeAH)
- Illinois
- H-TCP
- Low Extra Delay Background Transport (LEDBAT)
- Data Center TCP (DCTCP) -- under review
Loss detection and recovery algorithms

- Loss detection
  - Traditional timeout
  - Traditional 3 DUPACKs
  - SACK
  - RACK (under review)
- Recovery mechanisms
  - Traditional timeout
  - NewReno fast retransmit and recovery
  - Proportional Rate Reduction (PRR)
TCP implementation in ns-3

- Source code can be found at: `src/internet/model/
  - tcp-header.{h,cc}
  - tcp-socket.{h,cc}
  - tcp-socket-base.{h,cc}
  - tcp-socket-factory-impl.{h,cc}
  - tcp-l4-protocol.{h,cc}
  - tcp-congestion-ops.{h,cc}
  - tcp-recovery-ops.{h,cc}
  - ...
TcpHeader class

- This class implements the TCP header and contains:
  - port numbers
  - sequence numbers
  - acknowledgment numbers
  - flags
  - ...

- It also contains:
  - setters and getters
  - methods for serialization
  - and deserialization
**TcpSocket class**

- This class:
  - is an abstract base class for all TcpSockets
  - contains TcpSocket attributes that can be reused across different implementations.

- Examples of such attributes include:
  - SndBufSize
  - RcvBufSize
  - SegmentSize
  - InitialCwnd
  - DelAckCount
  - DelAckTimeout
  - ...

![Diagram showing the relationship between ns3::Socket, ns3::TcpSocket, ns3::NscTcpSocketImpl, and ns3::TcpSocketBase.](image)
TcpSocketFactory class

- This class:
  - is an abstract base class
  - defines API for TCP sockets
  - contains global default variables to initialize new sockets
TcpSocketFactoryImpl class

• This class:
  – is an implementation of socket factory for ns-3 TCP
  – creates sockets of type TcpSocketBase
TcpSocketBase class

• This class:
  – is a base class for the implementation of TCP stream socket
  – contains essential components of TCP and provides a socket interface for upper layers to call
• Examples of components include:
  – Connection orientation
  – Sliding window mechanism
  – Fast retransmit
  – Fast recovery
  – Enable/disable window scaling, timestamps
  – Congestion state machine
  – Congestion control interface
TcpSocketState class

• This class:
  – records the congestion state of a connection
  – saves the information that is passed between the socket and the congestion control algorithms

• Examples of such information include:
  – the current value of congestion window
  – the current congestion state (CA_OPEN, CA_RECOVERY, etc)
  – the current value of slow start threshold
  – Last sequence number acknowledged
  – Next sequence number to be transmitted
  – …
TcpCongestionOps class

- This class:
  - is an abstract class for congestion control
  - provides an interface between the main socket code and congestion control; variables are stored in TcpSocketState
  - inspired by the design in Linux
- Some methods implemented in this class include:
  - GetSsThresh (Ptr<TcpSocketState>, uint32_t)
  - IncreaseWindow (Ptr<TcpSocketState>, uint32_t)
  - CongestionStateSet (Ptr<TcpSocketState>, TcpSocketState::TcpCongState_t)
  - PktsAcked (Ptr<TcpSocketState>, uint32_t, Time)
TcpCongestionOps class
Example review

• **found in** `examples/tcp/tcp-variants-comparison.cc`
  
  – based on past WNS3 paper:
  
  – PCAP output
  
  – flow monitor output
  
  – the need to defer connection of trace sinks until after time 0