Realizing the aims of Transport-Next Generation (TNG): COBS and SSL Minion

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Outline

- Motivation: Ad-hoc evolution of internet
- Brief Introduction to the TNG Project
- Minions
- Problem Introduction
- COBS Minion
- SSL Minion
- Network Simulator
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Ad-hoc evolution.

- The current Internet architecture tightly bundles several functions into the Transport Layer, all of which were originally intended to operate "end-to-end" between hosts. We are still using the TCP/IP settings evolved in 1974 (Cerf et al) when user count was merely in few thousands!
- End-to-end model has been under duress due to proliferation of middleboxes like NATs, Firewall.
- Legacy transport work well but deployment black-holes for newer technology.
- Hence, Limiting evolution of internet.
Transport Next Generation (TNG)

A new transport service architecture that decomposes "true" end-to-end transport functions such as reliable packet delivery and security from middlebox-relevant functions such as endpoint naming and congestion control.
The Minion Suite

- Minion suite: a suite of protocols that uses legacy transports—UDP, TCP, and SSL—to provide a generic unordered datagram service between communicating end-points.
- Acts as a substrate on top of which more sophisticated communication primitives (such as partial-ordering) can be built and deployed.
- The minions are modified forms of the legacy transports where the protocols appear unmodified on the wire, thus making deployability through middleboxes possible. (Transparent)
Explaining the Problem

- TCP, which is a stream based protocol, delivers data in form of contiguous chunks to higher layers.
- Even though the out-of-order data is available at lower layers, it is not delivered.

![Diagram showing the Minion API (libminion) and its components: Kernel, TCP Minion, SSL Minion, UDP Minion, Ipv6 Minion]
If user (appl layer) is given ability to decide!
New Layer Design

**Fig. Current Architecture.**

**Fig. COBS/SSL Class Minion Architecture**
COBS Minion

➢ One such attempt is Consistent Overhead Byte Stuffing (COBS) Minion.
➢ The COBS Minion ensures that the data is delivered to higher layers as soon as it is available to the lower layers.
➢ The task of data delivery is difficult because of numerous factors!
➢ Like Disordered packet arrival, packet loss, packet duplication, record extraction dependencies, packet concatenation and fragmentation.
Packet Reordering

• We need to extract data out of even the reordered packet upon it's arrival. (No waiting)
• Specialized data structure designed for this purpose which maintains holes for the data unarrived.
• If higher layers have extracted complete info from that packet, the memory is released, but meta-data is maintained indicating successful arrival for future use, like duplicate arrival. (Efficient Memory Management)
Unshaped Packet Arrival

- Network can concatenate, duplicate or fragment the packets hence we need to get rid of such packets.
- But we use the data as soon as it arrives and release it after use, dealing with concatenated packets become difficult.
- Maintaing meta-data helps, imagine any virtual content based on meta-data.
- We need to extract only new data from the arrived packet!
Some scenarios of packet manipulation in the network
Extraction of new data from duplicates

- A new segment is formed.
- Whole process transparent to upper layer.
- Now we may proceed to extract "record" from newly arrived segment.
Modifications to kernel for obtaining meta-data

Normal TCP
n=read(sd,buff,max);
Data of next higher sequence number returned in buffer.
Data size=n

• Modified TCP
n=read(sd,buff,max);
• Latest available TCP segment with 5 byte header in beginnig.
• 1st byte is flag.
• Next 4b seq. number.
• Data Size = n-5
What do we want to extract?

We need to extract "records" which are lying inside the payload of arrived "segment". These records are to be delivered to higher layers. But we don't know where are they lying in a segment!!!!!!
We need some kind of "marker" to indicate record starting.

This is provided by Consistent Overhead Byte Stuffing (COBS).

Removes all occurrences of 0x00 from "record" with a trade-off of some data size. (<0.4%) 0x00 can be used as marker byte.
Algorithm
Rules: 0x01 indicate 0 bytes followed by a 0x00.
   0x02 indicate 1 byte followed by a 0x00.
   0xfe indicate 253 bytes followed by a 0x00.
   0xff indicate 254 bytes not followed by a 0x00.

Find 0x00 in data given.

Break into parts at point of occurrence of 0x00 or continuous 255 bytes which ever is less.

Encode parts using rules.
Example

Data in hex.

12 23 00 --- 300 bytes --- 00 ff e4 78 00 89 00 00

03 12 23 ff --254 bytes -- 2e --46 bytes-- 04 ff e4 78 02 89 01
Extraction Algorithm

(1) Locate all markers in the new "segment".
(2) Extract the "records" that are fully inside.
(3) For partial "records" check if either previous or/and next segments have arrived.
(4) If so then, check if partial "record" can be extracted from data of previous/next segment.
(5) The beginning of partial record can be in nth segment before current one. Check recursively.
(6) Keep on updating log and meta-data as records are extracted.
(7) Release data memory if all records are extracted. Do recursively for all seg. in influence.
Advantages of COBS Minion

● It efficiently solves the problem of out of order data delivery to the higher layers.
● The encoding limits maximum overhead to 0.4%.
● Does not require any key exchange or handshake before transfer.
● The process is reversible without any loss.

● Other class of minion can be based on MAC checking and does not involve use of markers!
The SSL Minion

- Uses TLS Message Authentication Codes for ascertaining the presence of a "record".
- Sender appends a header (TLV) in the beginning and MAC at the end.
- $\text{MAC} = f(\text{KEY, data})$;
- KEY is already exchanged using TLS Handshake Protocol.
- Standard TLS record layer header used with a record.
Process in figures.

Application Layer  SSL Minion Layer  Modified TCP Layer

<-Sender

^  

Receiver

Modified TCP Layer  SSL Minion Layer

To be sent over IP Layer

Missing Data

Duplicate Data
Extraction in SSL Minion

(1) Guess and Verify Policy: Starting of record is guessed on basis of certain parameters like length field in TLV has to be less than MAX etc.
(2) Based on guessed header we obtain length of record. MAC must be after this.
(3) MAC is calculated on this entire message. If it matches the MAC sent then we have identified the record.
(4) We again may have partial records and even worst partial headers extending to other segs.
(5) We need to examine the influence range of the newly arrived segment.
Contd.

(6) All guesses which have not been verified in active influence range are checked.
(7) Log and meta-data to be updated if either a guess fails or record is found.
(8) Local optimizations. (If success, remove all guessed headers in it's range)
(9) Release memory when complete extraction done.
The Network Simulator

A simulator layer was developed to check the working of both the minions. It was necessary as existing local simulators (e.g., Netem or dummynet) do not simulate modified TCP kernel.

It can perform the following functions:
1) Duplication
2) Re-ordering
3) Concatenation

Both minions were successfully tested using the simulator.
Simulator layer is based on netem and works on either end point. (not in the network) The degree of reordering, duplication etc. Can be easily controlled by the user. Has to be installed on just both sides on top of TCP layer(normal).
Conclusion

- Both minions were successfully tested for performance under varied load.
- The purpose of quick delivery of data (record) is achieved as the processing is done segment by segment.
- The minions provide quick delivery to higher layers but it is up to the application on how to make use of the out-of-order data.
Future Work

• Work is to be done to develop Minion API which will integrate minion suite to higher layer.

• Applications which can make use of out of order data are not available and need to be developed.

• New naming schema is to be developed for internet browsing to accommodate minion suite.
References

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QUESTIONS?