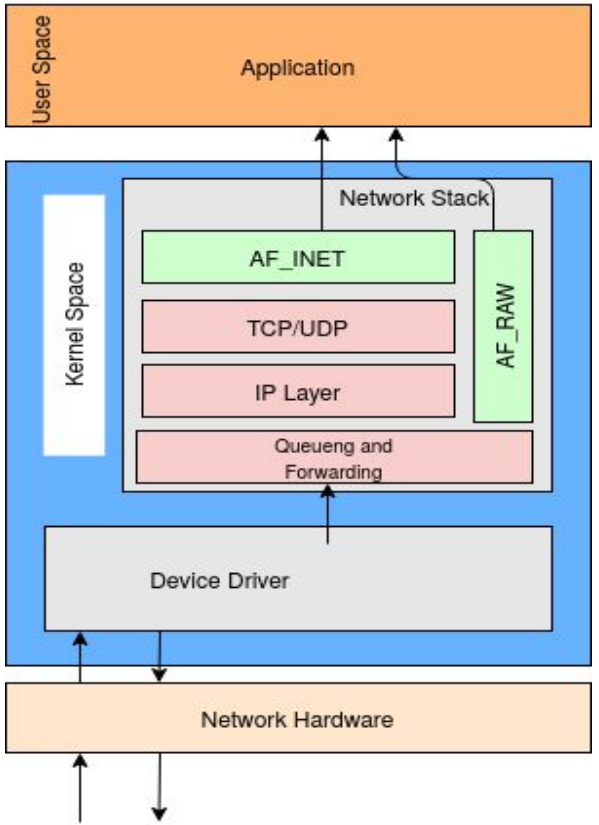
Network Security Tutorial

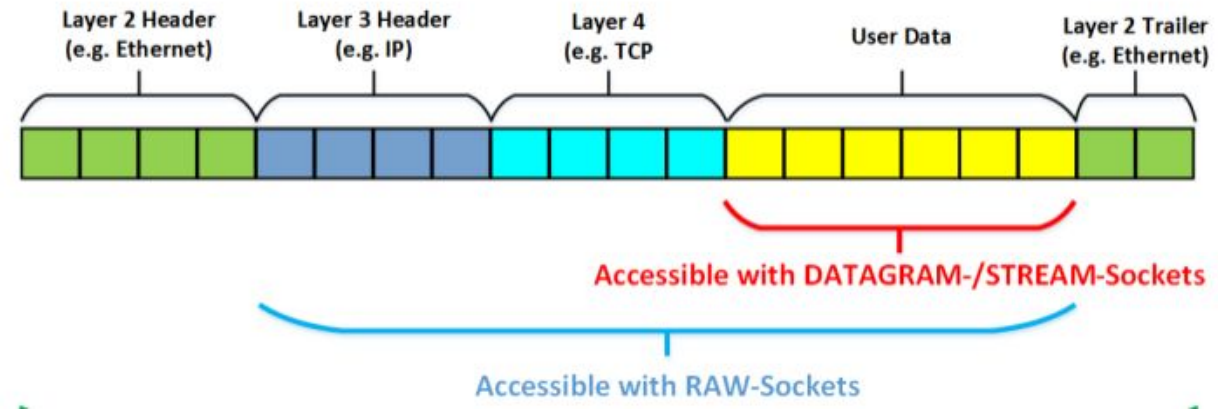
Raw Socket Programming

Raw Socket

- Directly access lower layer protocols in the network stack.
  - Link Layer - L2 (Ethernet)
  - Network Layer - L3 (IP)
  - Transport Layer - L4 (TCP/UDP/SCTP)
- Socket Creation
- Add relevant header information based on the protocol specified in the socket
- Protocols
  - IPPROTO_ICMP = 1
  - IPPROTO_TCP = 6
  - IPPROTO_UDP = 17
  - IPPROTO_SCTP = 132
  - IPPROTO_RAW = 255
  - IPPROTO_ESP = 50
  - IPPROTO_AH = 51



Raw Socket Programming



- Important Headers
  - sys/socket.h
  - netinet/in.h
  - ethernet.h
  - netinet/ip.h
  - netinet/tcp.h
  - netinet/udp.h

- socket(AF_INET, SOCK_RAW, IPPROTO_RAW) -> For IP /L3 level - SEND only
- socket (PF_PACKET, SOCK_RAW, htons (ETH_P_ALL)) -> For all ethernet type L2 packet processing
- socket (PF_PACKET, SOCK_RAW, htons (ETH_P_IP)) -> For all ethernet type, IP Packets only at L2
- socket (AF_INET, SOCK_RAW, IPPROTO_UDP) -> For UDP only
- socket (AF_INET, SOCK_RAW, IPPROTO_TCP) -> For TCP only

Stack Layers Headers

```
struct ether_header
{
  u_int8_t  ether_dhost[ETH_ALEN];
  u_int8_t  ether_shost[ETH_ALEN];
  u_int16_t ether_type;
} __attribute__ ((__packed__));

/* Ethernet protocol ID's */
#define ETHERTYPE_PUP           0x0200
#define ETHERTYPE_SPRITE        0x0500
#define ETHERTYPE_IP            0x0800
#define ETHERTYPE_ARP           0x0806
#define ETHERTYPE_REVARP        0x8035
#define ETHERTYPE_AT            0x809B
#define ETHERTYPE_AARP          0x80F3
#define ETHERTYPE_VLAN          0x8100
#define ETHERTYPE_IPX           0x8137
#define ETHERTYPE_IPV6          0x86dd
#define ETHERTYPE_LOOPBACK      0x9000
```

File: /usr/include/net/ethernet.h

```
struct iphdr
  {
#if __BYTE_ORDER == __LITTLE_ENDIAN
    unsigned int ihl:4;
    unsigned int version:4;
#elif __BYTE_ORDER == __BIG_ENDIAN
    unsigned int version:4;
    unsigned int ihl:4;
#else
# error "Please fix <bits/endian.h>"
#endif
    u_int8_t tos;
    u_int16_t tot_len;
    u_int16_t id;
    u_int16_t frag_off;
    u_int8_t ttl;
    u_int8_t protocol;
    u_int16_t check;
    u_int32_t saddr;
    u_int32_t daddr;
    /*The options start here. */
  };
```

File: /usr/include/linux/,
/usr/include/netinet/ip.h

Stack Layers Headers

```
struct tcphdr {
        __be16  source;
        __be16  dest;
        __be32  seq;
        __be32  ack_seq;
#if defined(__LITTLE_ENDIAN_BITFIELD)
        __u16   res1:4,
                doff:4,
                fin:1,
                syn:1,
                rst:1,
                psh:1,
                ack:1,
                urg:1,
                ece:1,
                cwr:1;
#elif defined(__BIG_ENDIAN_BITFIELD)
        __u16   doff:4,
                res1:4,
                cwr:1,
                ece:1,
                urg:1,
                ack:1,
                psh:1,
                rst:1,
                syn:1,
                fin:1;
#else
#error  "Adjust your <asm/byteorder.h> defines"
#endif
        __be16  window;
        __sum16 check;
        __be16  urg_ptr;
};
```

File: /usr/include/linux/tcp.h

```
struct udphdr
{
  __extension__ union
  {
    struct
    {
      u_int16_t uh_sport;
      u_int16_t uh_dport;
      u_int16_t uh_ulen;
      u_int16_t uh_sum;
    };
    struct
    {
      u_int16_t source;
      u_int16_t dest;
      u_int16_t len;
      u_int16_t check;
    };
  };
};
```

File: /usr/include/linux/,
/usr/include/netinet/udp.h

Code Walkthrough

- Packet Snooping on Linux
- Receive all IP packets on a specific Ethernet interface
- Parse the packet
- Print all the IP header fields
- Identify the type of transport protocol
- Print specific transport protocol fields (TCP/UDP/SCTP)
- Build: **make**
- Final binary: **rawSocket**
- Execution: **sudo ./rawSocket <n/wk interfacename>**
- Example: **sudo ./rawSocket wlp2s0**

UDP Chat - Demo

- Execution: **sudo ./rawSocket <n/wk interfacename>**
- Example: **sudo ./rawSocket wlp2s0**
- Receive a UDP chat message and send a reply message on raw socket.

Task 1 - DNS Packet Parser

Using the RAW socket program shared, identify the DNS packets received on your interface. Print various fields of DNS like identification, query/response, type of query/response, number of different records (like question, answer, authority, resource).

Use dig/your own DNS client to send the DNS query to your local configured virtual IP

E.g: Dig @192.168.1.22 rawsocket.tut

Add screenshots of your execution along with your source files. If you are adding a new source file add it to Makefile to include it for build.

The code should be successfully built with existing instructions only. There is no need to change the final binary name. If you do, add a readme in your submission.

Task 2 - DNS Client with RAW Socket

Using the RAW socket program shared, build your own DNS client to send a simple DNS A Record query. Use the DNS packet parser from Task 1 to print the query details at the other end.

Add screenshots of your execution along with your source files. Add a short readme in your submission explaining details of building and executing your client program.

Report Submission

- Prepare a report including Task1 and Task2 with specific details asked in individual tasks' slides. Add relevant screenshots of the execution showing the respective output.
- Submit it to google classroom

References

- $man 7 raw
- Chapter 8 Security in Computer Networks from COMPUTER NETWORKING A Top-Down Approach Kurose and Ross
- Guide to IPsec VPNs Recommendations of the National Institute of Standards and Technology
- https://wiki.openssl.org/index.php/EVP
- https://man7.org/linux/man-pages/man7/netdevice.7.html
- https://www.wireshark.org/

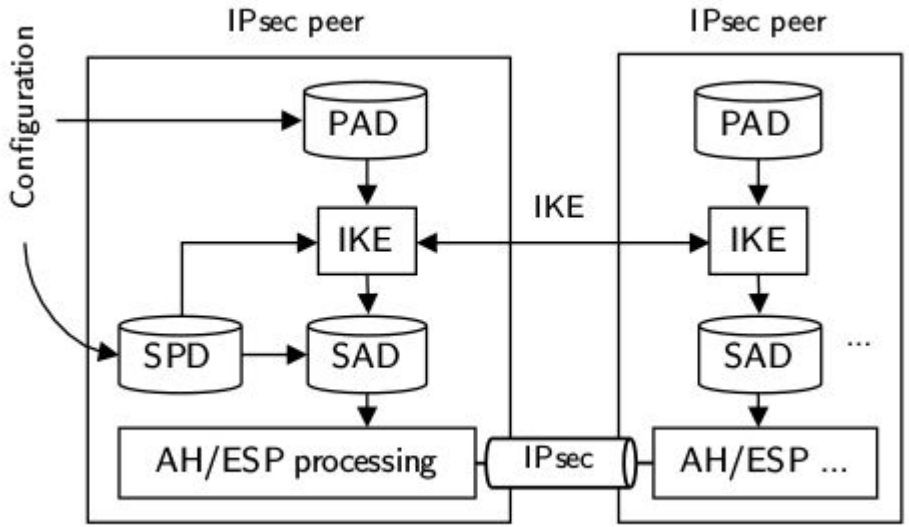
- NOTE: A protocol of IPPROTO_RAW implies enabled IP_HDRINCL and **is able to send** any IP protocol that is specified in the passed header. **Receiving of all IP protocols via IPPROTO_RAW is not possible using raw sockets.**

Assignment- IPSec

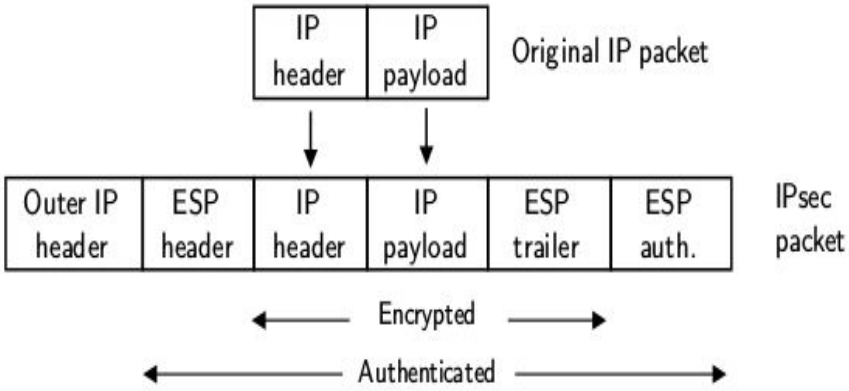
- IP security protocol
- Used for network layer security
- Ensures private communications over public networks.
- Typically used to host VPNs
    - Secure communications mechanism for data and control information transmitted between networks.
    - Protection Mechanisms
        - Confidentiality,
        - Integrity,
        - Data origin authentication,
        - Replay protection
- Secures IP Datagrams between
    - Site to Site
    - Host to Site
    - Host to Host

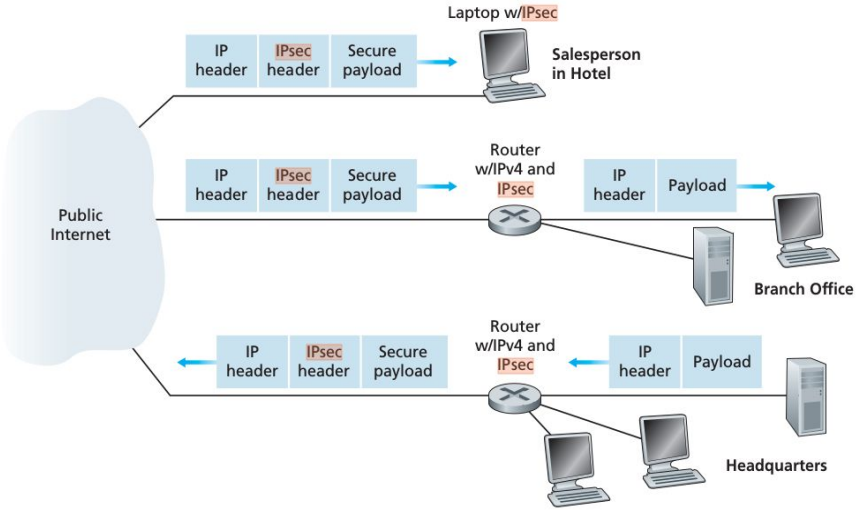
IPSec Peer Communication

- Secure Association (SA) between IPSec Peers
- IKE: Internet Key Exchange before secure exchange of data on IPSec
  - Two phases
  - Key Exchange and session key establishment
  - SA creation
  - Successor: Internet Key Exchange v2
- IPSec Modes
  - Tunnel Mode
  - Transport Mode
- IPSec Protocols
  - ESP
  - AH
- IPSec Databases
  - SPD
  - SAD

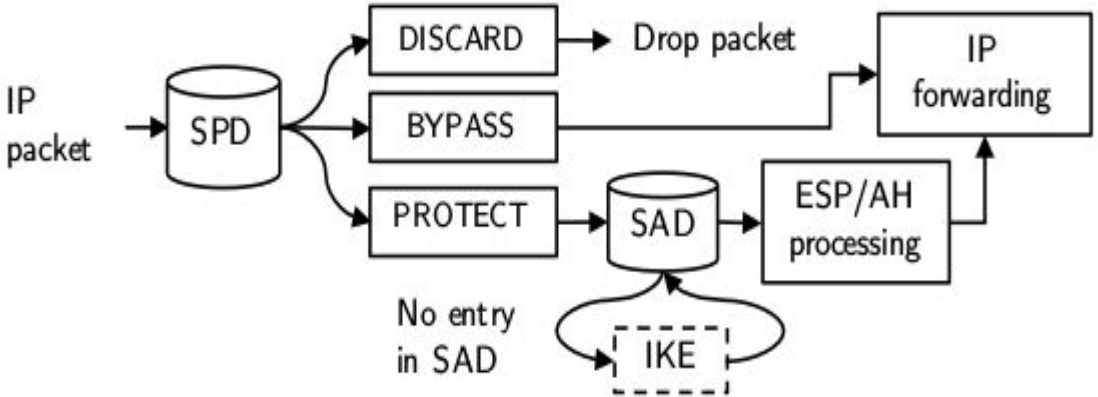


IPSec Packet Structure





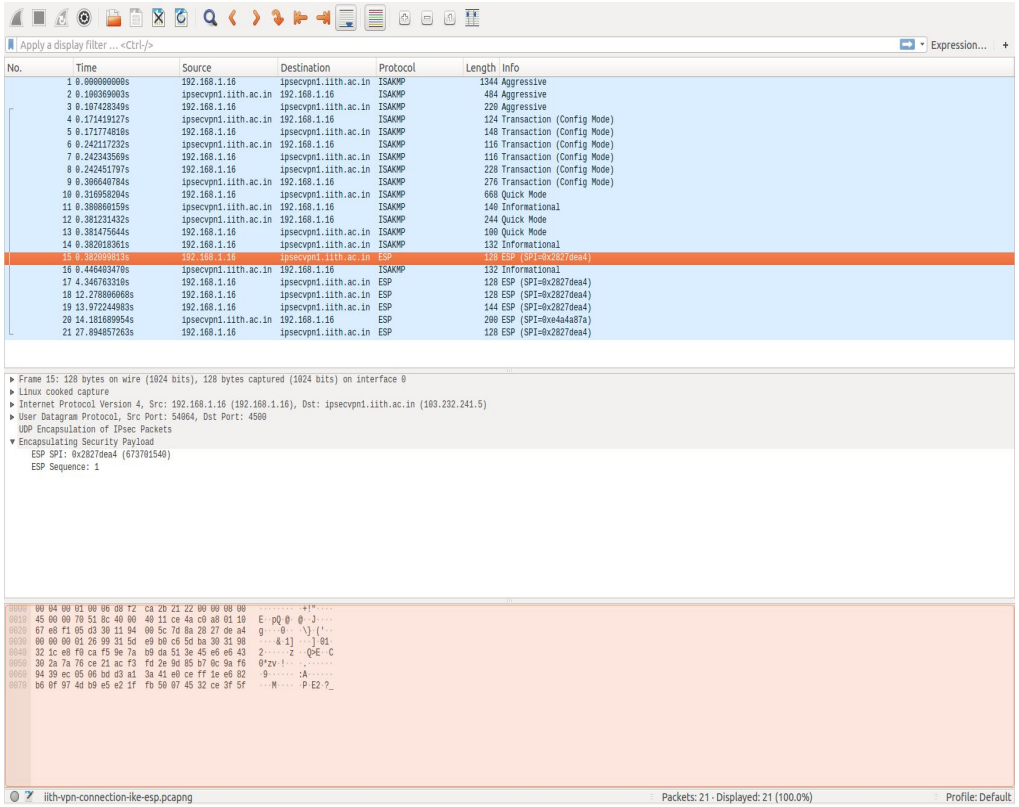
IPSec Packet Processing



Helper Exercise 1 - OPENSSL APIs

- Demonstration of confidentiality with client-server execution
- Libraries: crypto, pthread and booost_system
- openssl version 1.1.1
- Build
  - g++ client.cpp -o oclient -lcrypto -lpthread -lboost_system
  - g++ server.cpp -o oserver -lcrypto -lpthread -lboost_system
- APIs from https://wiki.openssl.org/index.php/EVP
- Dependency Installation
  - sudo apt-get install libssl-dev
  - Boost Installation

IPSec Packet Capture



- Wireshark Filters
  - ESP
  - ISAKMP

Helper Exercise 2 - IPSec Packet Format

Capture traffic on Wireshark for 1-2 minutes, when connecting to IITH VPN. Observe the involved IPSec related packet exchange by placing appropriate packet filters.

- IKE Packets
- IPSec packet format
- Data encrypted