Deployable Overlay Network for Defense against distributed SYN flood attacks

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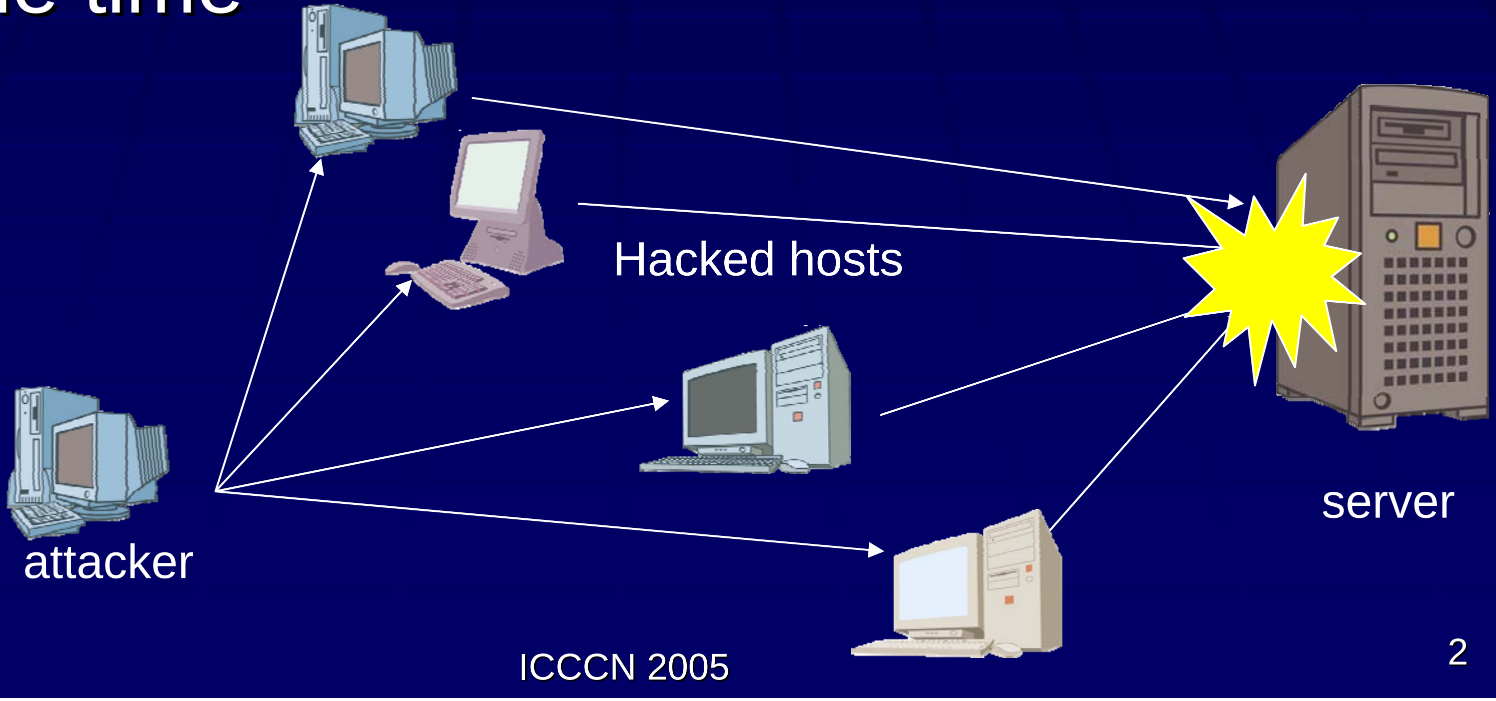
What is DDoS?

- An attacker hacks remote hosts and installs attack tools
- The hosts attack the same server at the same time



What is DDoS?

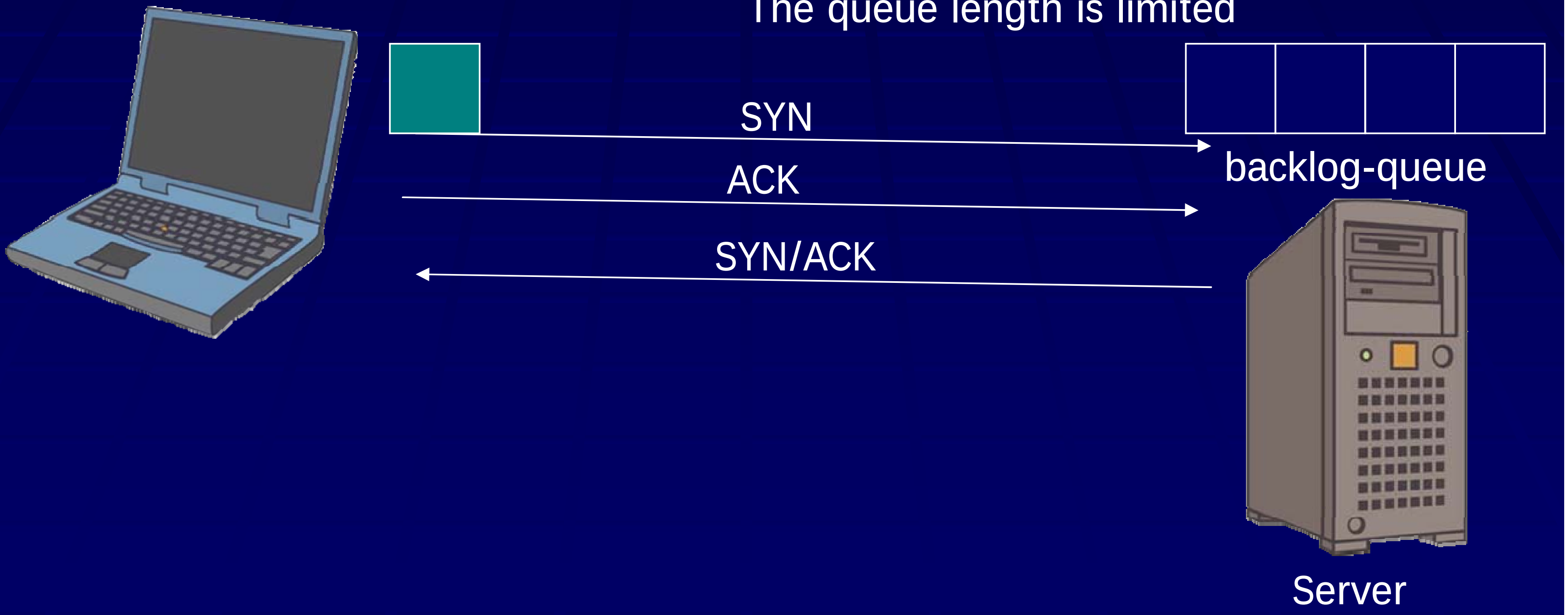
- The number of attacks is increasing
- The number of attack nodes is very large and attack nodes are highly distributed
- The most are SYN flood Attacks
  - Because SYN flood can put servers into denial-of-service state easily
  - More than 90% of DoS Attacks

What is SYN flood?

- Normal 3-way handshake

The in-progress connection requests are held in the backlog-queue

The queue length is limited

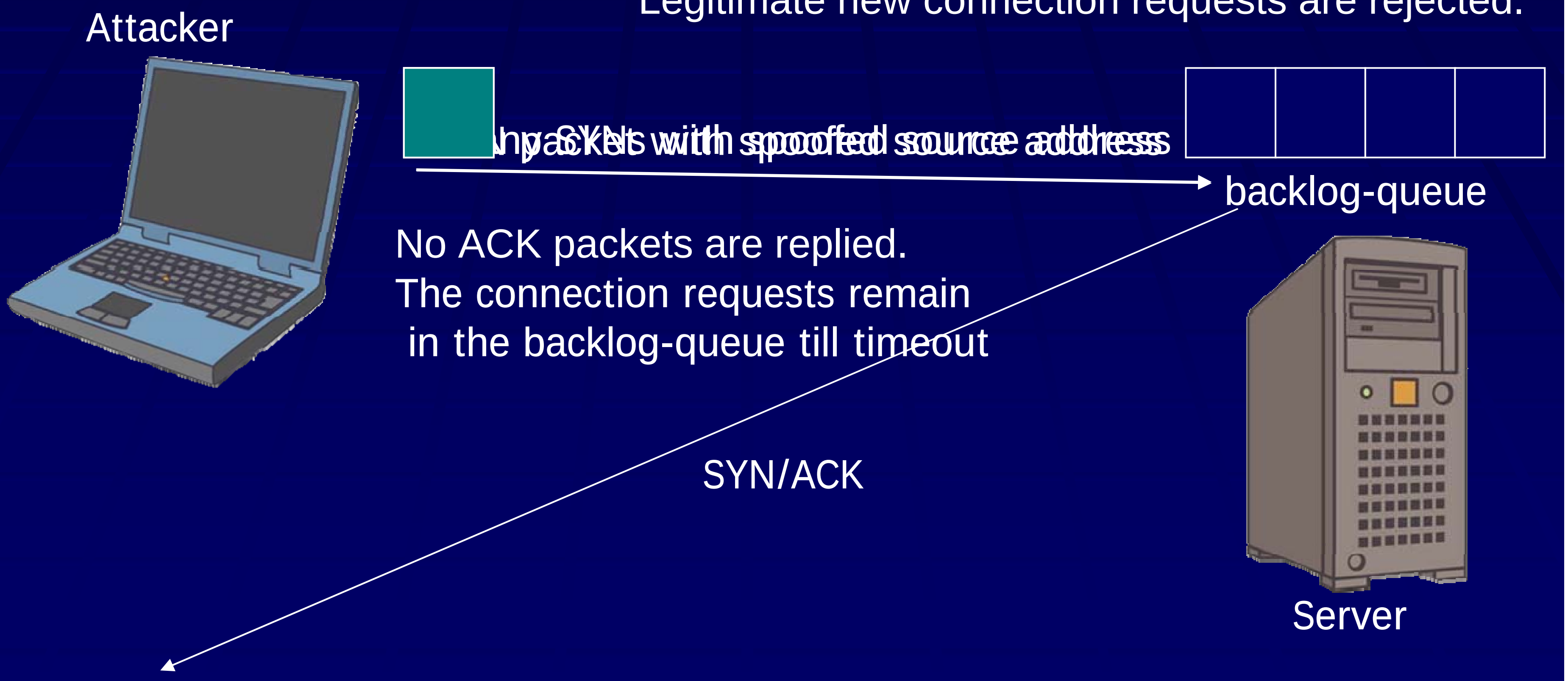


What is SYN flood?

- Mechanism of SYN flood

The backlog queue is filled by malicious requests.

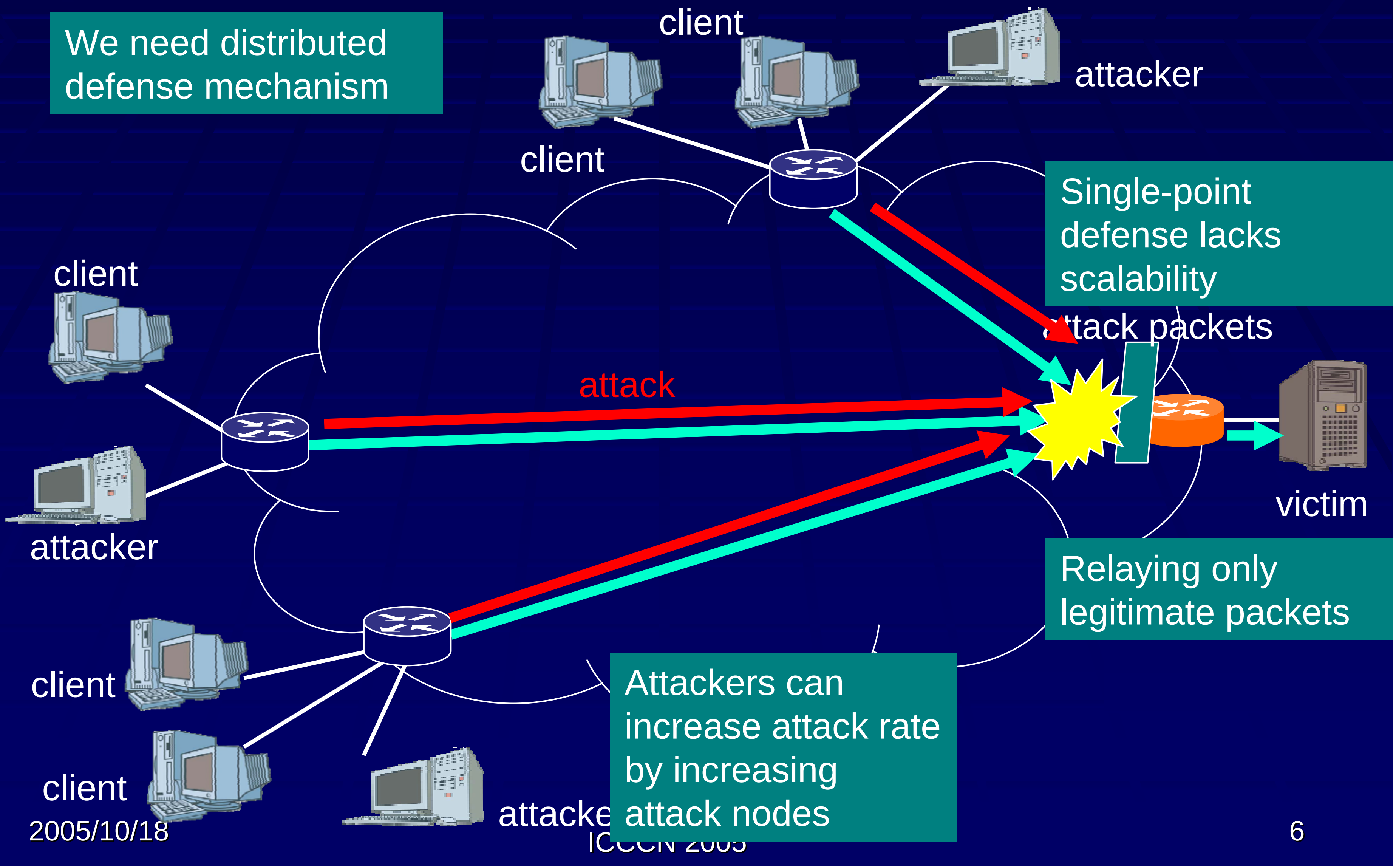
Legitimate new connection requests are rejected.



Attacker
ny SYNs with spoofed source address
packet with spoofed source address
backlog-queue
SYN/ACK
Server

No ACK packets are replied.
The connection requests remain
in the backlog-queue till timeout

Traditional firewall against SYN flood



We need distributed defense mechanism

Single-point defense lacks scalability

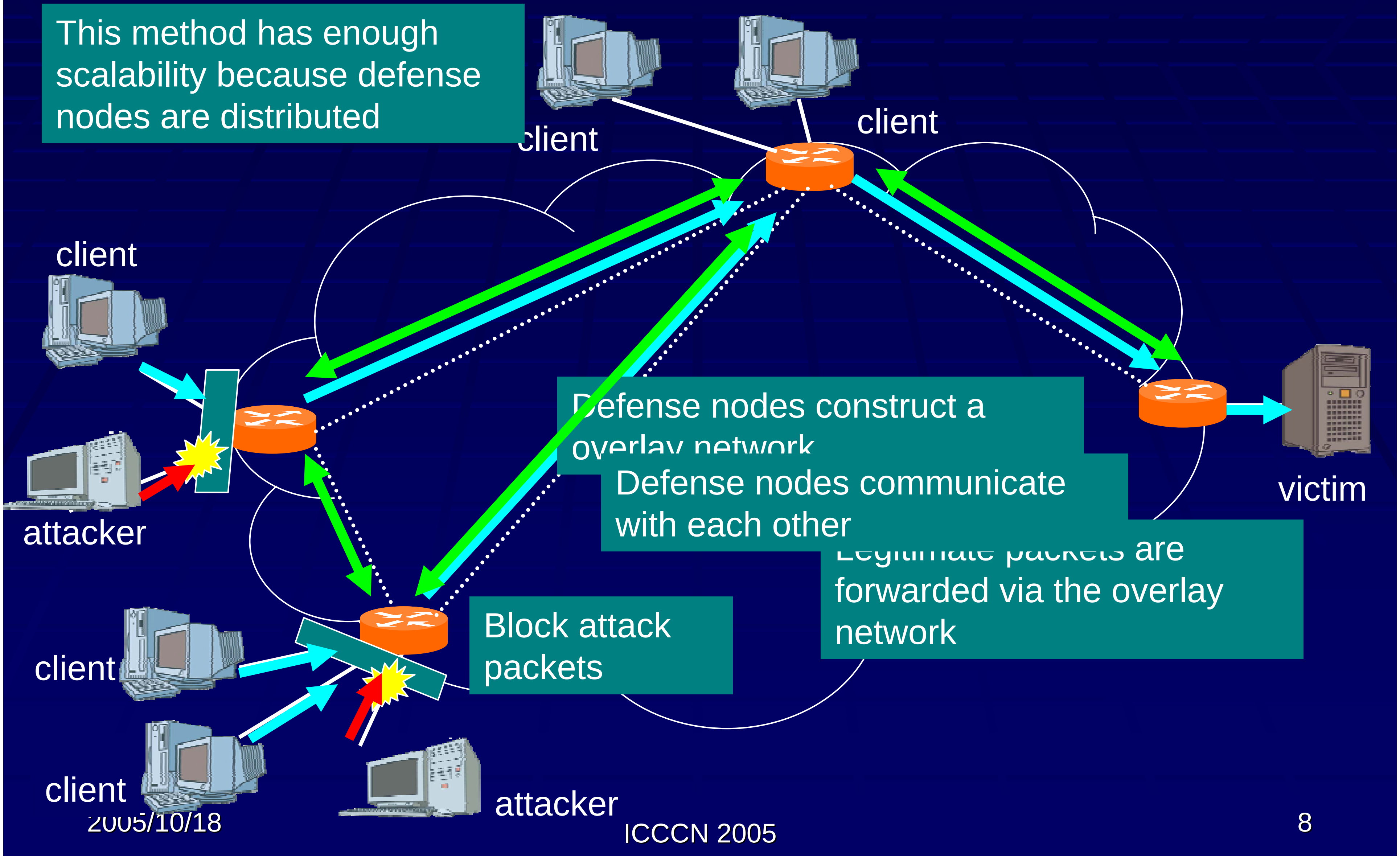
Relaying only legitimate packets

Attackers can increase attack rate by increasing attack nodes

Our goal

- Problems of traditional defenses
  - Lack in scalability
    - Unable to protect legitimate packets in the case of a high-rate and highly distributed attack
- Our goal
  - Defense mechanism having enough scalability
    - Distributed defense
      - Attack packets are blocked at distributed places
    - Deployment in a phased manner
      - Using a overlay network mechanism

Overview of our method



This method has enough scalability because defense nodes are distributed

Defense nodes construct a overlay network

Defense nodes communicate with each other

Legitimate packets are forwarded via the overlay network

Block attack packets

Operations of Defense nodes

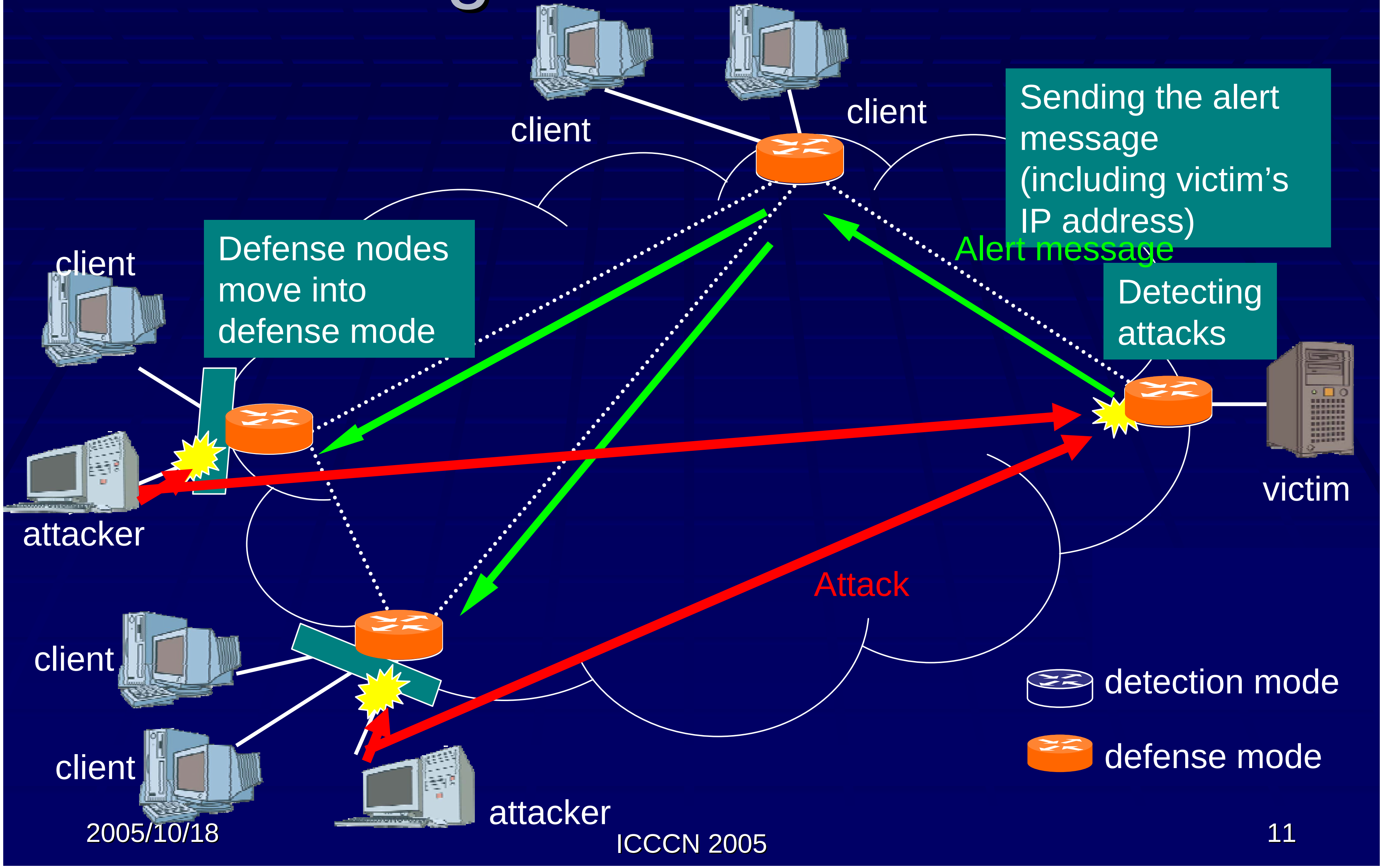
- Attack detection mode
  - Detecting attacks
- Defense mode
  - Alerting all defense nodes
  - Delegation of SYN/ACK packets
  - Relay of legitimate packets
  - Ending the defense mode

Detecting attacks

- Attacks are detected at server-side
  - Attacker-side
    - Few attack packets ⇨ **difficult**
  - Server-side
    - Many attack packets ⇨ **easy**
- Method to detect attacks
  - Detection by comparing the SYN arrival rates with normal distributions[1]
    - Able to detect attacks fast regardless of time variation of traffic.

[1] Y. Ohsita, S. Ata, and M. Murata, "Detecting distributed Denial-of-Service attacks by analyzing TCP SYN packets statistically," Proceedings of IEEE Globecom 2004, November2004.

Alerting all defense nodes



Sending the alert message (including victim's IP address)

Defense nodes move into defense mode

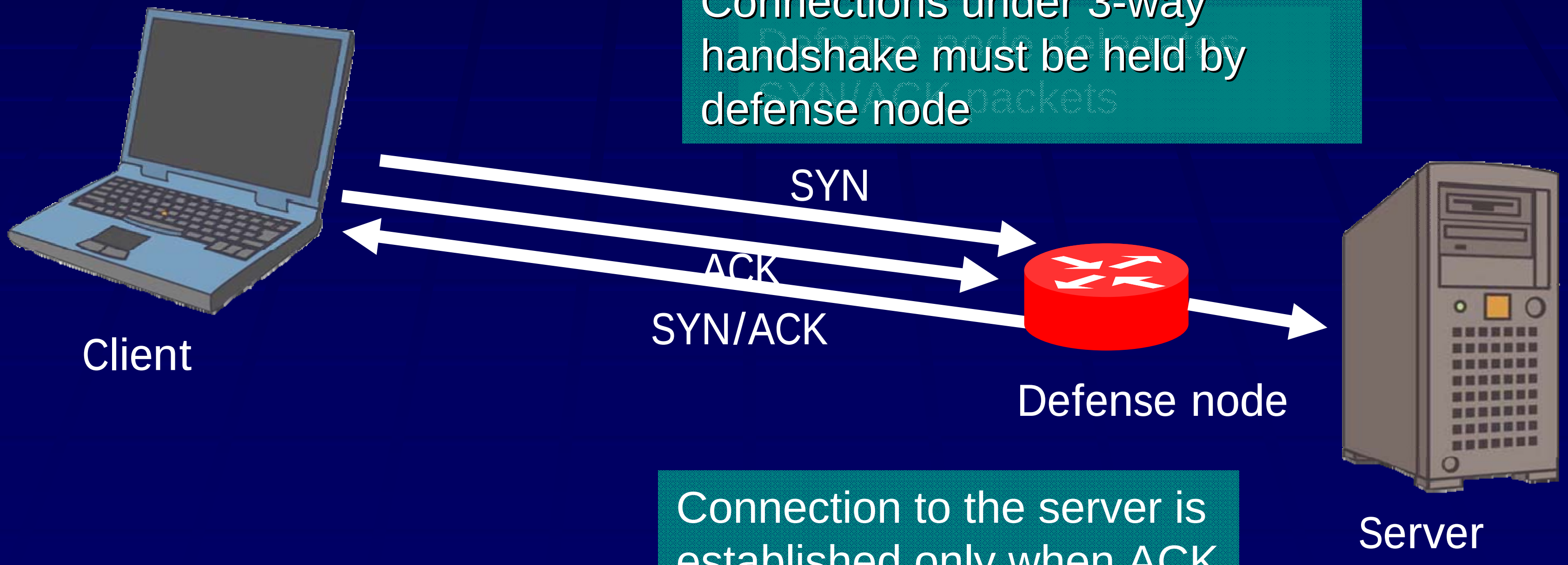
Detecting attacks

Delegation of SYN/ACK packets

- Legitimate packets are identified by delegation of SYN/ACK packets
  - Attacker cannot respond to SYN/ACK packets

Connections under 3-way handshake must be held by defense node

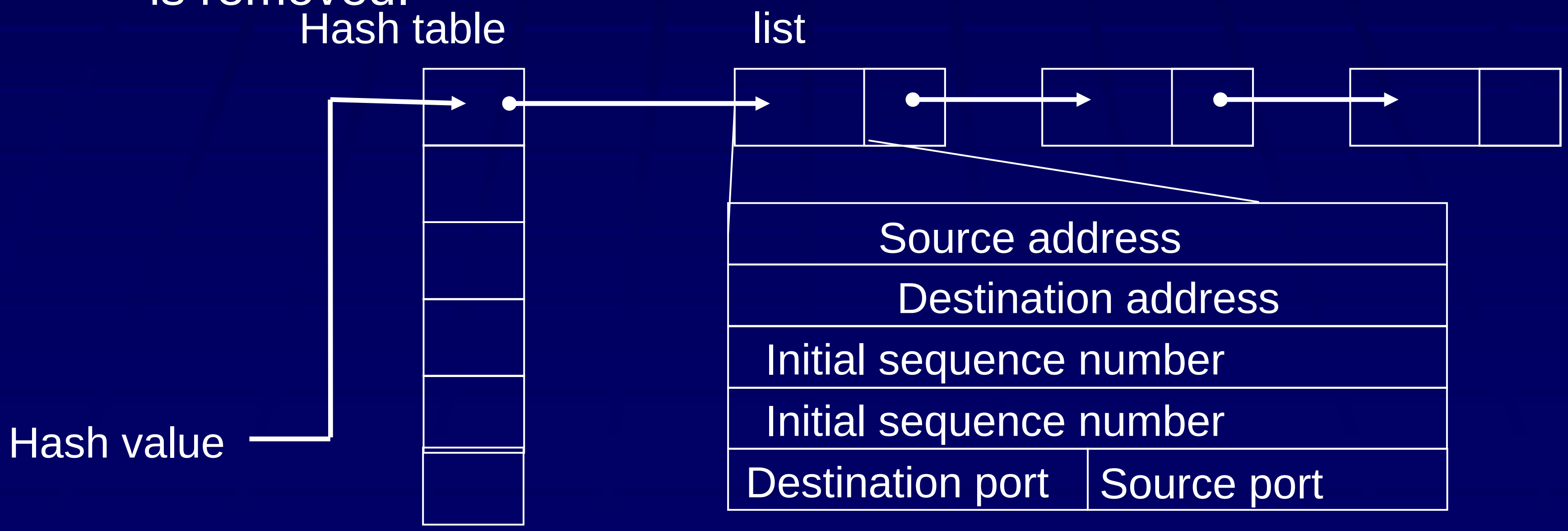
Defense node delegates SYN/ACK packets



Connection to the server is established only when ACK of SYN/ACK is received

Holding connection under 3-way handshake

- We use the same approach as the SYN cache
  - The hash value is computed from the source and destination IP addresses and the source and destination port.
  - Entries having the same hash value are kept on a forward linked list.
  - The length of the list is limited. When the list is full, the oldest entry is removed.



Hash table

list

Source address

Destination address

Initial sequence number

Initial sequence number

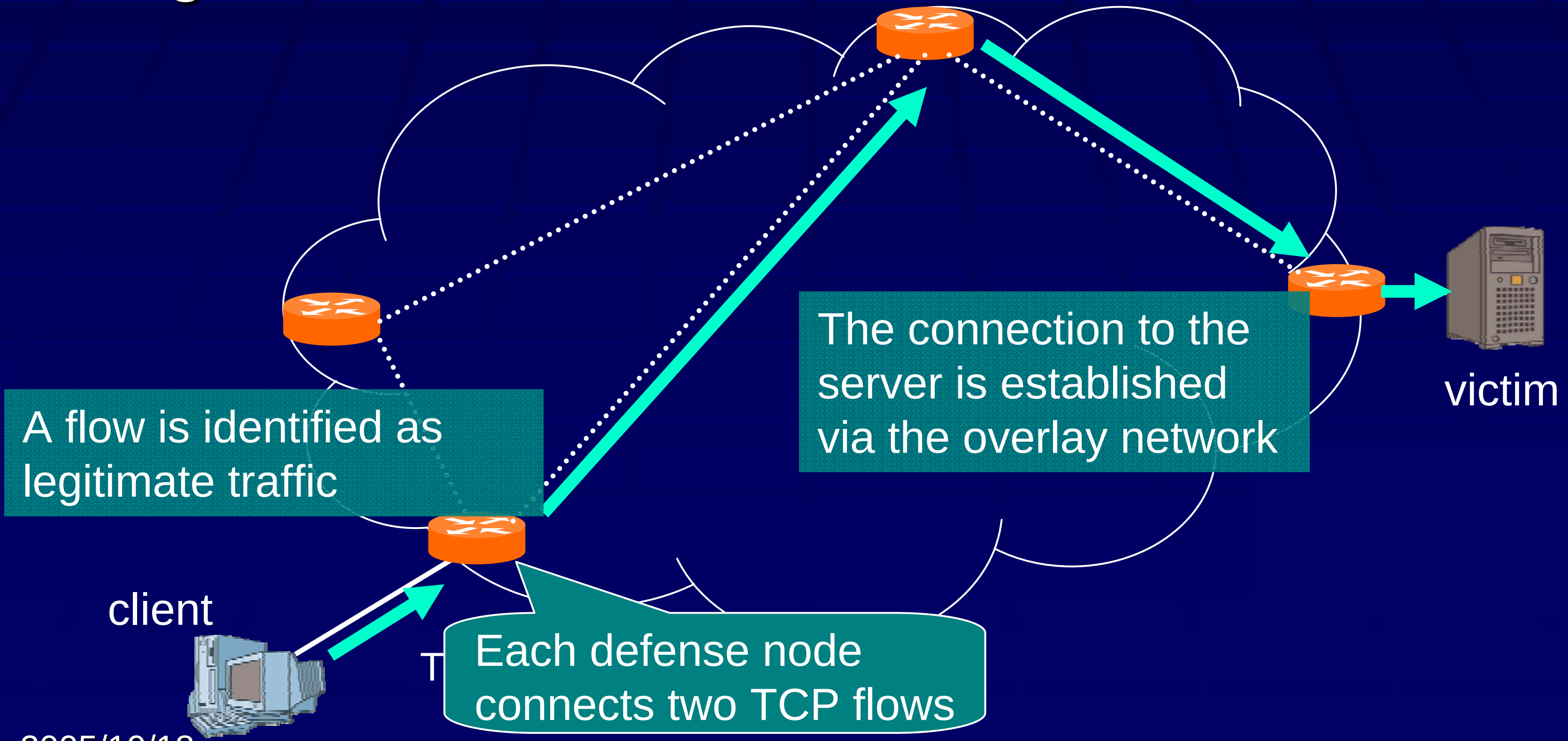
Destination port

Source port

Hash value

Relay of legitimate packets

- Legitimate packets are forwarded via overlay network
  - By using overlay network, we can distinguish legitimate flows from others



A flow is identified as legitimate traffic

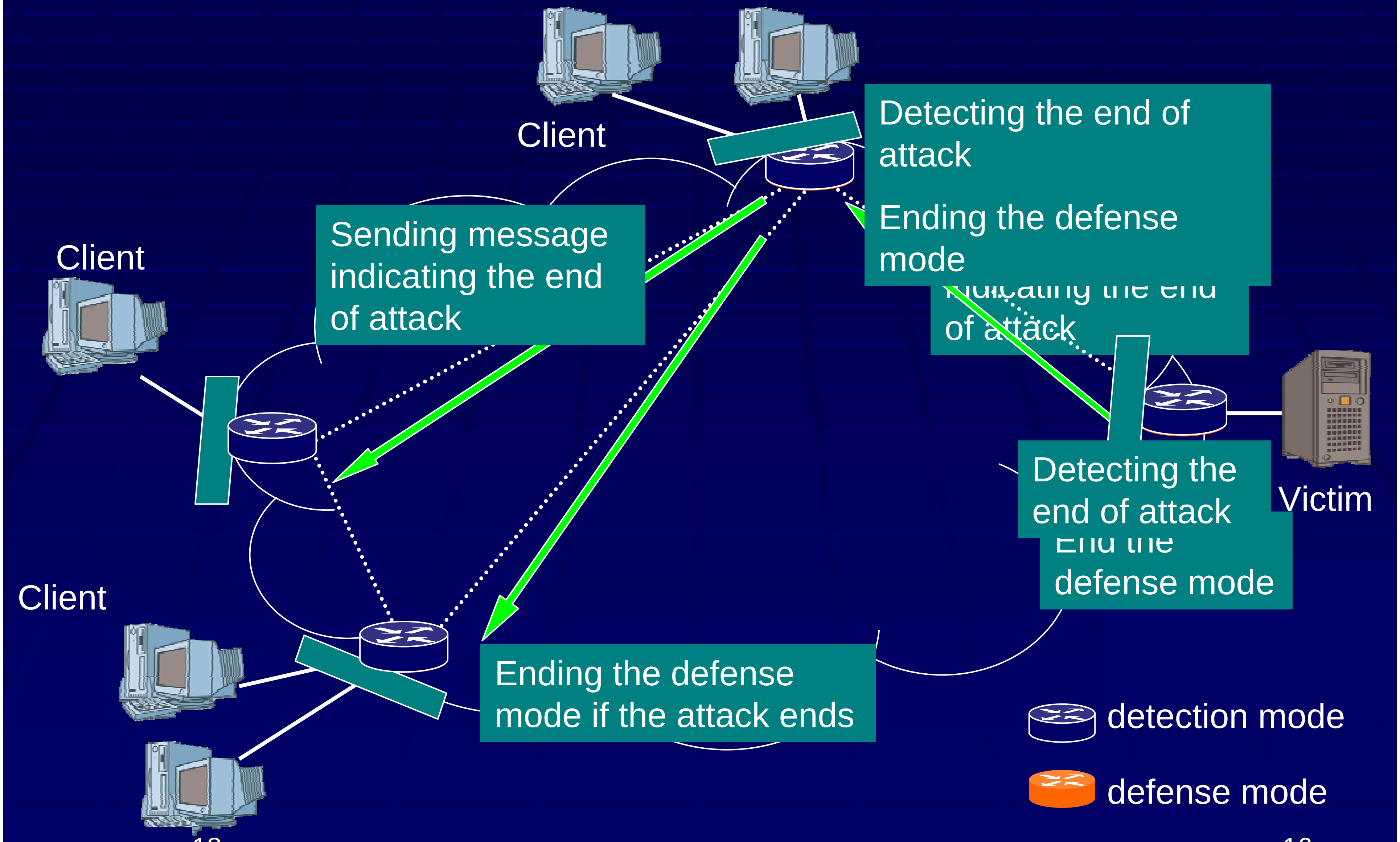
The connection to the server is established via the overlay network

Each defense node connects two TCP flows

When to end defense mode

- When a defense node should end defense mode?
  - The defense node receives no attack packets
    - The number of connection requests which time out or dropped is under a threshold
      - Ideally the threshold is 0, but some legitimate request may time out
  - Finishing defense mode does not cause high load on other nodes
    - No attack packets exist on intermediate defense nodes on the way to the victim node.

Ending the defense mode



Detecting the end of attack

Ending the defense mode

ndicating the end of attack

Sending message indicating the end of attack

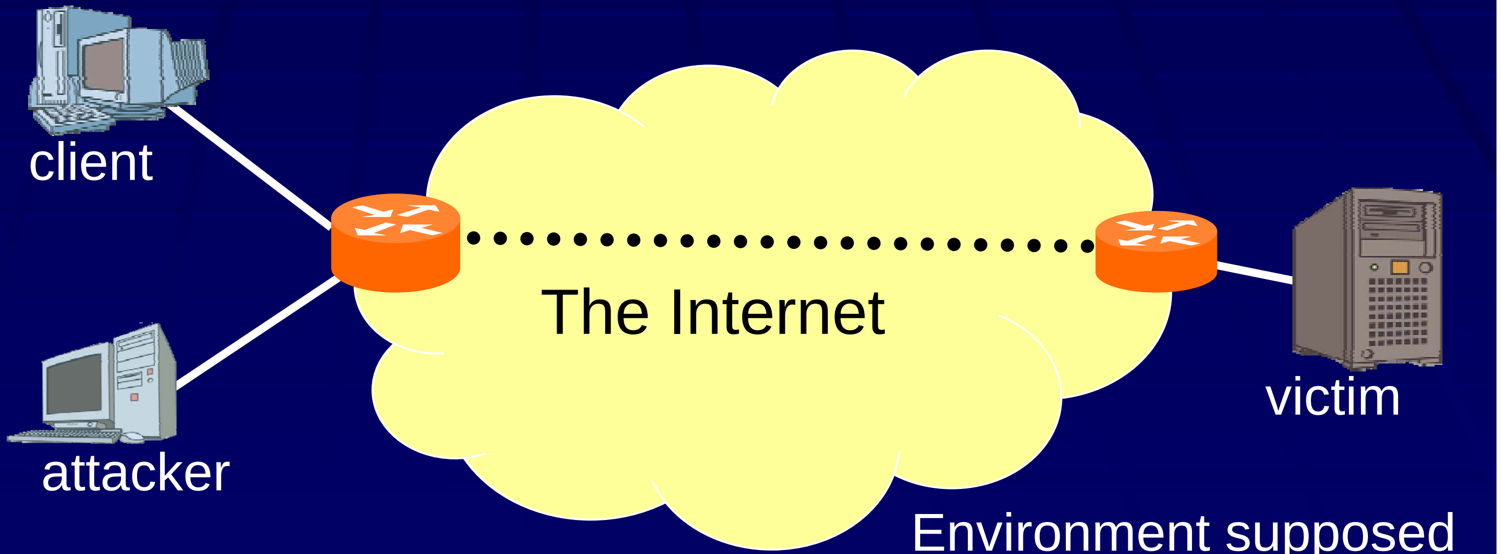
Detecting the end of attack

End the defense mode

Ending the defense mode if the attack ends

Evaluation of effectiveness of attacker-side defense

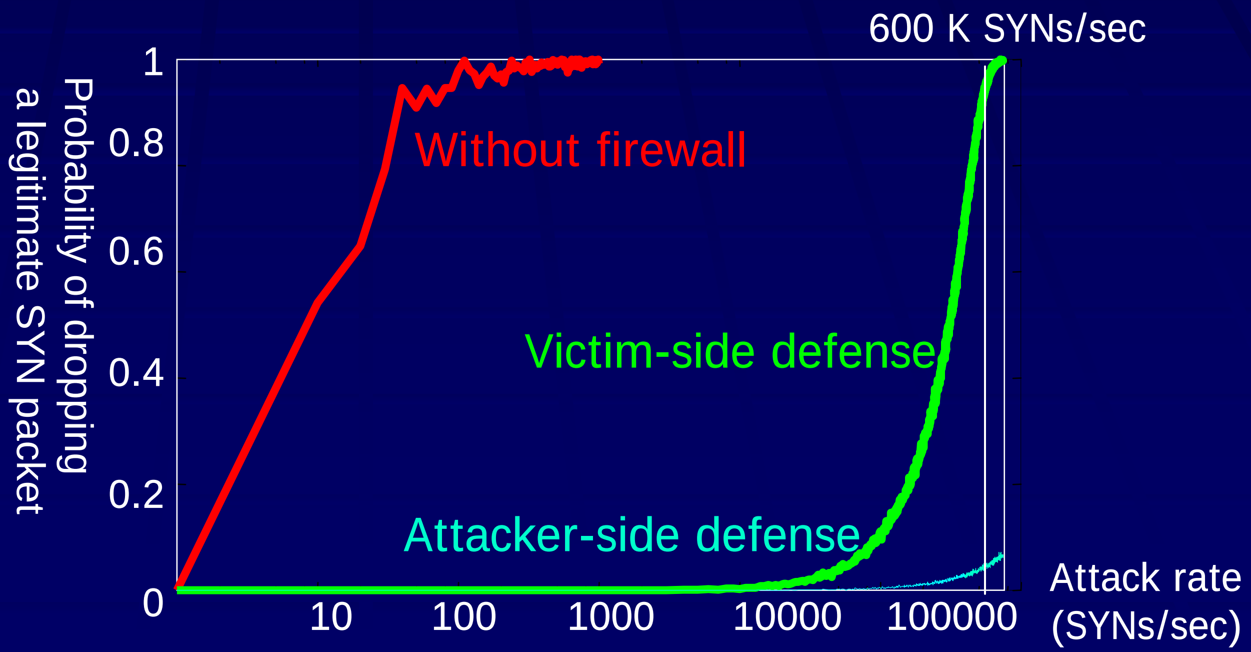
- We evaluate the effectiveness of attacker-side defense by simulation
  - We assume that single-attacker attacks.
  - We compare attacker-side defense with victim-side defense



Environment supposed in our simulation

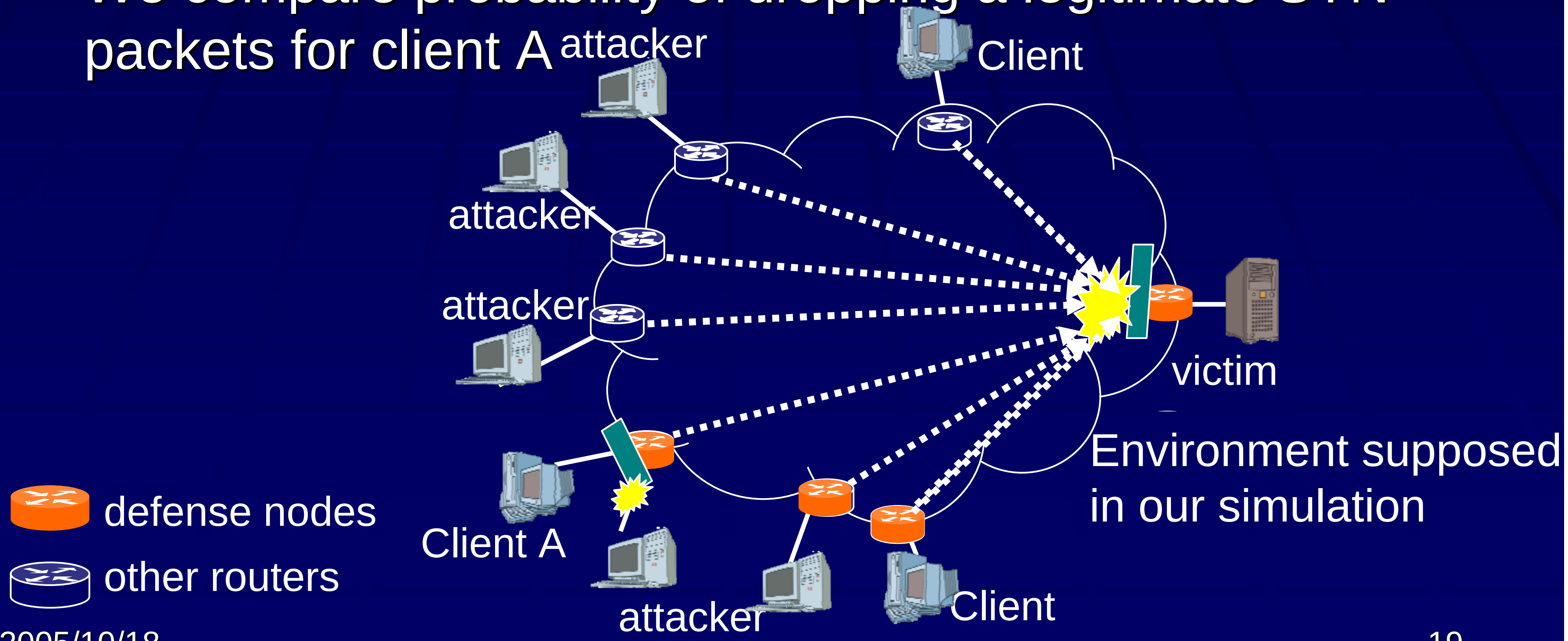
Effectiveness of attacker-side defense

- We compare the probability of dropping a legitimate SYN packet.
- The attacker-side defense can protect legitimate packets much better than the victim-side defense.
  - Because of small RTT, the average holding time for each connection request on the SYN cache is short.



Evaluation of effectiveness of distributed defense

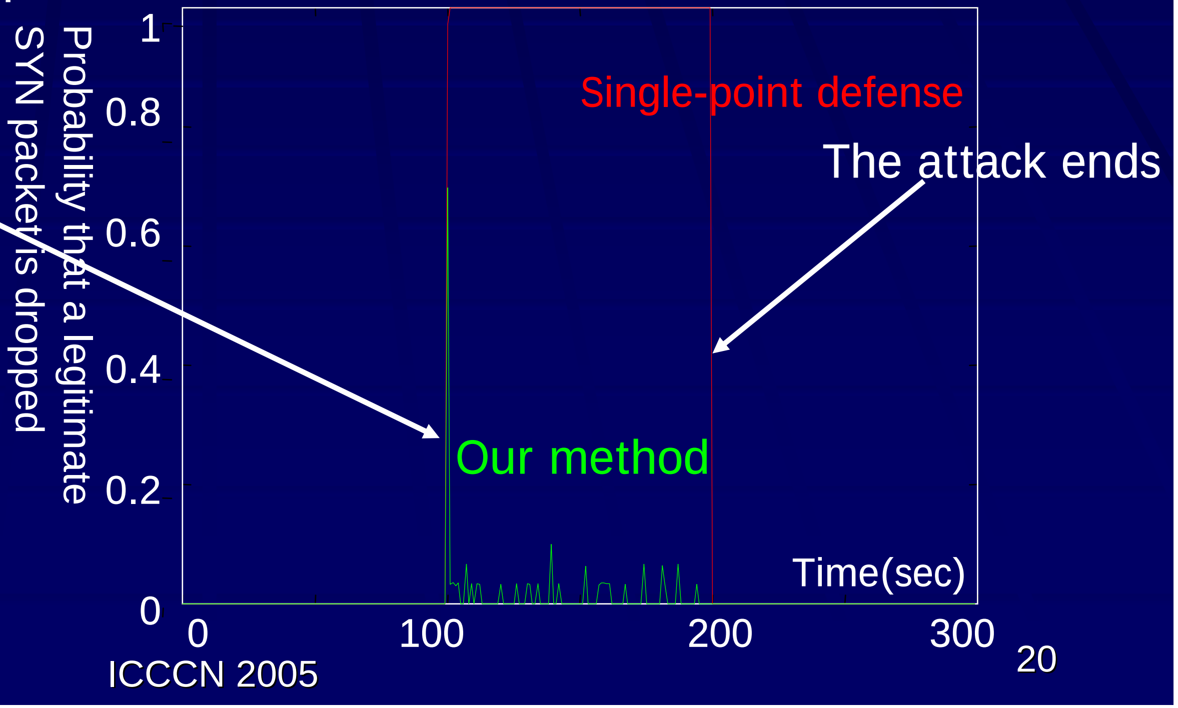
- We evaluate the effectiveness of distributed defense by simulation
  - Each attacker generates 200,000 SYN packets a second
  - We compare probability of dropping a legitimate SYN packets for client A



Environment supposed in our simulation

Probability of dropping SYN packets

- In the case of single-point defense, probability of dropping a SYN packets remains high
- With our method, probability of dropping a packets becomes very low soon after the attack started
  - Our method quickly detects attacks and distinguish legitimate packets from attack packets.



The attack starts

The attack ends

Conclusion and future work

- Conclusion
  - We have proposed a distributed defense mechanism against distributed SYN flood attacks.
  - Simulation results shows that our method has both effectiveness of attacker-side defense and effectiveness of distributed defense
- Future work
  - Identification of attack packets at the points where the routes of packets may vary.

Thank you