Università di Roma “Tor Vergata”

Traffic Flow Confidentiality in IPsec: Protocol and Implementation

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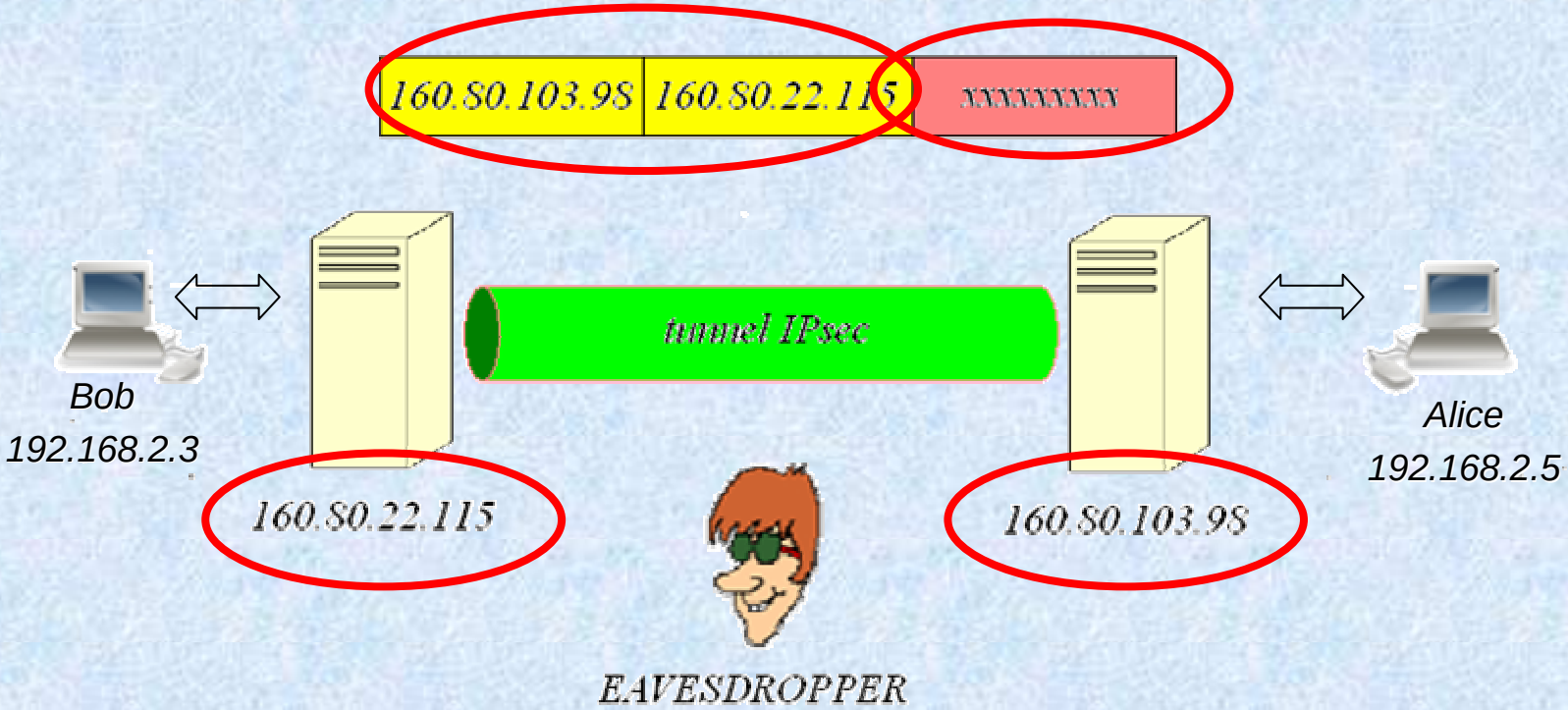
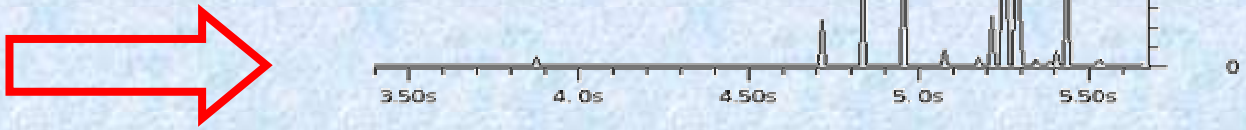
Malicious Traffic Analysis

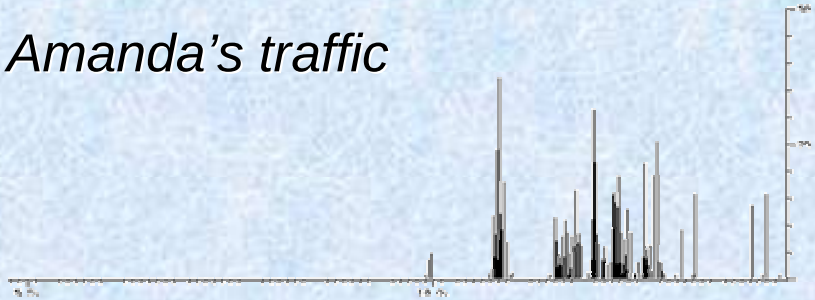


- **Length**
- **Arrival time**
- **Packets direction**



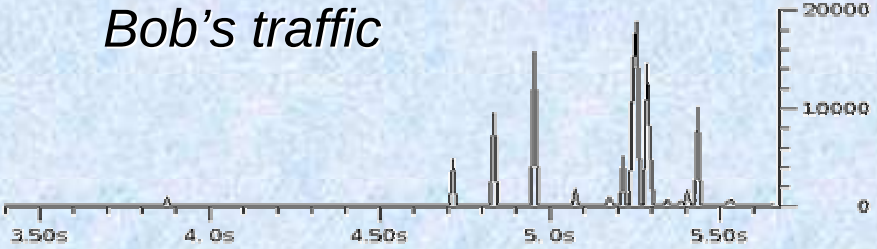
Source-Destination Link

Amanda's traffic

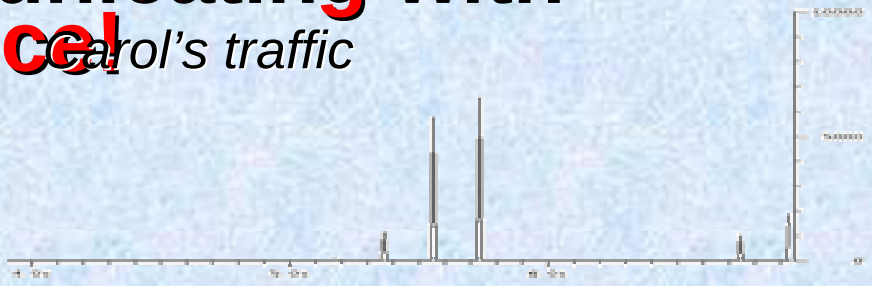


Bob is communicating with Alice!

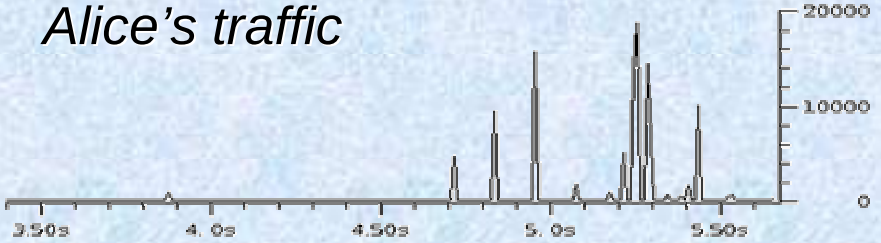
Bob's traffic



Carol's traffic

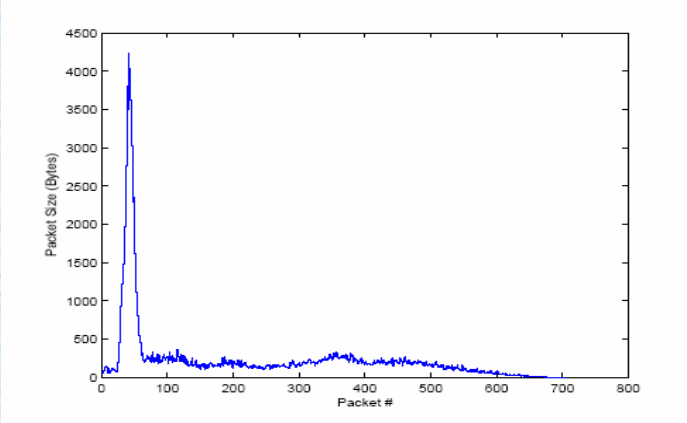


Alice's traffic

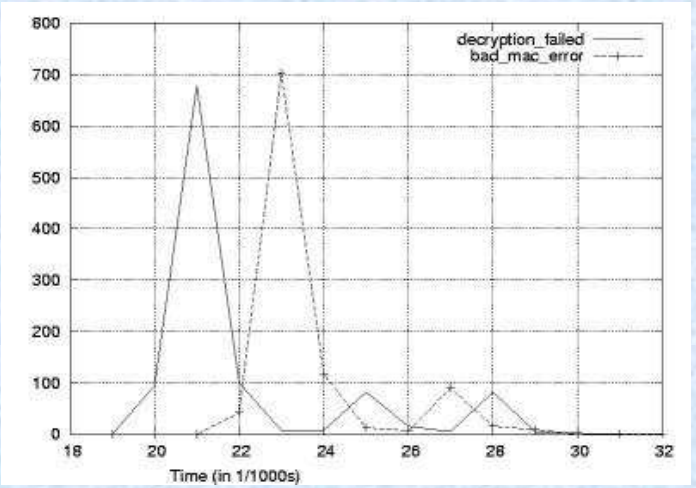


User information recovery

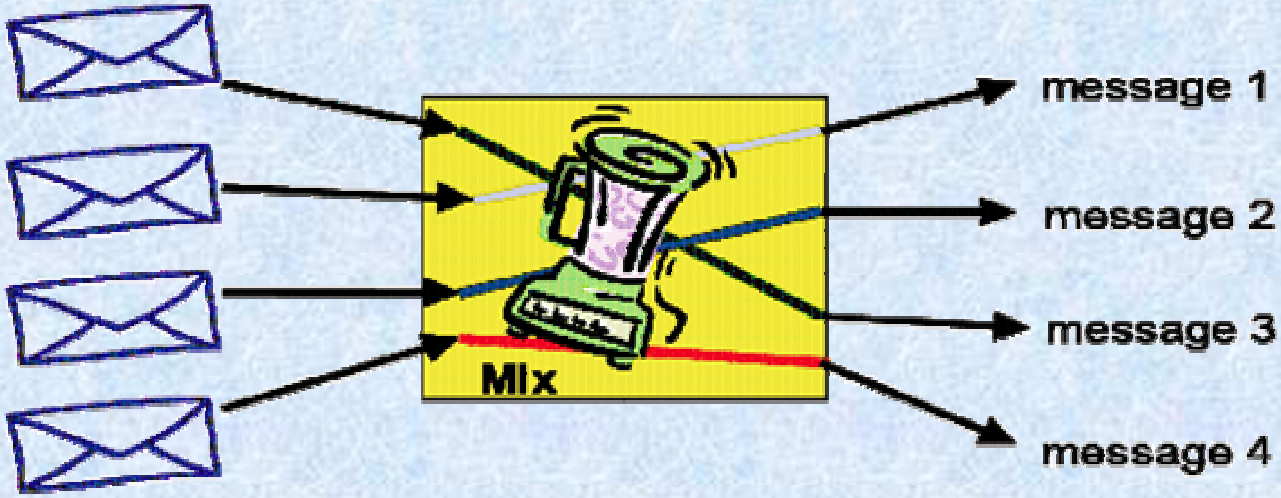
- Website fingerprinting
  - E.g. sample size profile for www.amazon.com
  - Bissias, Liberatore, Levine “Privacy Vulnerabilities in Encrypted HTTP Streams”



- Password recovery
  - Canvel, Hiltgen, Vaudenay, Vuagnoux, “timing-based attack to Intercept passwords in a SSL/TLS Channel”
    - Different log-in error are characterized by different server’s answer times
    - http://www.brice.info/crypto



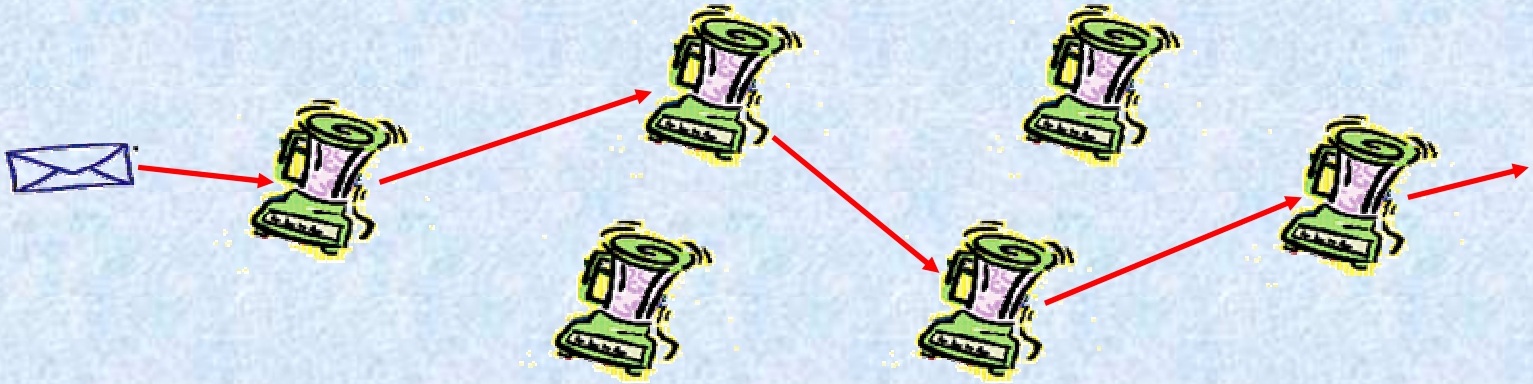
MixNet basic ideas



Messages:

- wrapped in fix length packs
- grouped and sent in lexicographical order
- in/out correspondence hidden by mix

- "Untraceable Electronic Mail, Return Addresses, and Digital Pseudonyms," D. Chaum
- Employs a “network” of mixes to avoid the need of a single trusted one

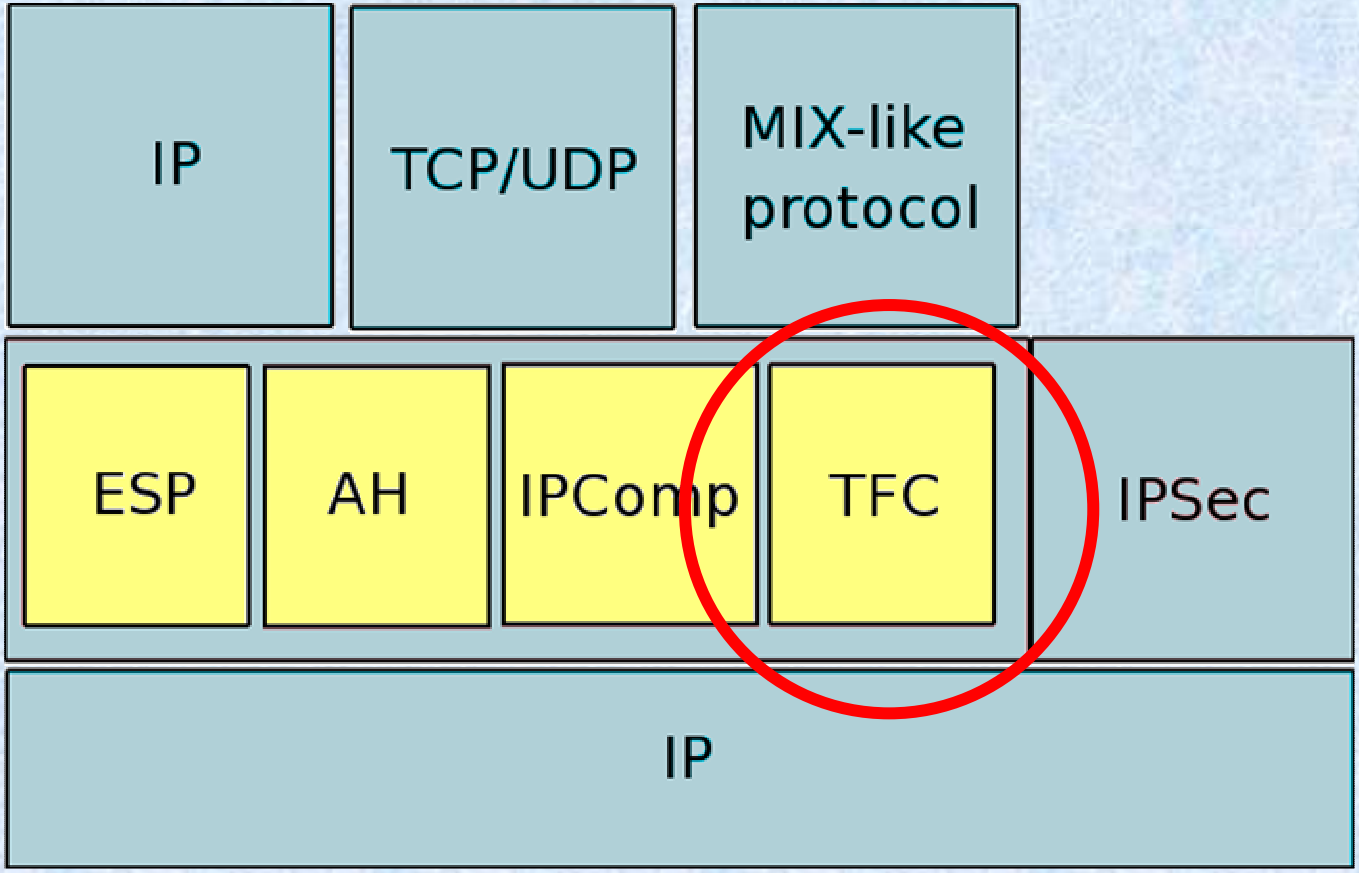


Goals

Our goals is to provide a tool:

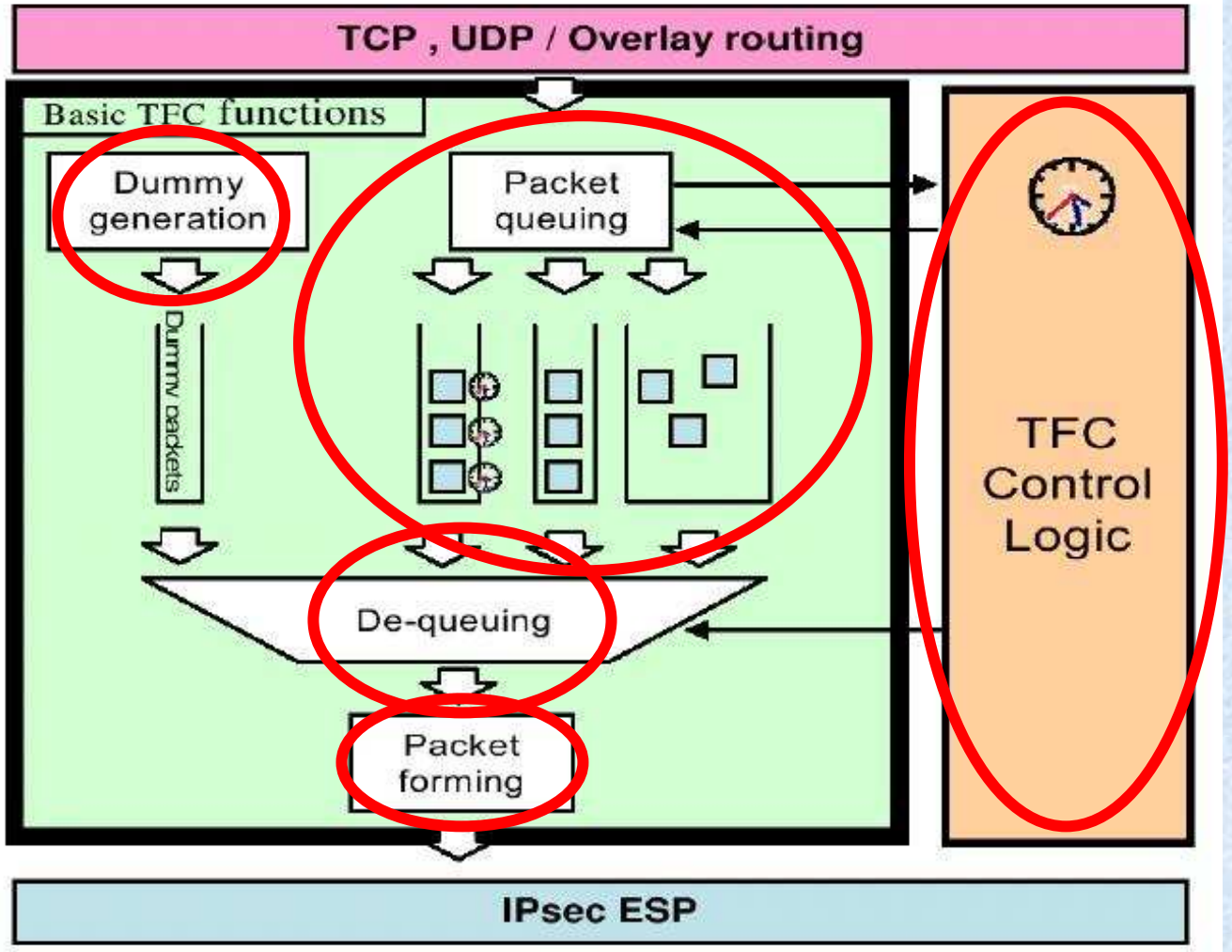
- implementing the basic mechanisms to prevent statistical traffic analysis attacks
  - Dummy traffic
  - Packets padding
  - Traffic re-shaping
- Flexible
- Reconfigurable
- Reprogrammable
- Based on common standard
  - IPsec
- Providing a underlying layer for the Anonymous Routing Networks
  - Supporting different kind of traffic

Traffic Flow Confidentiality Protocol



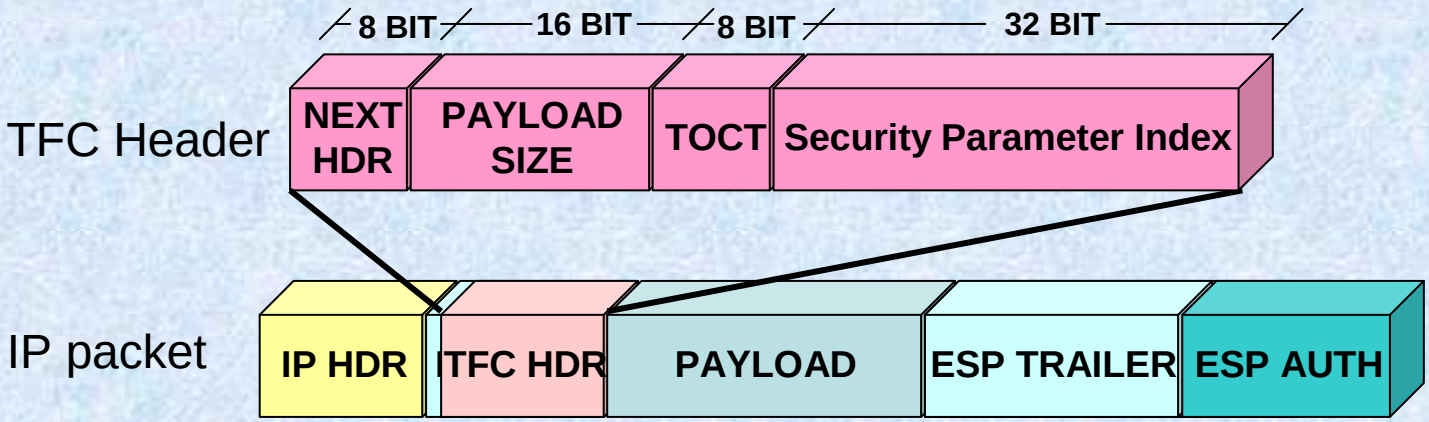
TFC, like ESP and AH, can be managed exploiting the instruments Offered by IPsec (SA, SAD, SPD, …)

TFC architecture



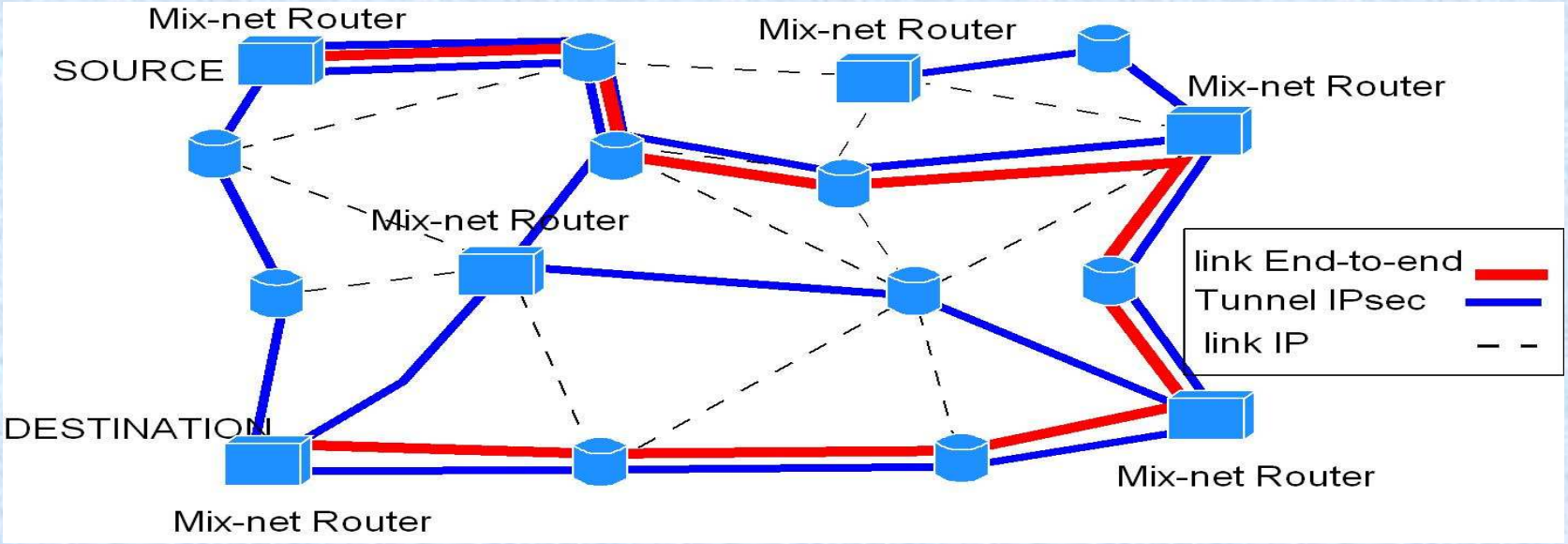
TFC Header

- TFC protocol header contains
  - Security Parameter Index (SPI)
  - Protocol transported
  - Size of the data
- The header is inserted between the ESP header and the payload
- The padding is added between the payload and the trailer ESP



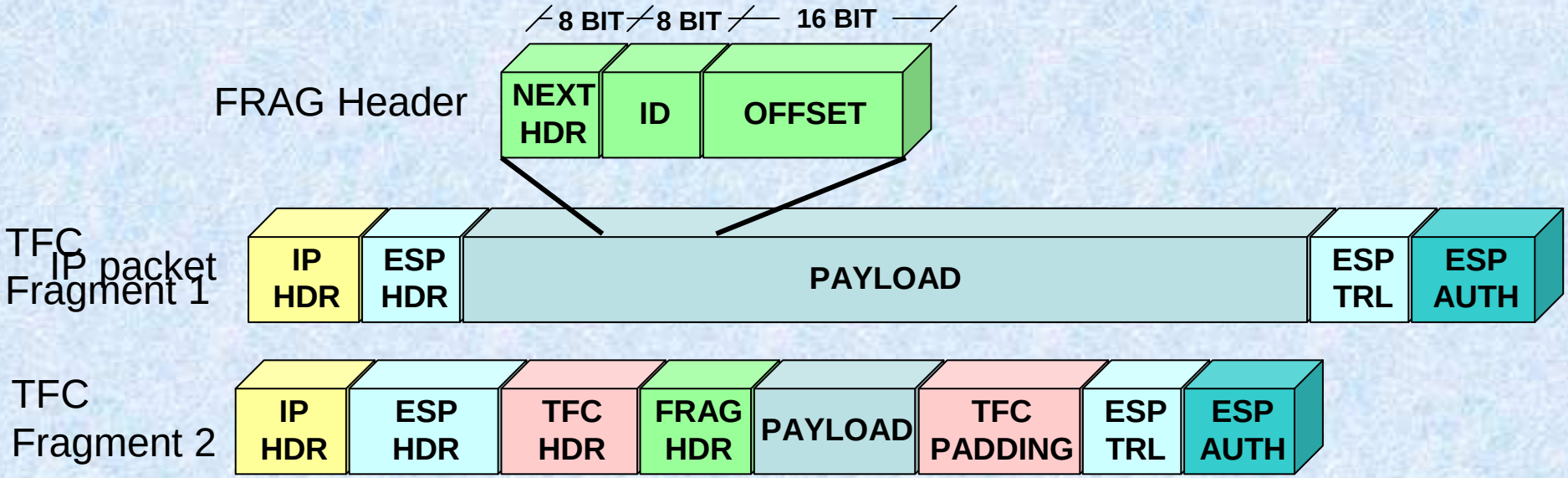
TOCT- Type of Confidentiality Treatment

- TOCT (Type of Confidentiality Treatment)
  - carry information about the type of treatment the packet may be subjected to
  - used in a multi-hop fashion, and especially for building IPsec-based Mix Networks.
- Still to evaluate information disclosed!!

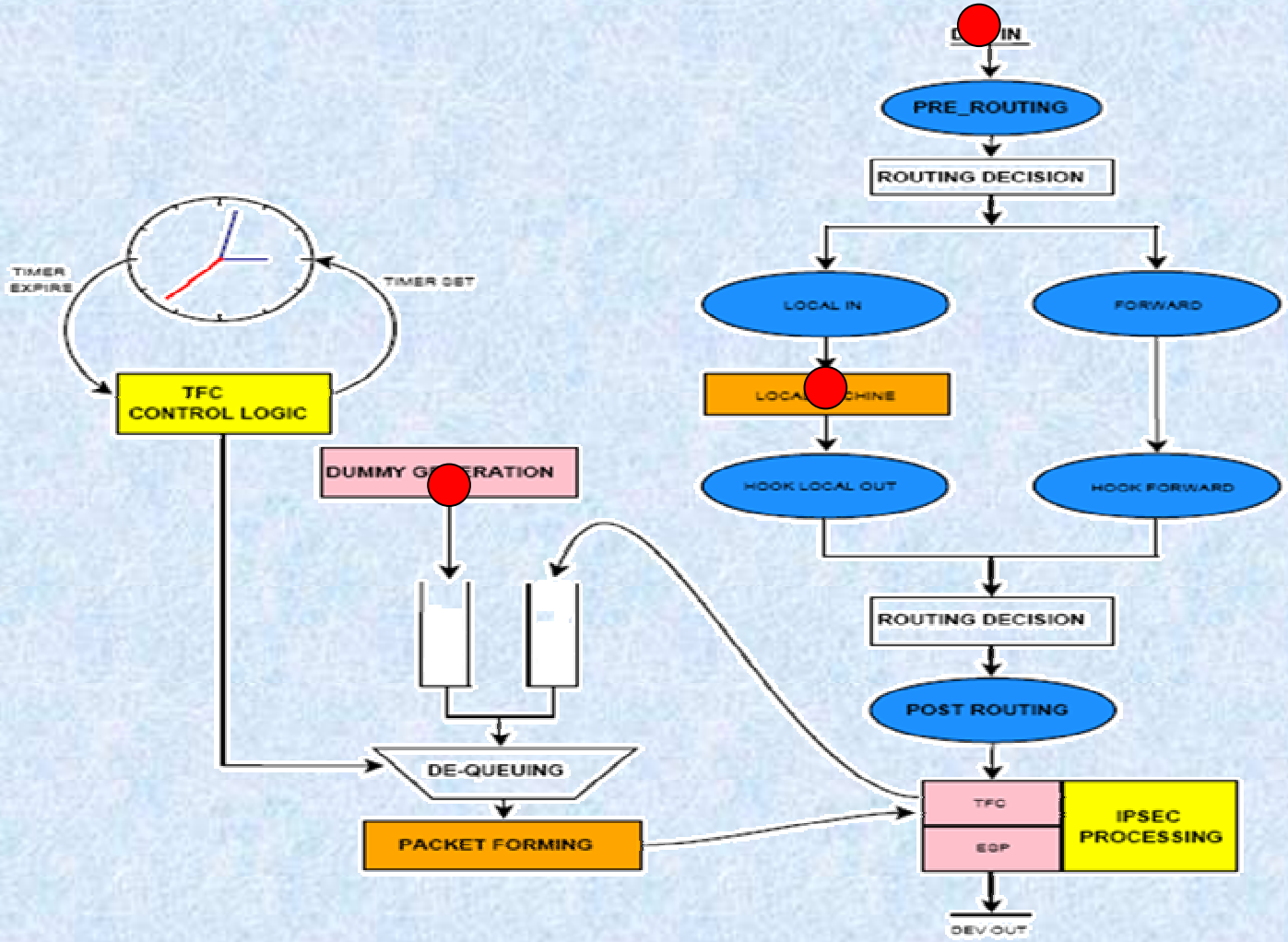


Packets fragmentation

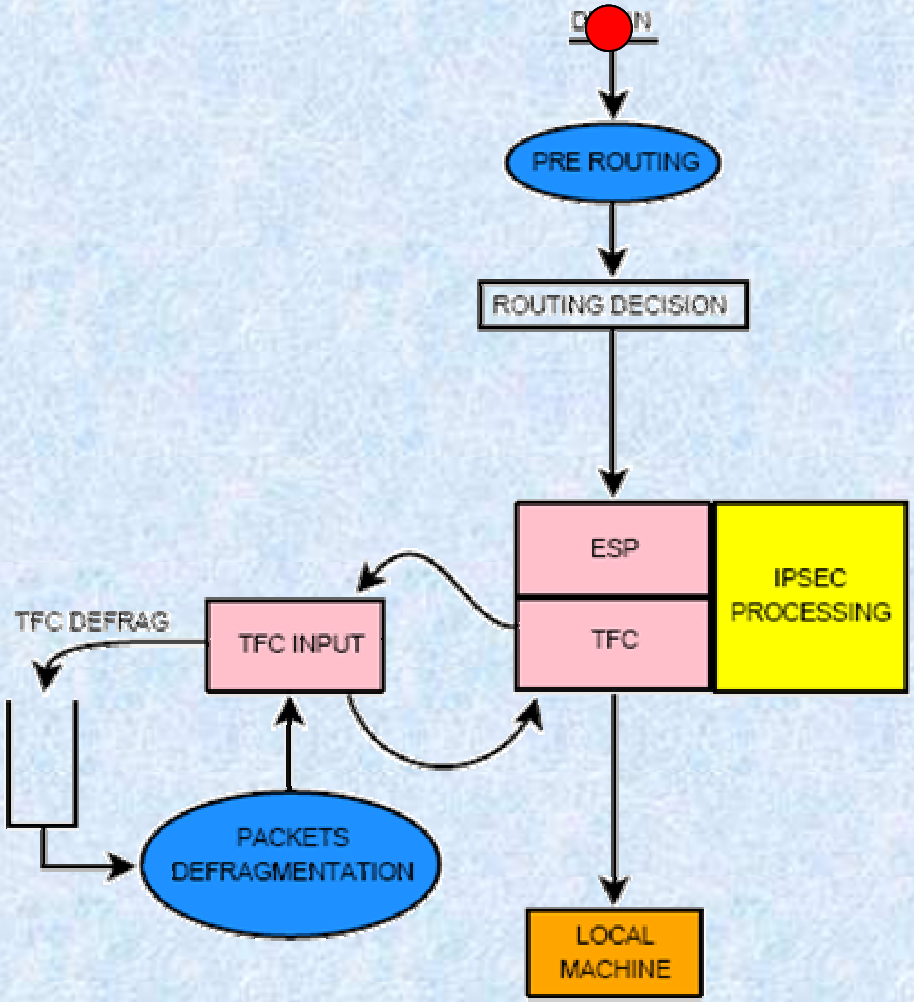
- It has been necessary to add an extension header (FRAG)
- If needed the last fragment is padded



Packets Output Stack



Packets Input Stack

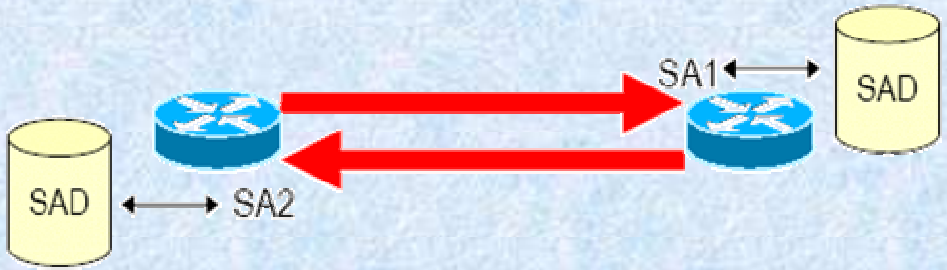


Control Logic

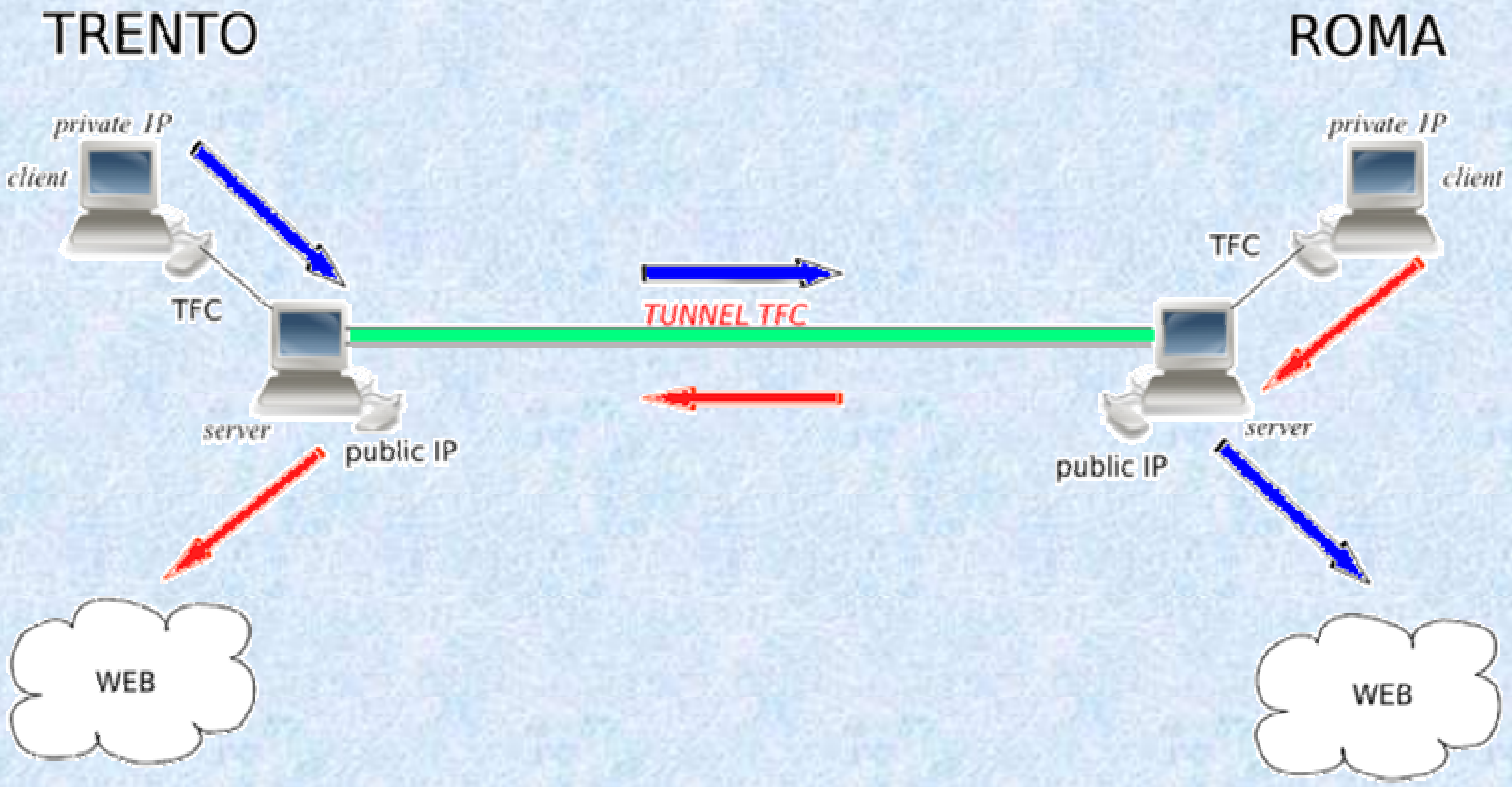
- The "control logic“ is the "intelligence" of the system
- It can combine the TFC basic mechanisms arbitrarily:
  - batching,
  - CBR (Continuous Bit rate),
  - random padding,
  - random delay algorithms
  - Queue congestion Reactive algorithm (still experimental)
- Simple methods (fixed or random packet clocking), may be easily replaced by more complex algorithms
  - Able to take into account the status of the queues and/or the congestion level
- The effectiveness of such adaptive approaches in terms of performance/privacy gains and trade-offs is still to be assessed

TFC SA parameters

- A User Space application allows to configure TFC SA parameters
  - Delay Algorithm
  - Dummy
  - Padding
  - Fragmentation
  - Packets Length
  - Bit Rate

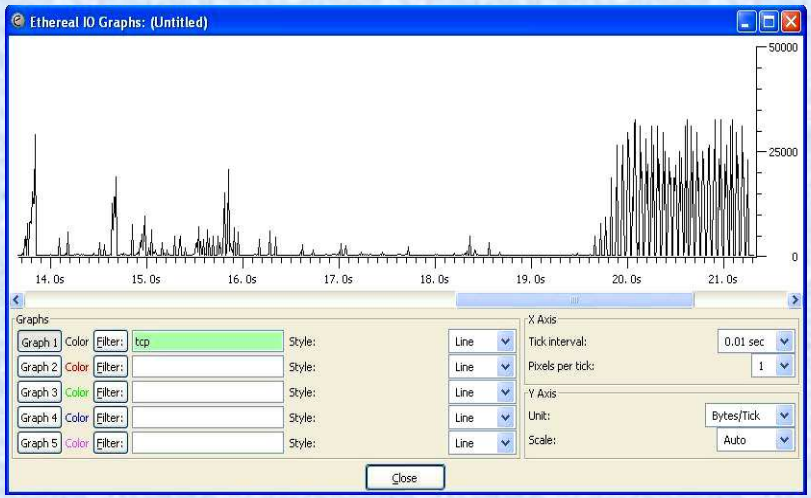


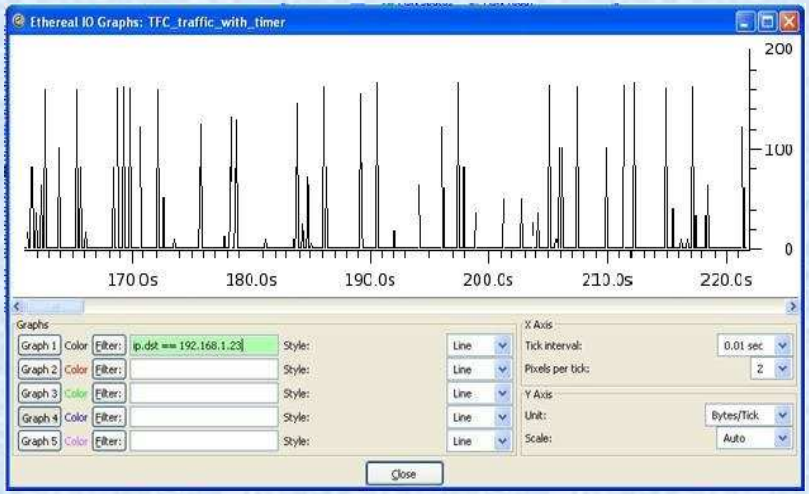
Test over Public Network
Tunnel Roma - Trento



TFC flows sample

- We tested the TFC basic mechanisms modifying the statistical characteristics of a Data flow, in order to obtain a Random Bit Rate, CBR (constant bit rate) traffic.



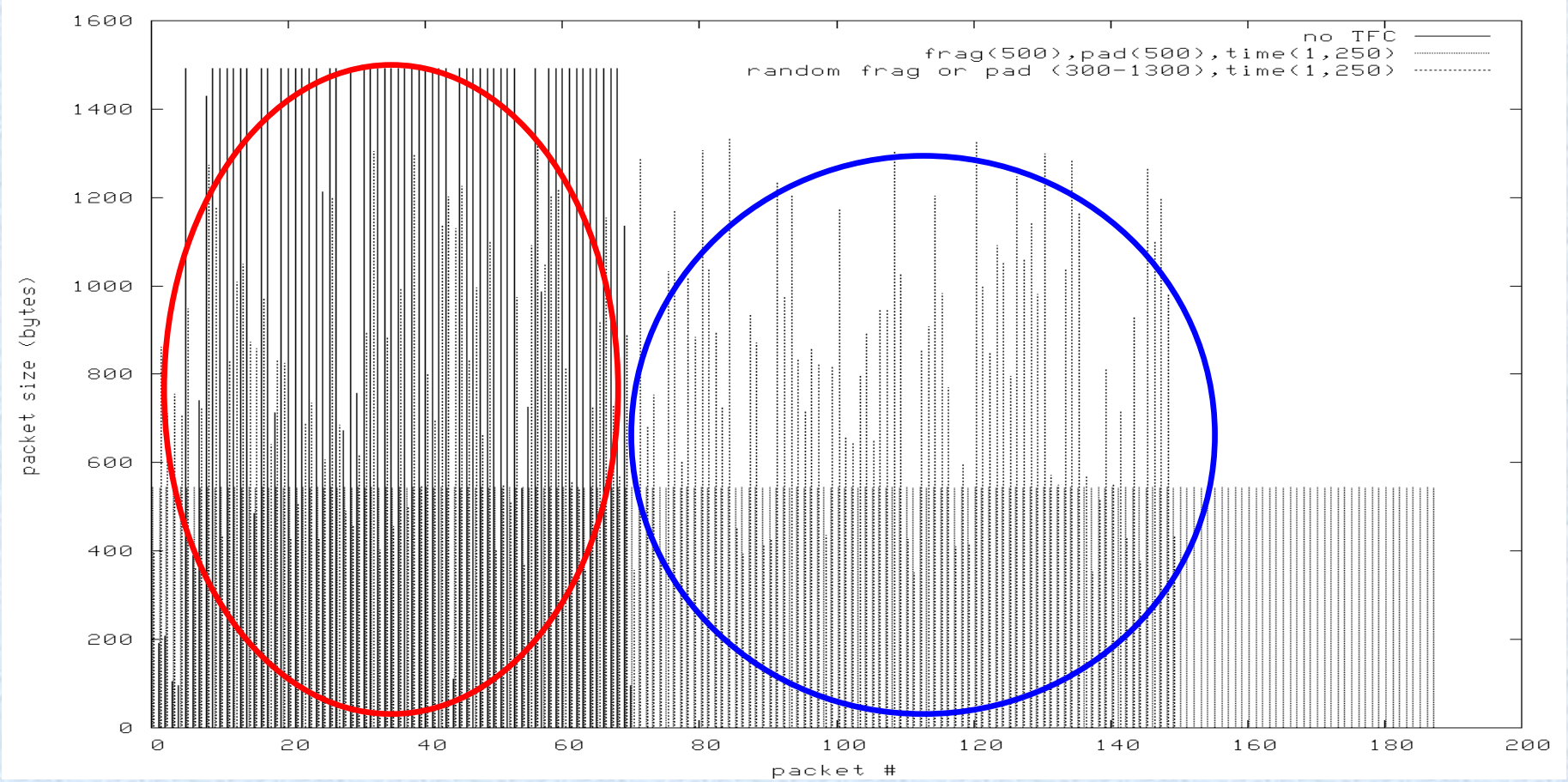


Protocol fingerprinting

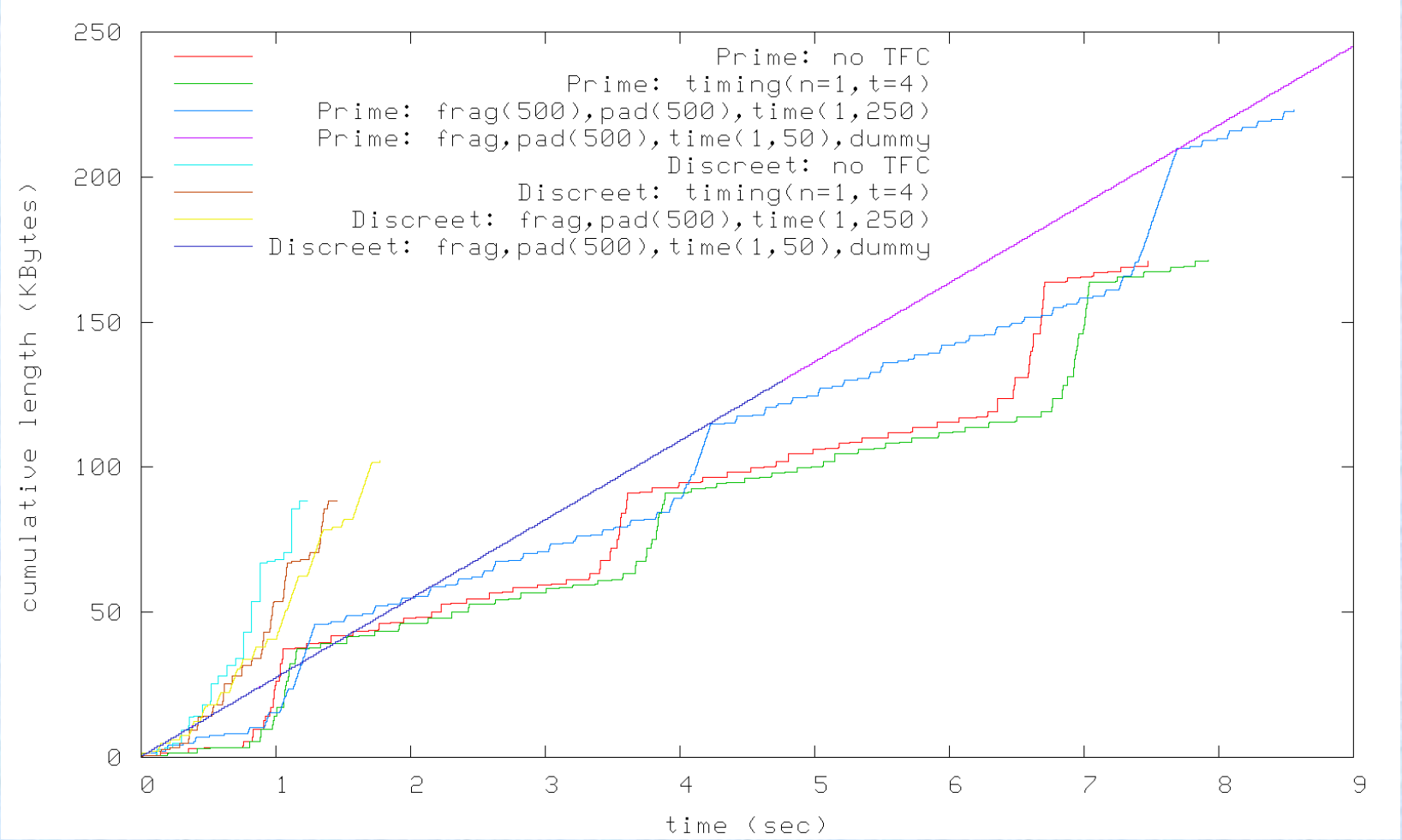
- Accurate flow classification exploit its very first packets
  - Length (L. Bernaille, R. Teixeira, and K. Salamatian, “Early Application Identification”, Proceedings of The 2nd ADETTI/ISCTE CoNEXT Conference, Portugal, 2006)
  - Inter-arrival time (M. Crotti, F. Gringoli, P. Pelosato, L. Salgarelli, “A statistical approach to IP-level classification of network traffic”, IEEE ICC 2006, 11-15 Jun. 2006)
- TFC tunnels avoid classification since
  - Packets are padded
  - Delay algorithms modify packets inter-arrival time
  - Different application flows can be multiplied on the same TFC SA.

Flows correlation

- The Discreet page downloads in 1.3 seconds and generates 88 Kbytes of traffic. The same download with CBR TFC takes 4.7 seconds and 130 KBytes



Web site fingerprinting

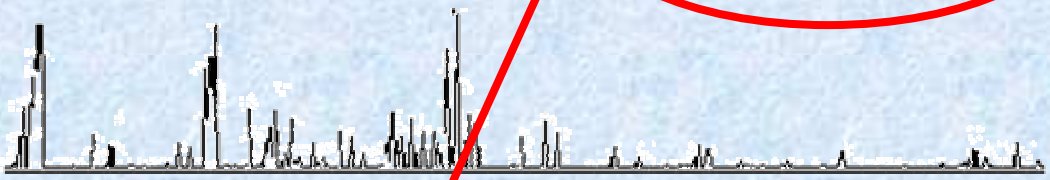


Conclusion

- The TFC IPsec security service provides effective protection against statistical traffic analysis techniques
- We introduces fragmentation and packet inter-arrival time variation to balance the protection-performance tradeoff
- We are evaluating how to increase the protection-performance tradeoff exploiting more complex control algorithms
- We are planning to include in the basic tools packets multiplexing

Malicious Traffic Analysis

client
192.168.100.45



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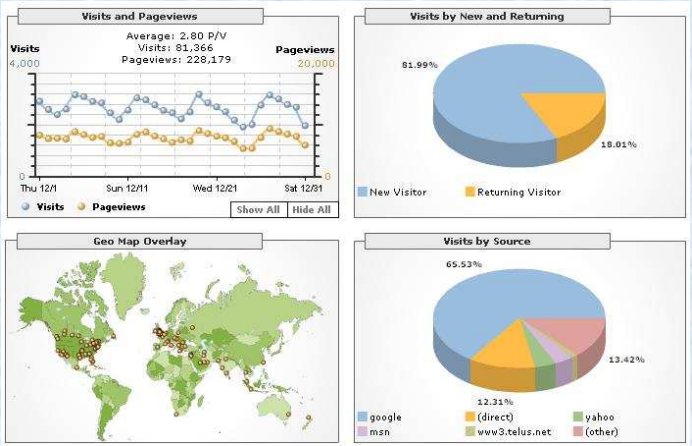
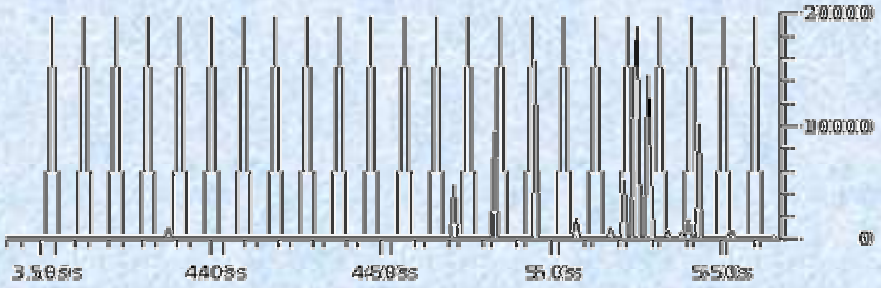
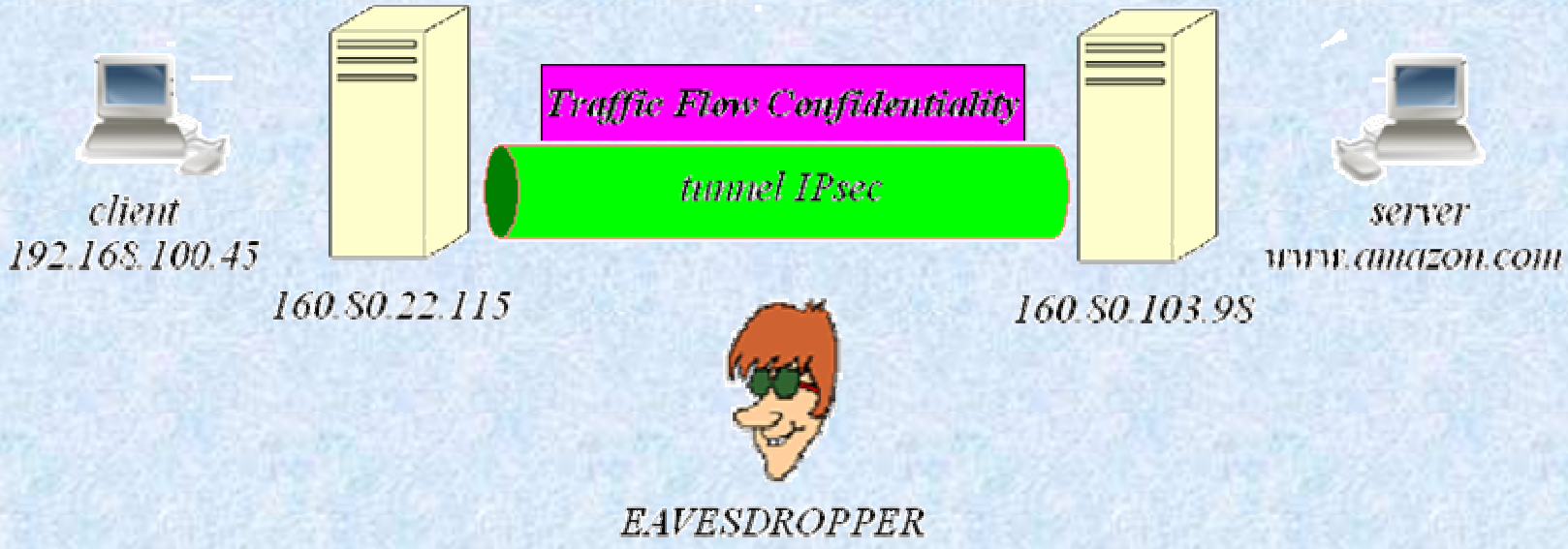
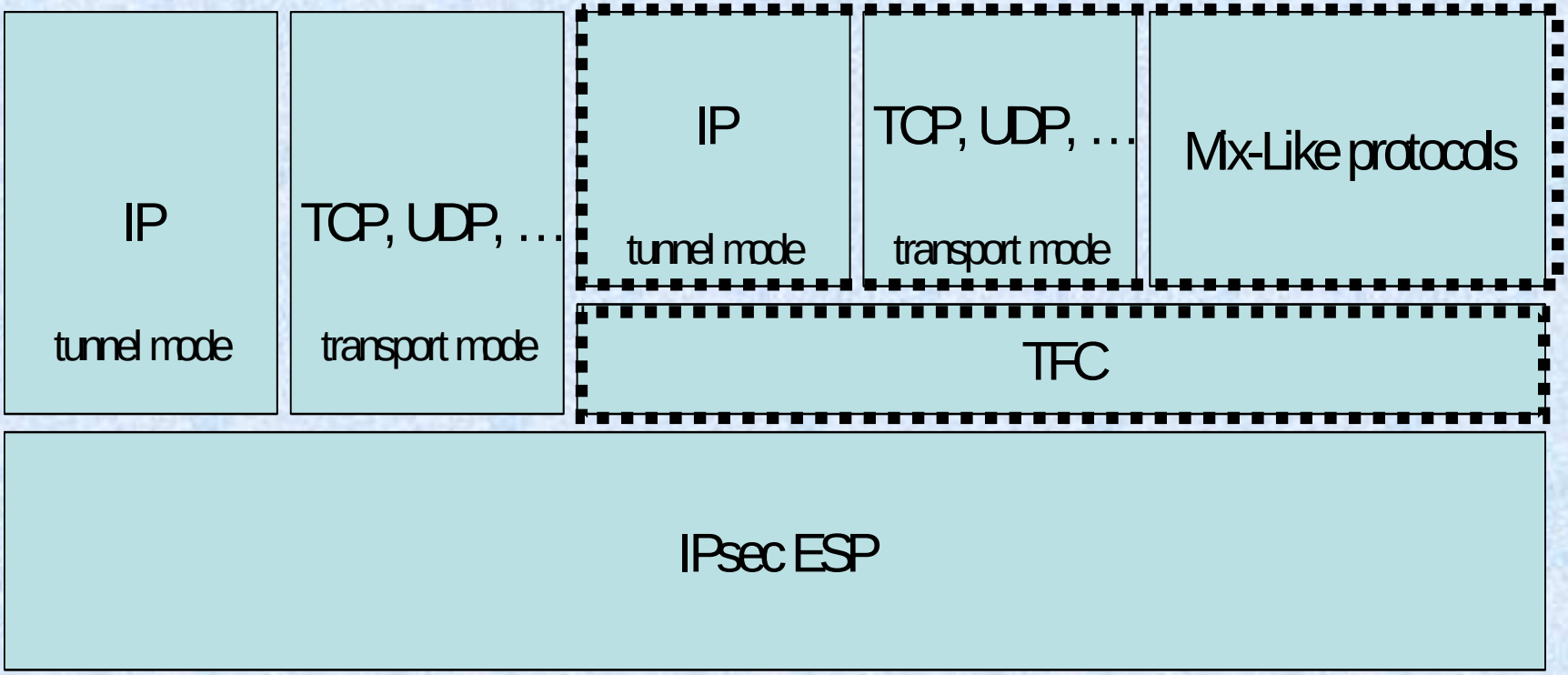


Traffic Flow Confidentiality

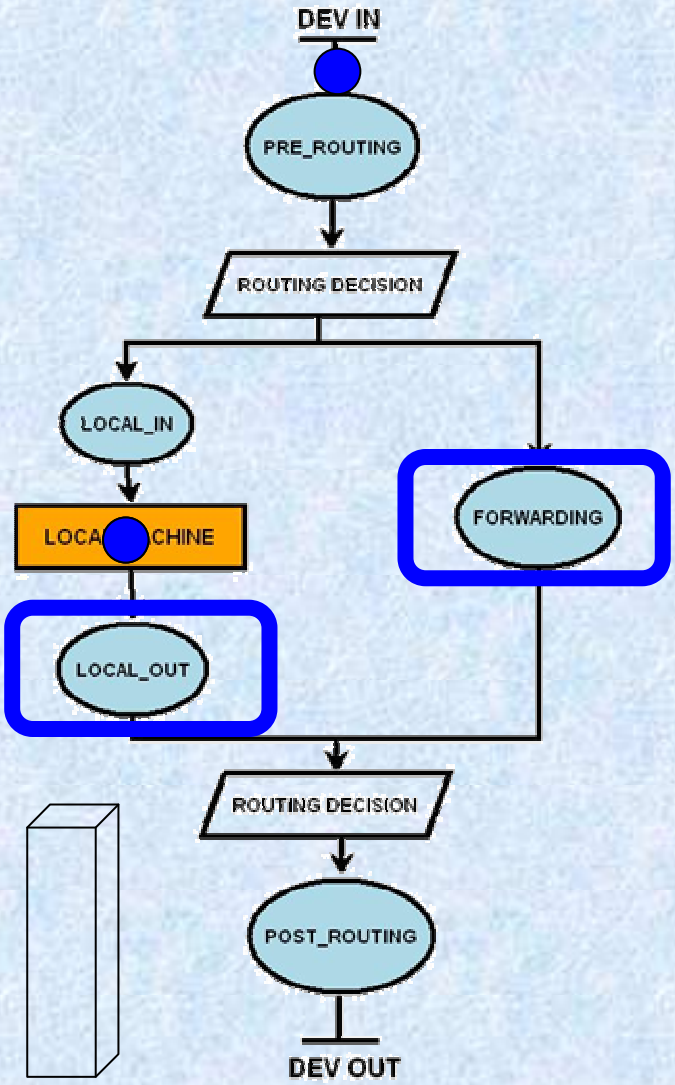




Traffic Flow Confidentiality



Output Stack



Dummy packets

- A timer is associated to each queue. When the timer expires, a packet from the head of the queue is sent and the next timer is set
- If the queue is empty, we create a new dummy packet (IP protocol = 59) and send it
- Since the queue is situated before IPsec encryption, dummy packets are sequentially encrypted with data packets