# Signature Based Intrusion Detection Systems

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# Intrusion Detection Systems

### Detect malicious activities/attacks

- Hacking/ unauthorized access
- DOS attacks
- Virus/ Malware

### Raise alarms

- Alert administrators
- Trigger defense mechanism if available

### Log events

- For Forensics and security auditing

### React to attacks

- Disconnect attack channels
- Quarantine infected systems

# Network IDSs

- Monitors and analyzes data packets on a network to look for suspicious activity
- Large scale servers can monitor backbone network links
- Small scale systems can monitor local routers/switches
- Two major approches
  - Signature based (this lecture)
  - Anomaly detection based

# Signature Based IDS

## Advantages

- Simple to implement
- Lightweight
- Low false positive rate
- High true positive rate for known attacks

## Disadvantages

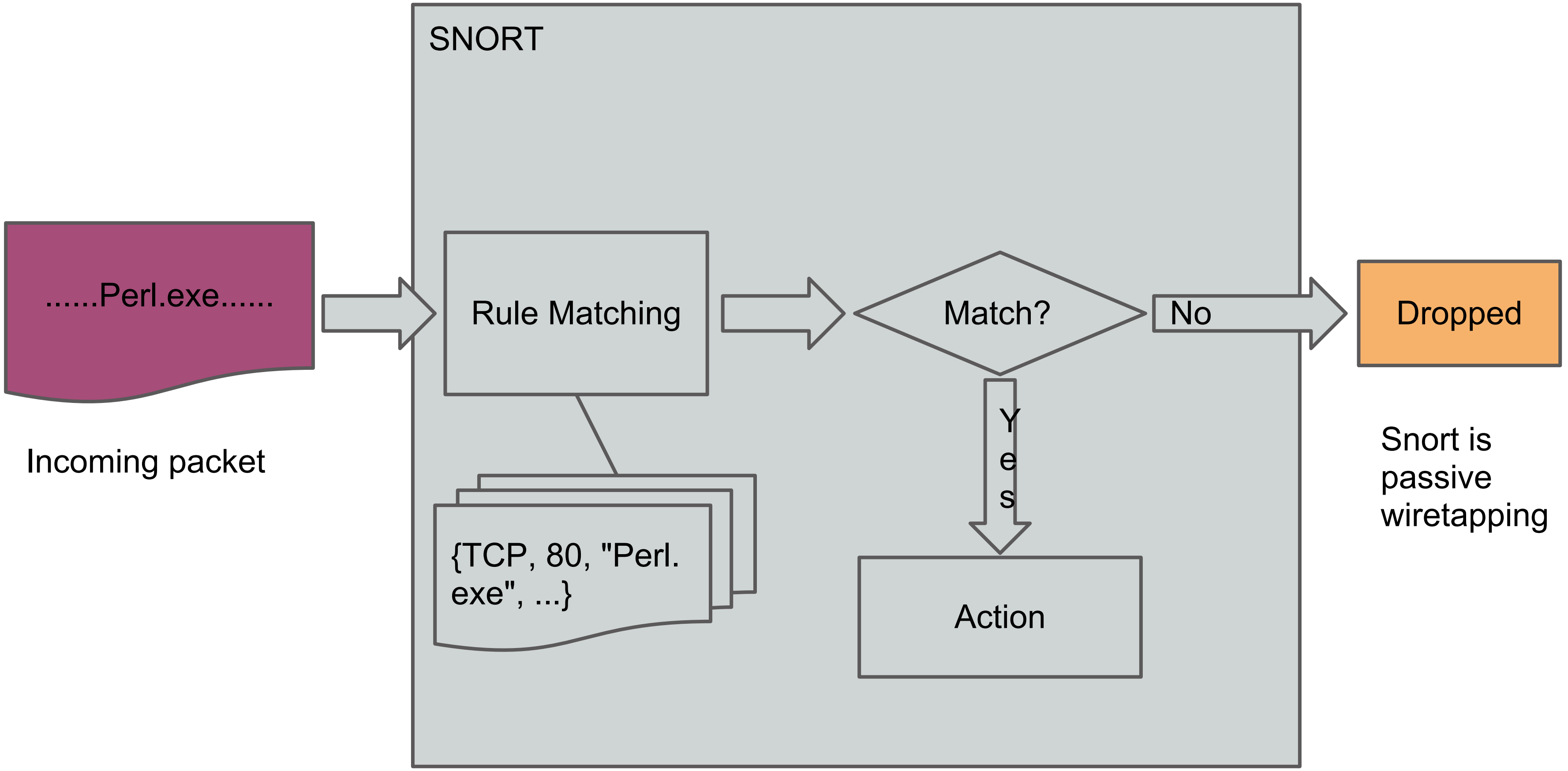
- Low detection rate for zero day attacks

# Signature Based IDS

Key Challenges

- Packet analysis is major bottleneck
    - How fast can signature string matching be done?
        - Exact string matching
        - Approximate string matching

# Example


SNORT
......Perl.exe......
Incoming packet
Rule Matching
{TCP, 80, "Perl.
exe", ...}
Match?
No
Dropped
Yes
Action
Snort is
passive
wiretapping

# Aho-Corasick Algorithm

- One pass multi-string matching
  - Can find all occurrences of any number of keywords in a string, in ONE pass
- Constructs a finite state string pattern machine
- Construction of state machine proportional to sum of lengths of keywords
- FSM input: text string

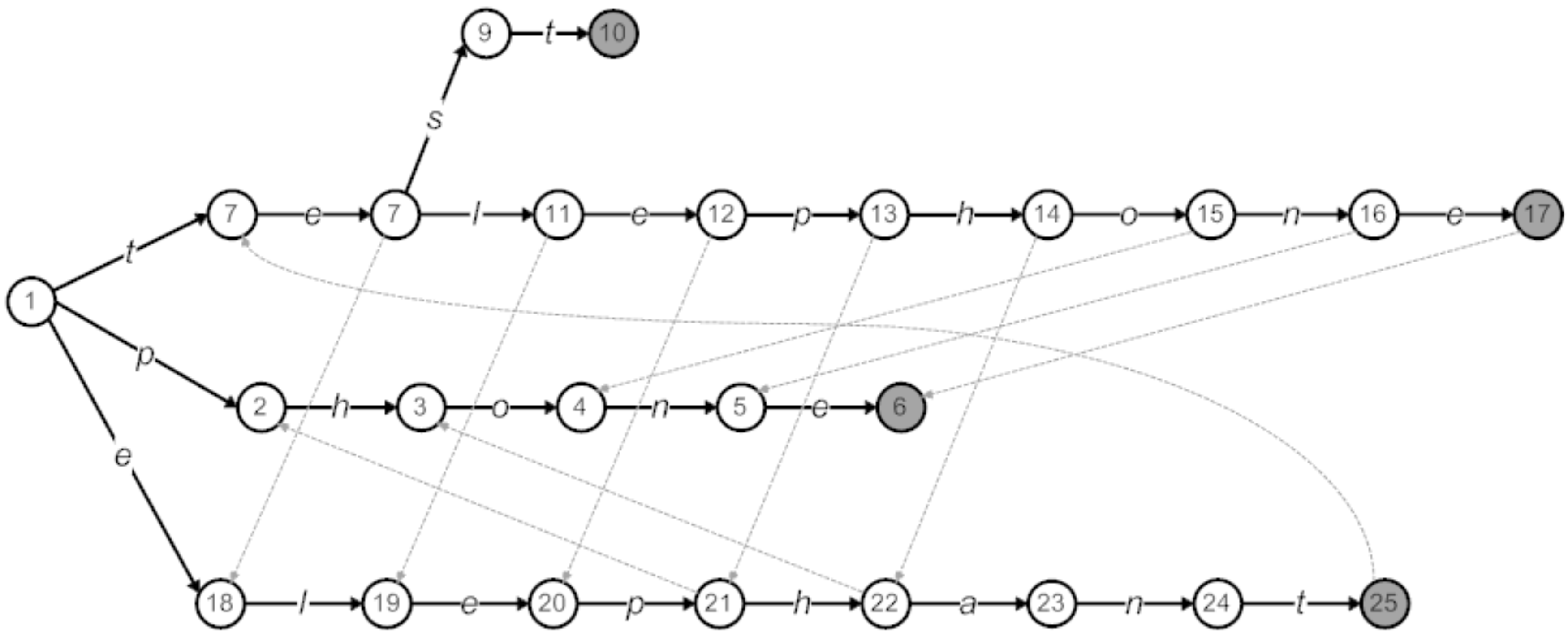
# Aho-Corasick Algorithm

- Naive approach
  - Assume keyword starts at byte 0 of payload, traverse trie
  - If failed, start from byte 1 and traverse, etc
  - Worst case: L * h
    - L : length of payload
    - h : height of trie

# Aho-Corasick Algorithm

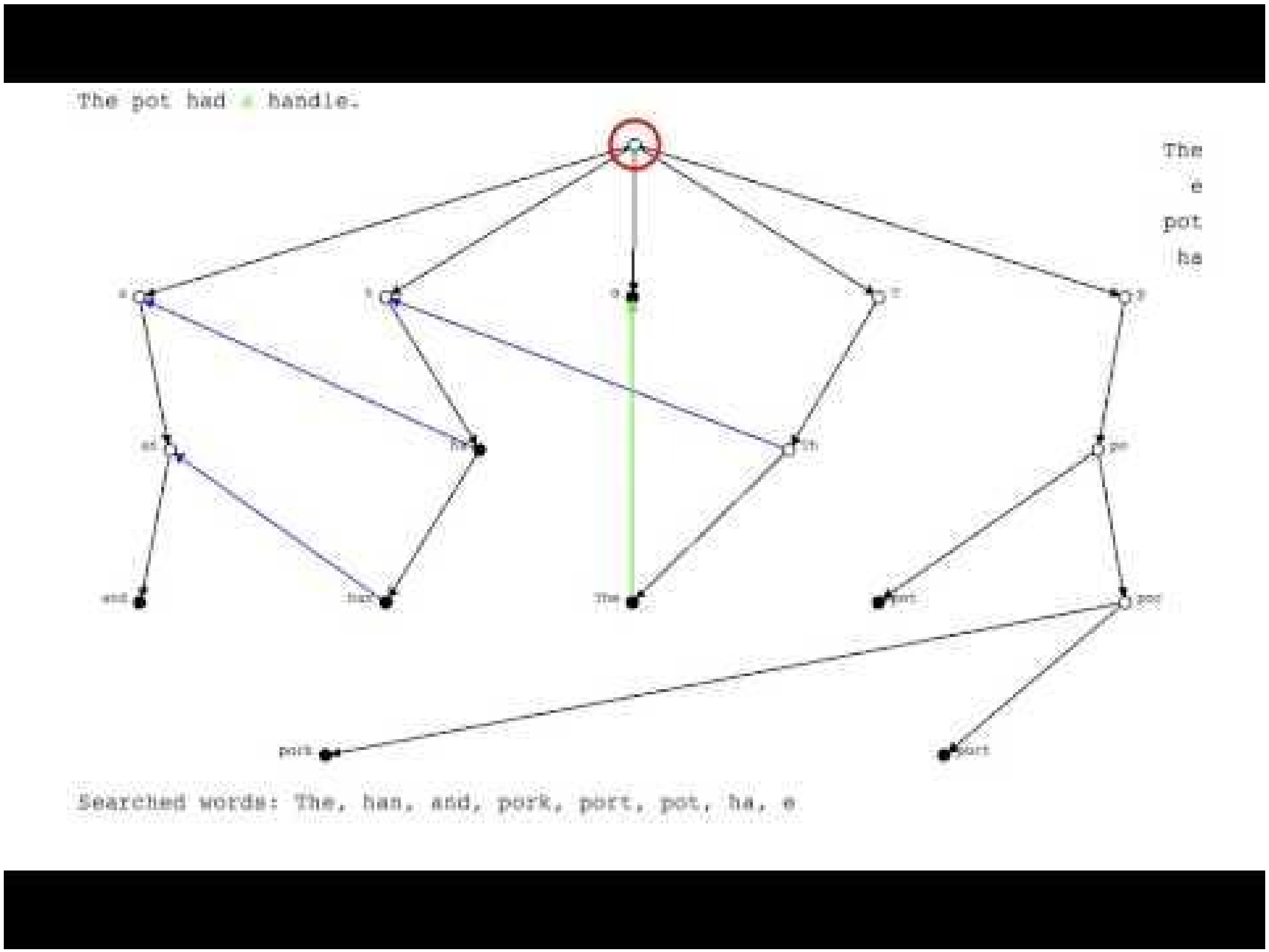
- Aho-Corasick
  - Computes internal failure pointers and suffix pointers
    - Eliminates needs to backtrack and restart at top of trie every time
  - Complexity: O(len(payload) + #pattern occurrences)
    - assuming FSM is precomputed offline

# Aho-Corasick Algorithm




- Keywords: {test, telephone, phone, elephant}
- Solid lines: Normal transitions
- Dotted lines: Failure transitions

# Aho-Corasick Algorithm



# Boyer-Moore Algorithm

- Fast one pass *single-string* matching
- Explicit character comparison at different alignments of keywords in payload
  - Keywords preprocessed
  - Skip as many alignments as possible
- Compare strings from END of keywords
- Usually very fast in practice
  - skips a large portion of characters
  - compared to Aho-Corasick which goes through whole string regardless

# Boyer-Moore Algorithm

- Shifting through alignments
  - Start with last char in keyword
  - Match: continue
    - All match: word found in payload
  - Not match: does char exist in keyword?
    - Yes: shift to that char closest to current position
    - No: skip whole string
  - Continue

# Boyer-Moore Algorithm

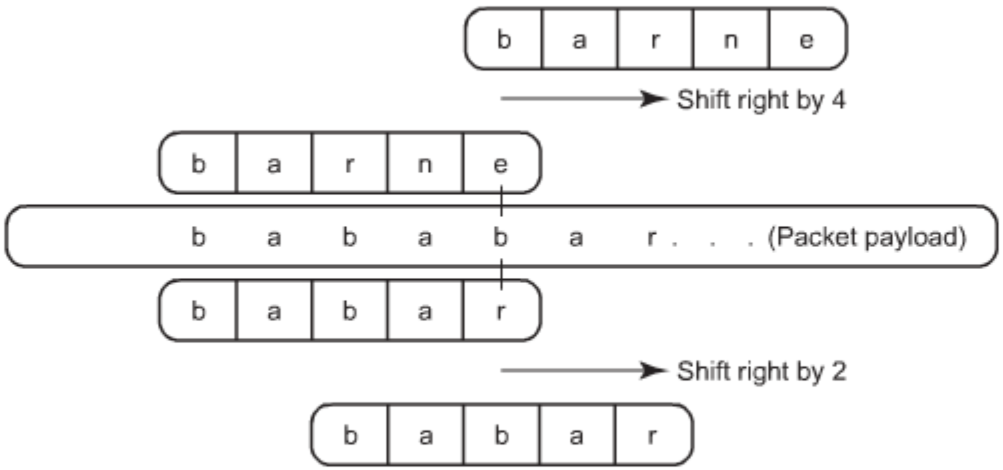



**FIGURE 17.3** Integrated Boyer–Moore by shifting a character.

- Slide keywords along payload
- Match compare from END of keywords
  - [Example]()

# Boyer-Moore Algorithm

- Concurrent  multi-keyword comparisons
    - Trunc all keywords to length of shortest keyword
    - Build trie in reverse (start from end of truncated keywords)
        - so concurrent comparison only requires current packet char to index into trie node
    - On success: continue down trie
        - If at leaf, check if truncated characters match
            - For small number of strings, this generally performs better than Aho-Corasick in implementation
    - On failure: shift by precomputed amount in failure pointer

# Performance

- In practice, Aho-Corasick and Boyer-Moore provides little performance improvement
  - Very little packets match a large number of strings/signatures
    - Naive method would generally also do well
  - More overhead due to code complexity
- However, large improvement for *worse-cast* traces
  - May be crucial from hardware perspective
- A lot of research in effort to enhance Aho-Corasick/Boyer-Moore to further improve performance

# Snort

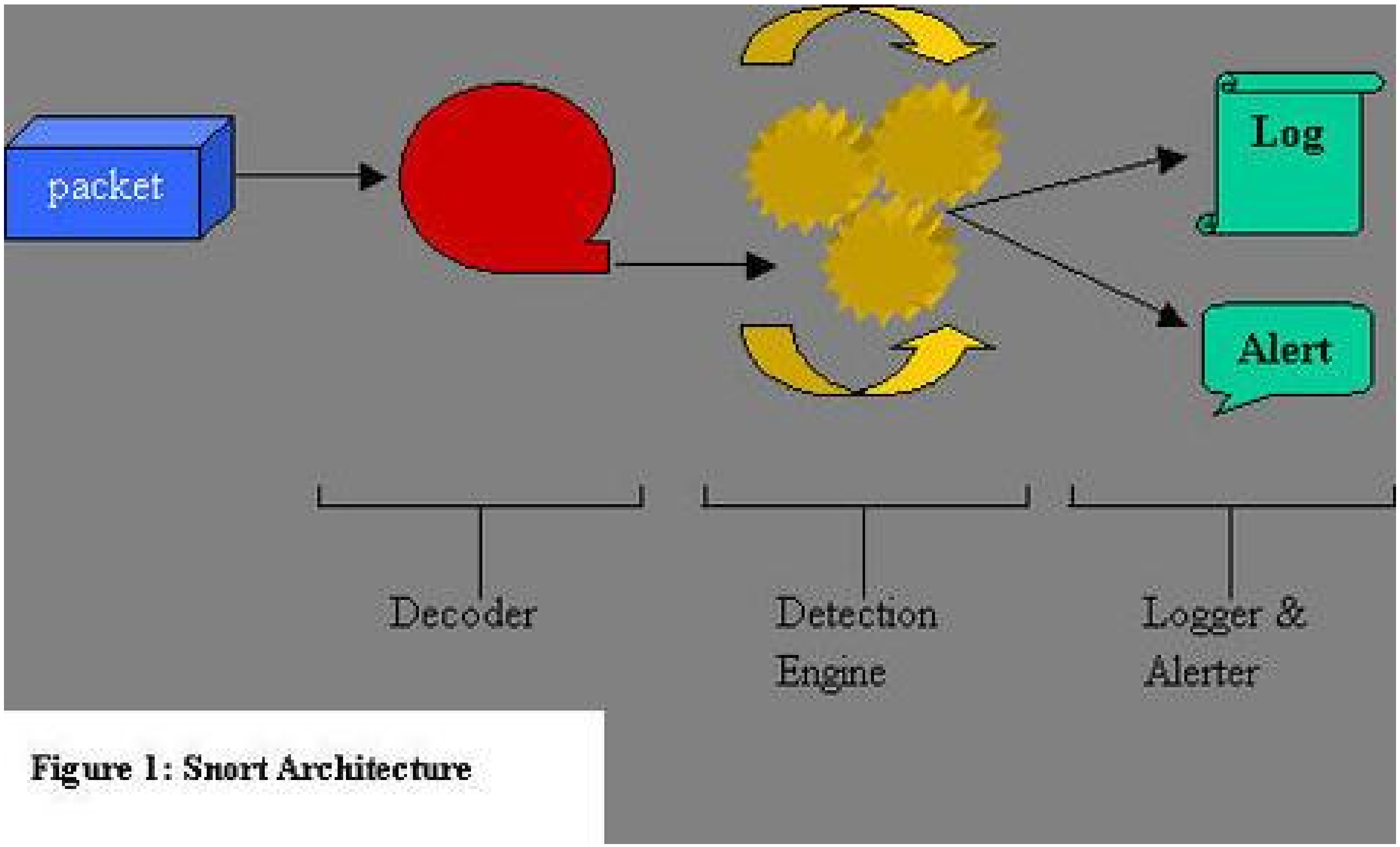



**Figure 1: Snort Architecture**

Source: Nalneesh Gaur, Snort: Planning IDS for your enterprise

# Snort

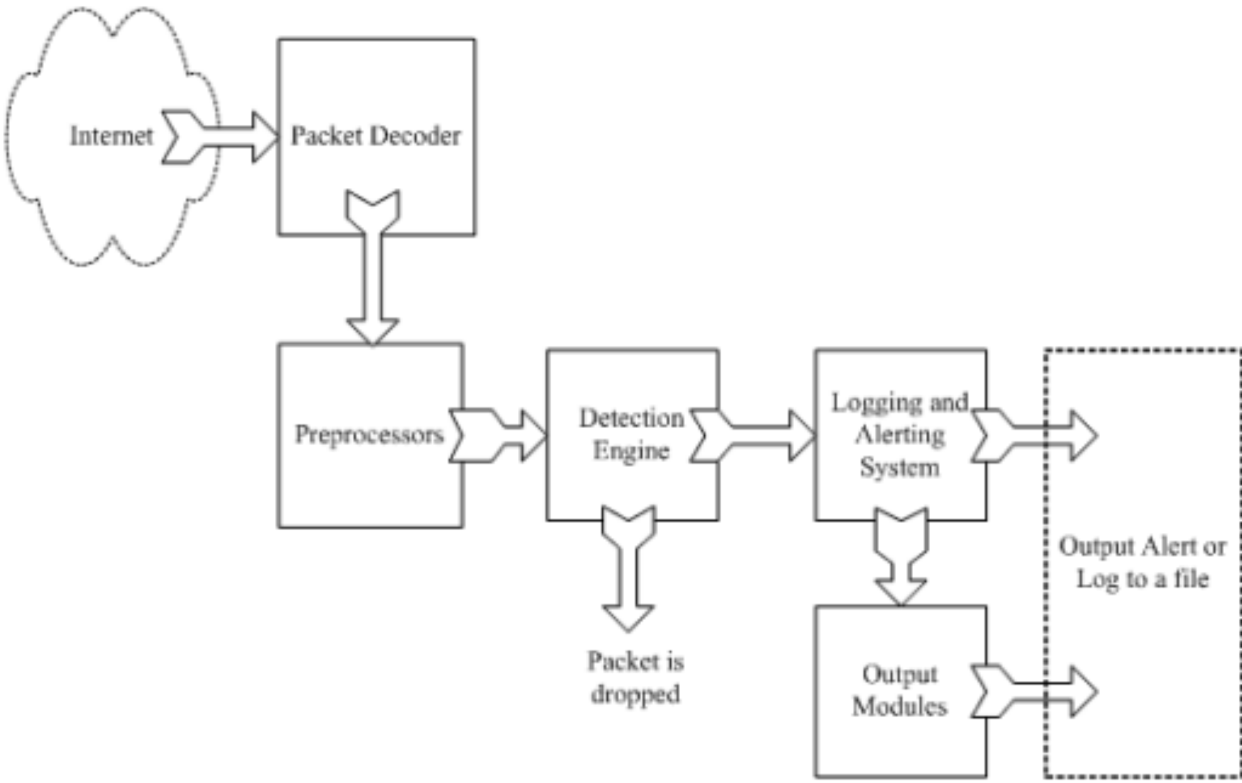
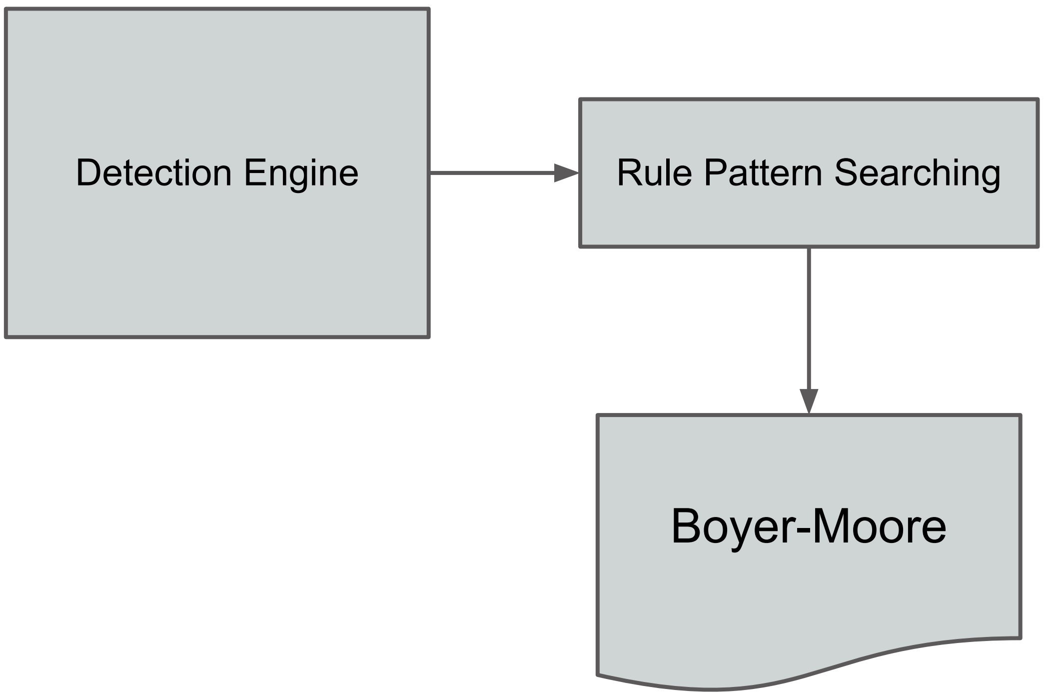



**Figure 1-5** Components of Snort.

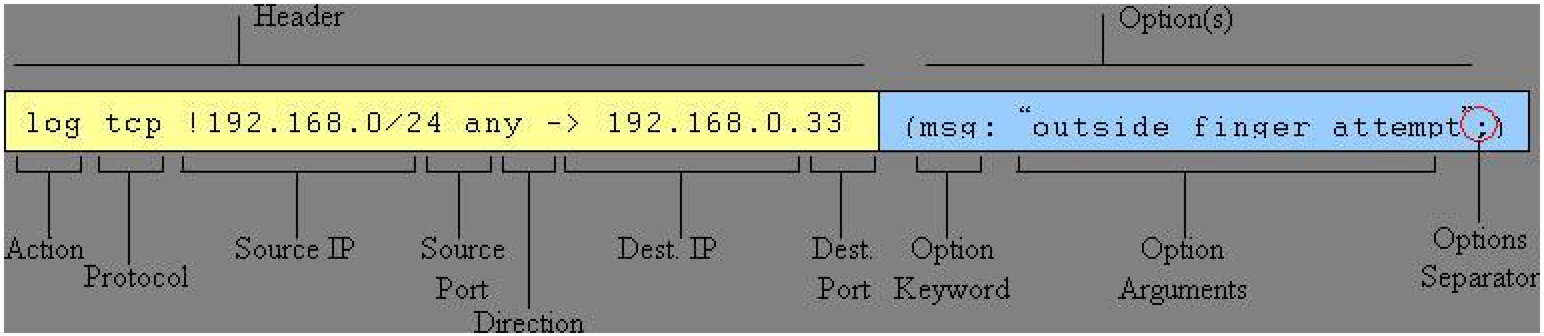
Source: Rafeeq Ur Rehman, *Intrusion Detection Systems with Snort: Advanced IDS Techniques with Snort, Apache, MySQL, PHP, and ACID*

# Snort - Detection Engine




Boyer-Moore works most efficiently when the search pattern consists of non-repeating sets of unique bytes.
e.g. in x86, avoid including 0x90 (NOP) in pattern to avoid repeated partial matches.

# Snort - Rules




Source: Nalneesh Gaur, Snort: Planning IDS for your enterprise

- written in single line in snort config file
- created by known signatures
- rule (type) scanning order
  - Alert -> pass -> log

# End

Questions?