Advanced Networking

Skype

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Credits for part of the original material to Saverio Niccolini NEC Heidelberg

Skype characteristics

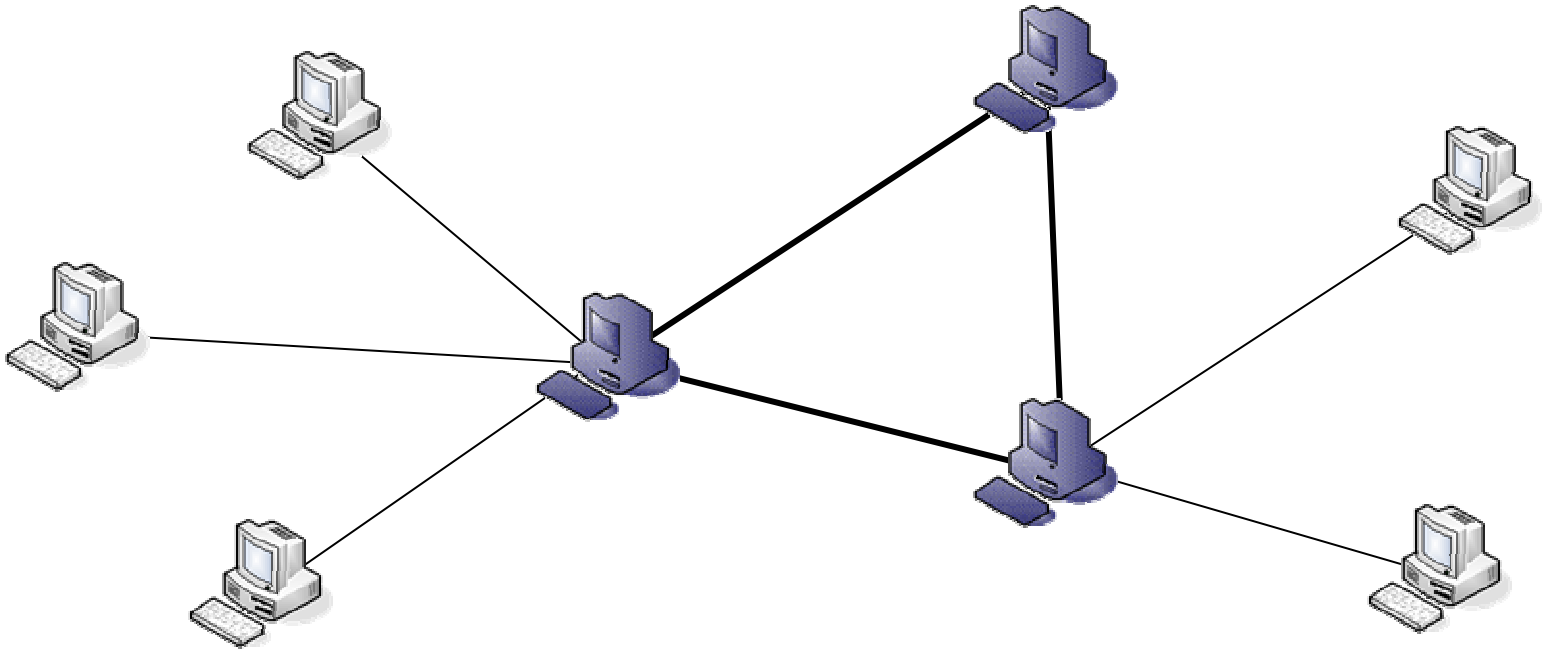
- **Skype is a well known P2P program for real time communications**
  - **Voice calls**
  - **Video (from version 2.0)**
  - **File sharing and instant messaging when in a call**
- **Seems to work with no problems in all network conditions compared to similar P2P applications**
- **One of the reasons of its success is its ability to work in network scenarios with middleboxes**
  - **such as firewalls and Network Address Translators (NATs)**
  - **usually, this is a problem for P2P applications**

How Skype works

- Skype overlay network
  - network structure
  - entities involved
- Skype function analysis
- Lesson learned
- Skype security analysis
  - Binary
  - Network protocol
  - Skype authentication
  - Traffic encryption

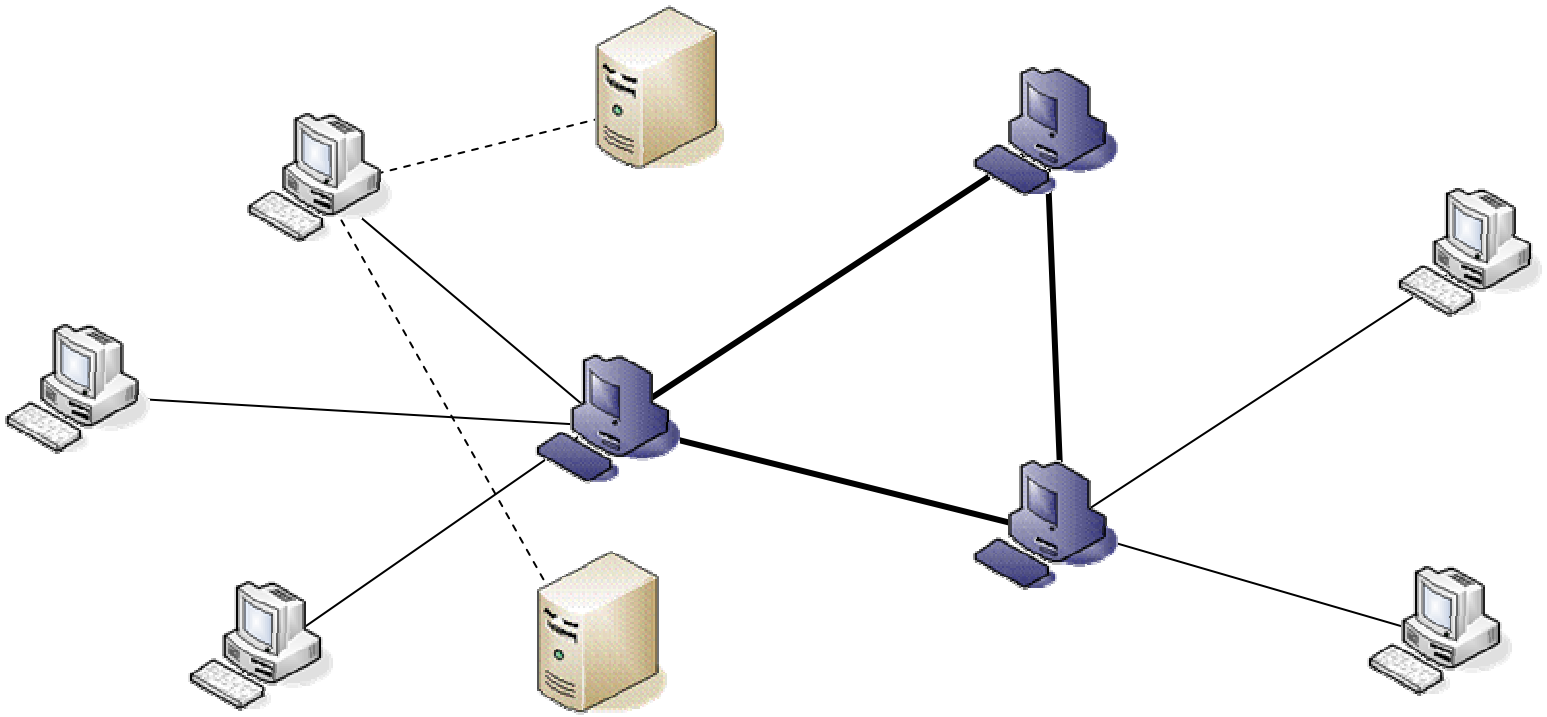
Skype overlay network (I)

- **Skype network relies on distributed nodes:**
  - **Skype Clients (SCs)**
  - **Supernodes (SNs)**



Skype overlay network (II)

- **Although there are also centralized entities:**
  - **HTTP Server**
  - **Login Server**



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Skype overlay network (III)

Skype Client

- used to place voice calls and send instant messages
- connection to skype network possible through a supernode (SN)
- connection with the SN (via TCP) maintained for the whole time the client is on-line
- client configuration and SN addresses are stored locally and refreshed periodically to maintain a coherent view of Skype network

Skype overlay network (IV)

Supernode

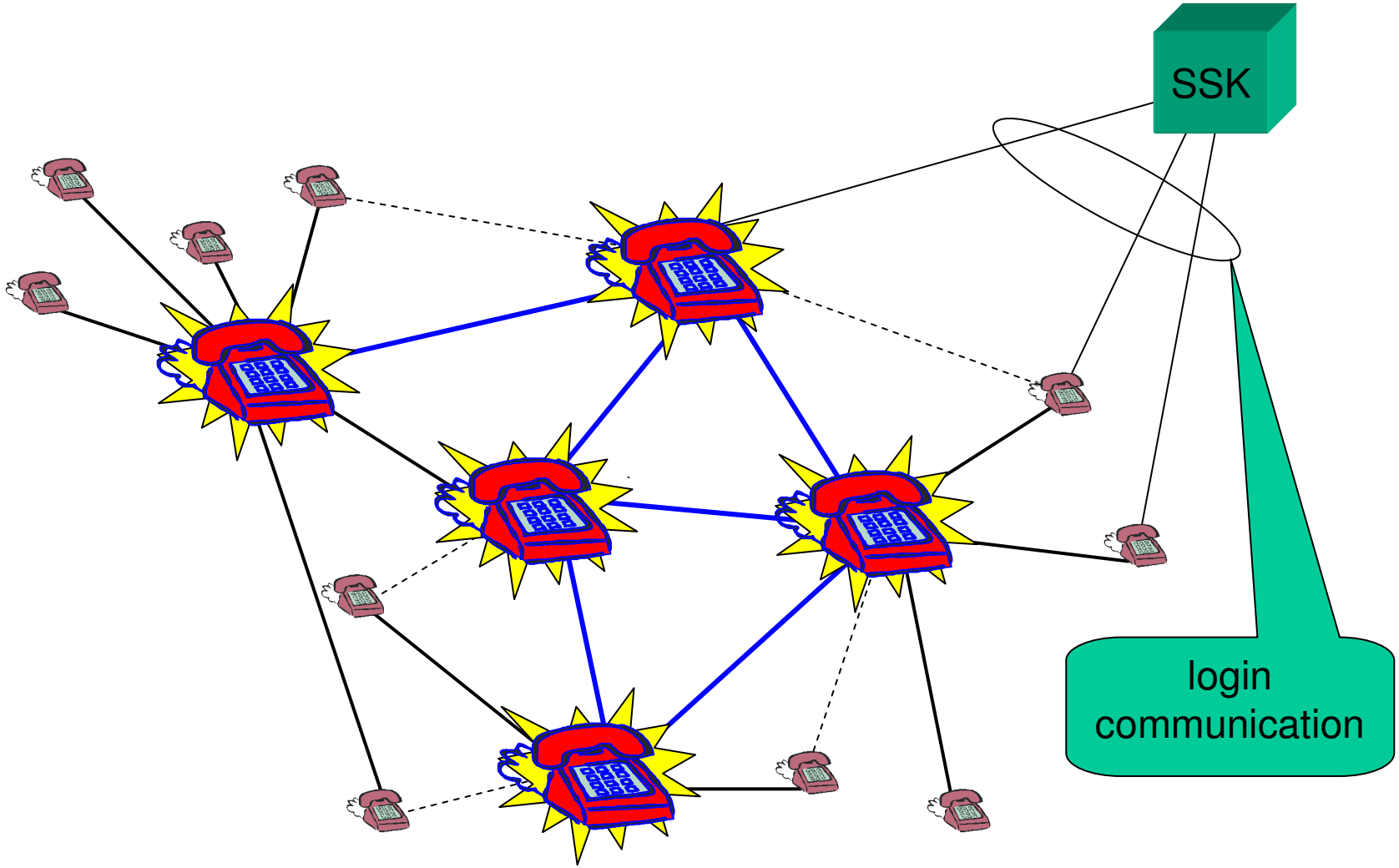
- Normal Skype Client that can accepts incoming TCP connections, with enough CPU, memory and bandwidth
- There are also a number of “default” Supernodes, used to increase network robustness and stability

Skype overlay network (V)

Servers

- Login server ensures that names are unique across Skype namespace. Also central point for authentication
- HTTP Server used by clients to check for updates

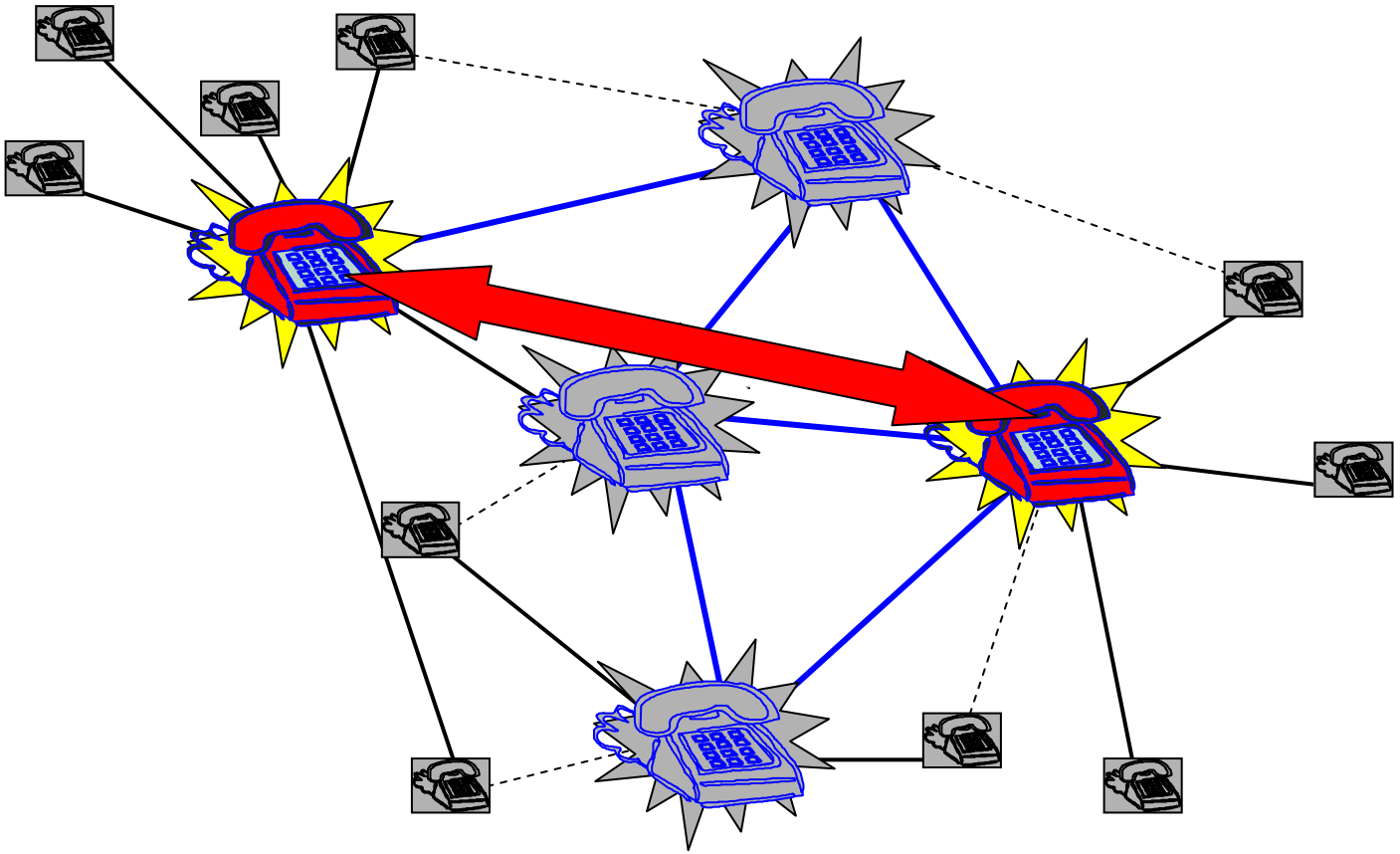
Topology



—— default connection

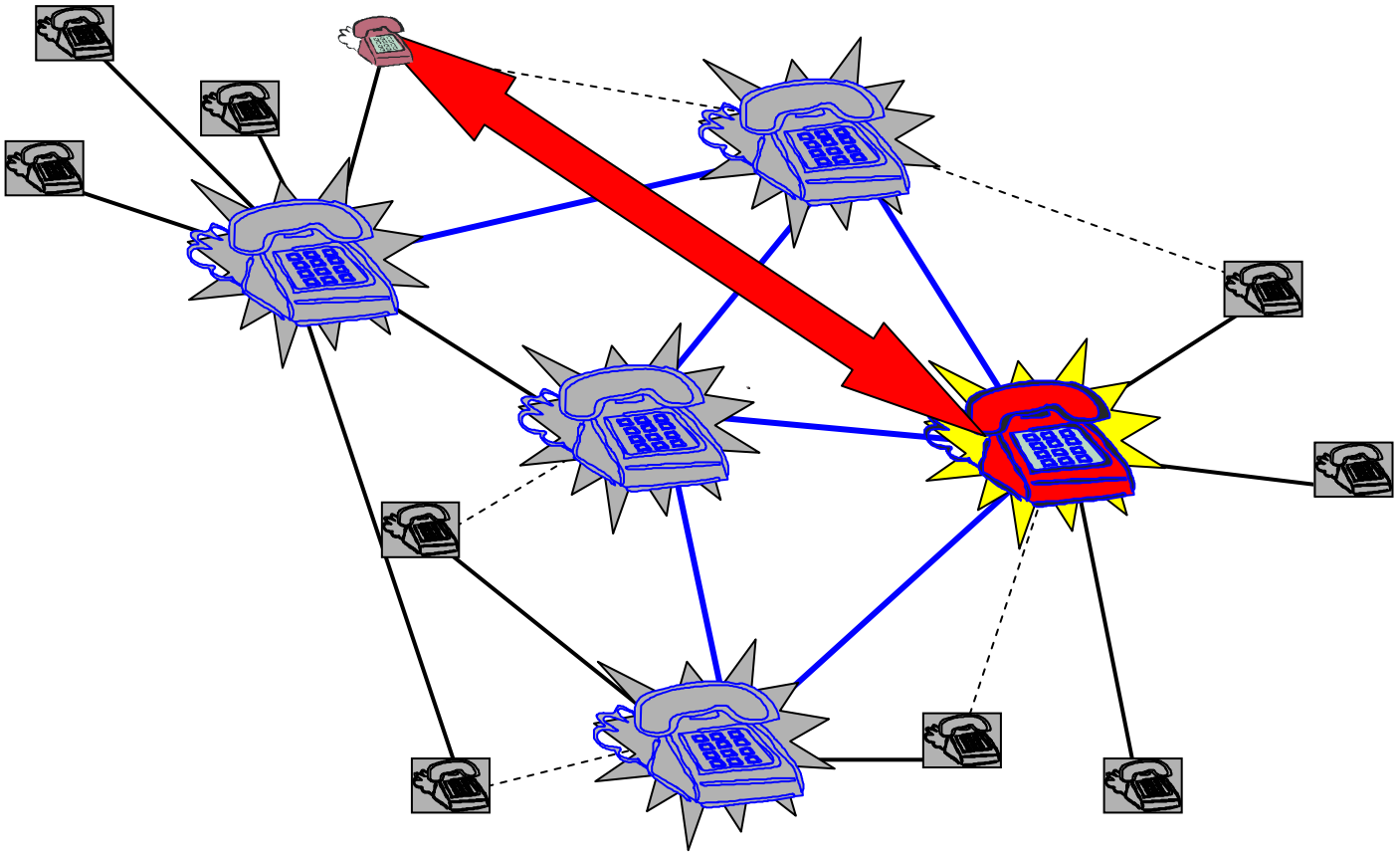
Topology: calls

Supernodes communicate directly ...



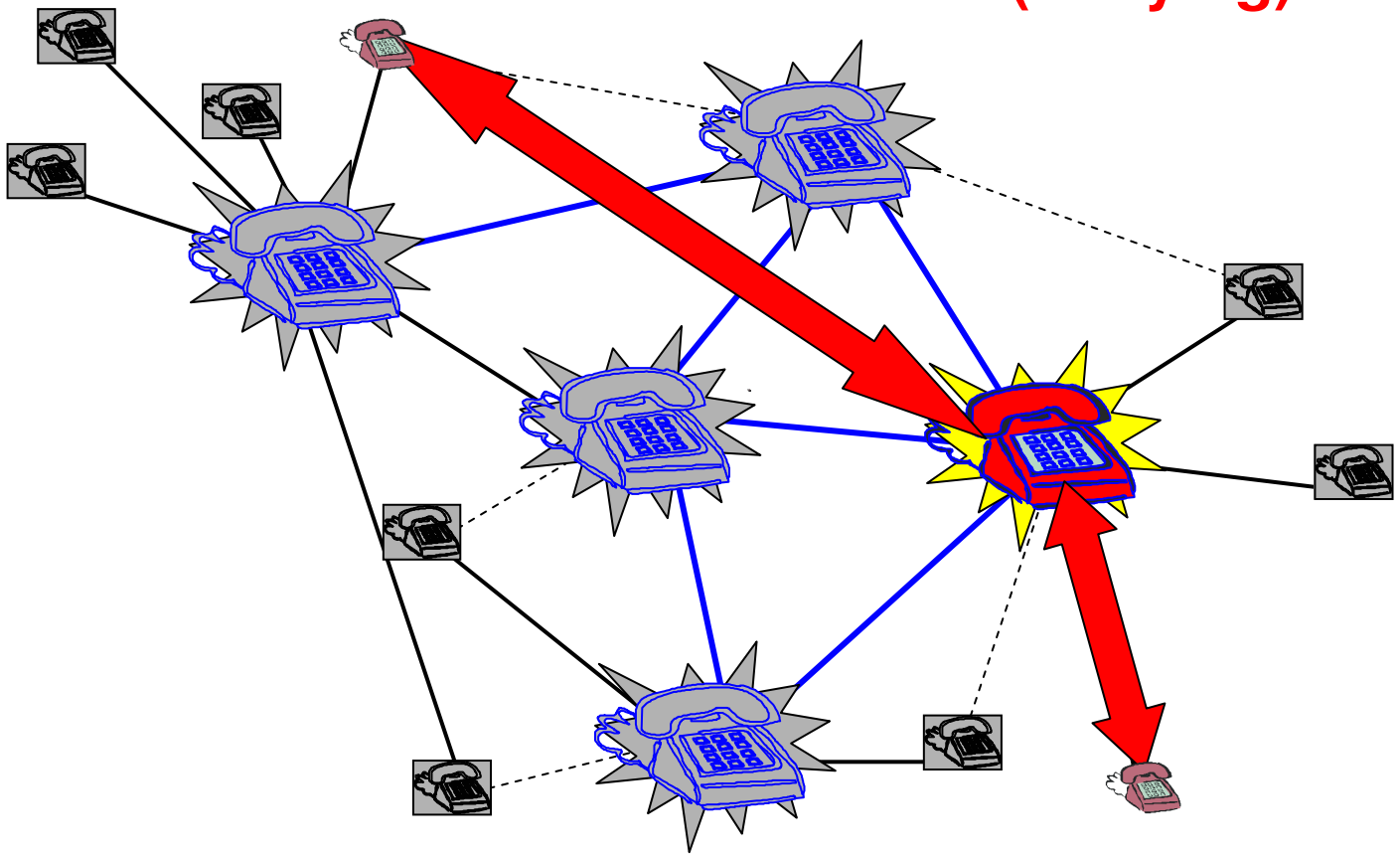
Topology: calls

... also with normal peers



Topology: calls

normal nodes require a supernode intermediation (relaying)



Some caratteristics

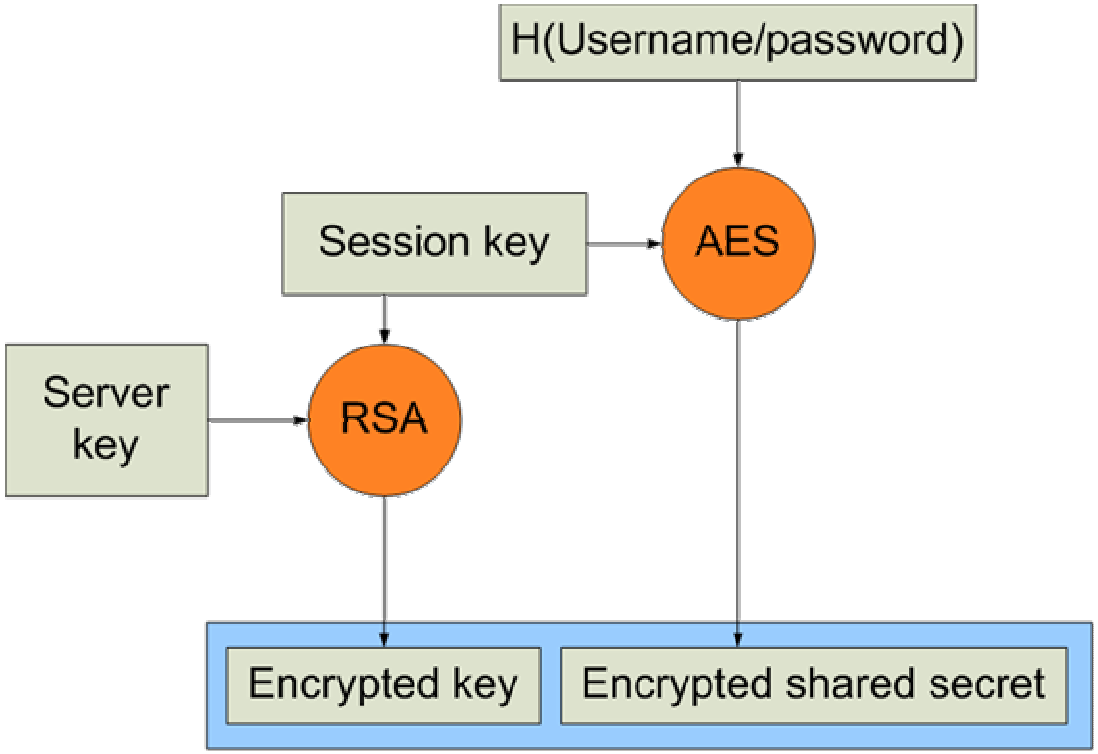
- CODECs
  - Default is a wideband (8 kHz-16kHz sampling) resulting in a transmission rate of 40 kbit/s in each direction (140 pck/s with payload of 67 bytes)
  - Quality in normal conditions is very good, much better than PCM telephony
  - No narrowband coding is provided, congestion is not considered a problem generated by skype
  - Under lab conditions over UDP the system works well even with only 16--20 kbit/s; below 12 kbit/s the system cannot work

Some Characteristics

- Ports
  - 80 (HTTP) e 443 (HTTPS) on TCP for signalin, random choice on UDP or TCP for voice
  - Ports are announced on the P2P network
- Encryption
  - All communications are AES (Advanced Encryption Standard) encoded

Skype Encryption

- **Authentication**
  - **At login time the client generate a RSA session key and uses it to encrypt his credentials.**
  - **Then encrypts the session key using the server's public key**
  - **and sends this information to the login server**



Some Characteristics

- Host Cache
  - List of supernodes (IP, Port) used to make the search phase faster
  - Roughly 200 entries dynamically updated
  - If the host cache is void skype does not work (some defaults entry are there from the beginning)
  - Une of the critical points for skype functioning
  - The idea is not new to P2P networks and answer to the bootstrap problem ... albeit in a naive way

Skype functions analysis

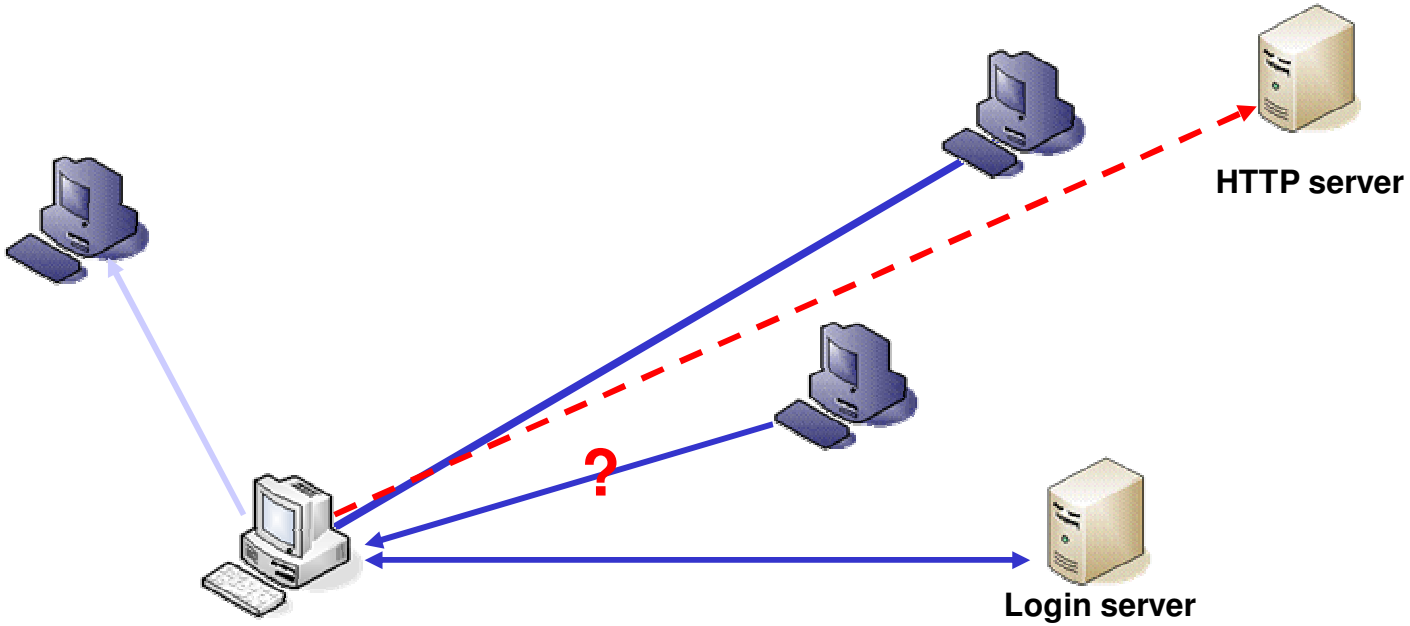
- **Essentials**
  - **Login**
  - **Search**
  - **Buddy list signaling**
  - **Call establishment**

Login function

- **Join and maintain overlay network:**
  - **Interaction with central servers**
    - **login server manage authentication and ensures unique names**
    - **HTTP server ensures client software updates**
  - **Refresh of shared.xml**
    - **file stored on the client containing SNs list and parameters identifying middlebox**
  - **Network tests if joining client can act as a SN**

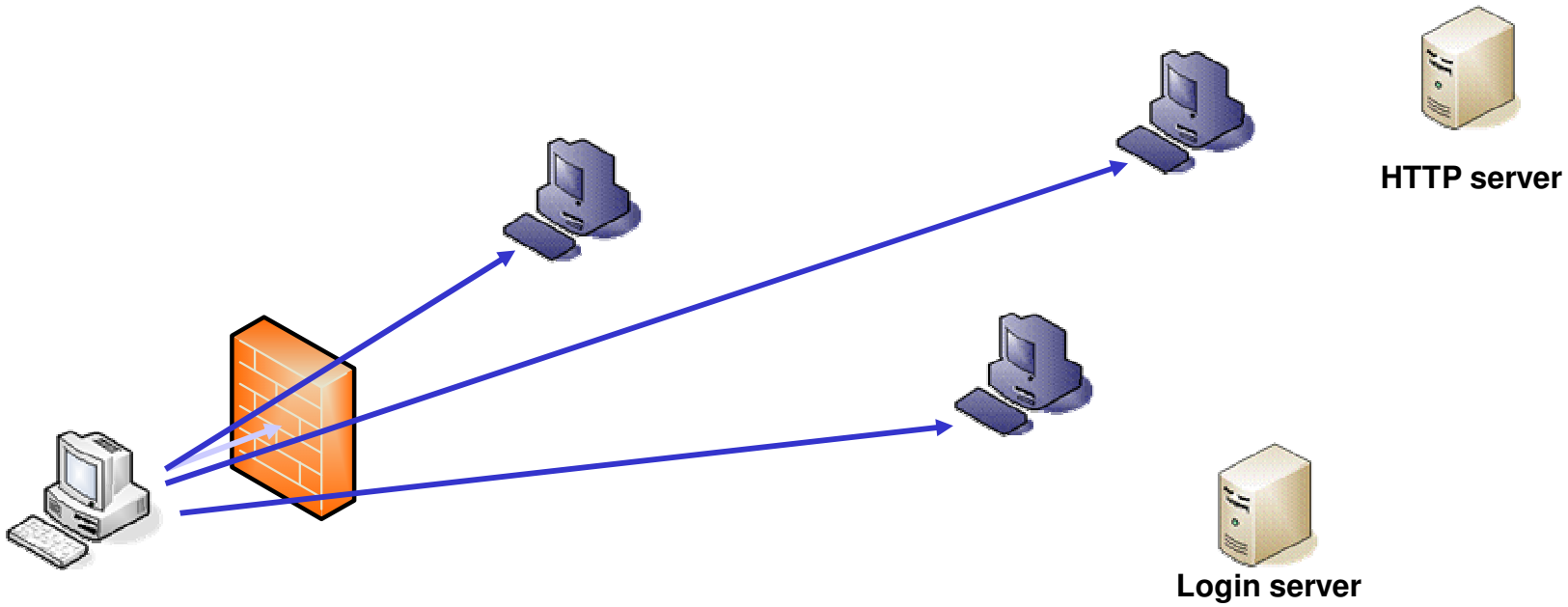
Login procedure

- At startup the client contacts the HTTP server to check for updates
- Sends UDP datagram to a -default SN- to refresh the list of supernodes
- Connects via TCP to a SN (connection maintained throughout Skype session) and exchanges info on online nodes
- Verify username and password via TCP with the Login server
- Another SN tests if client can act as a SN



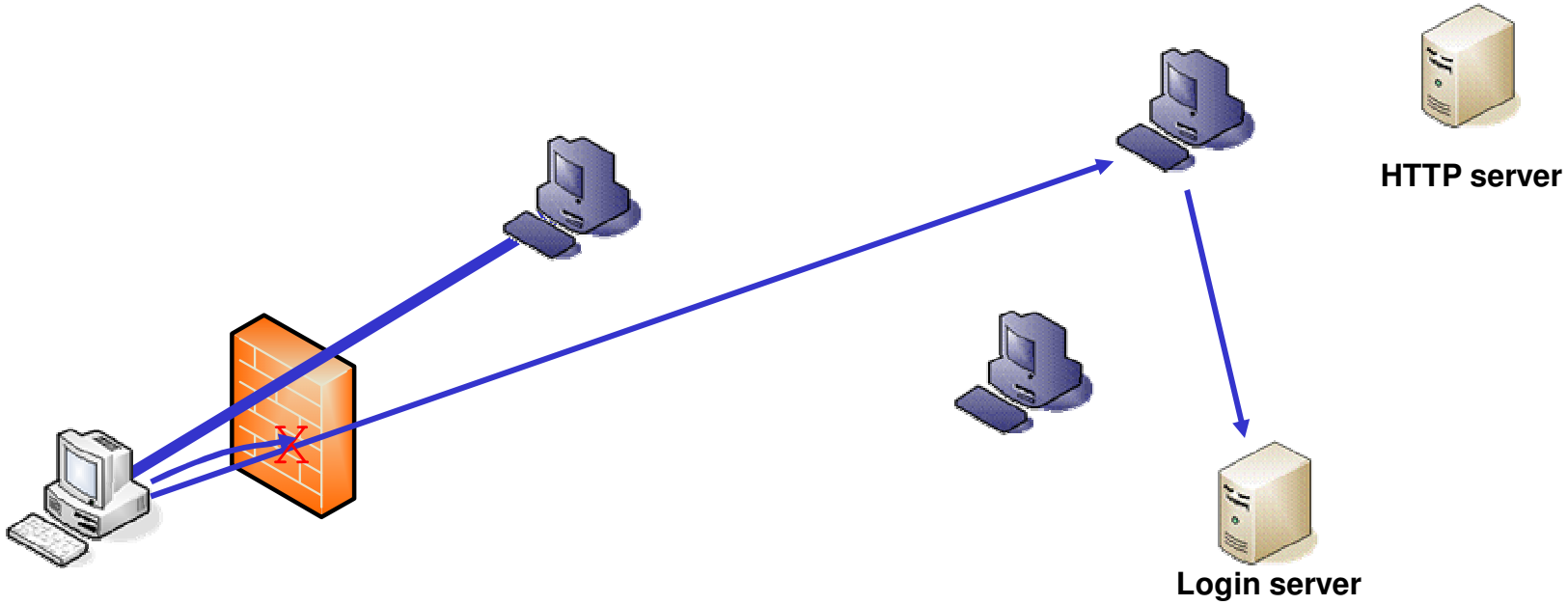
Login: Firewall blocks UDP

- **Firewall prevents UDP exchange for SN list refreshing**
- **Client establishes several TCP connections with SNs to gather information, when finished all but one are torn down**



Login: Firewall blocks Login sever

- After connection with the SN, attempt to connect with the Login server fails
- Client connect to the Login using a SN as a relay



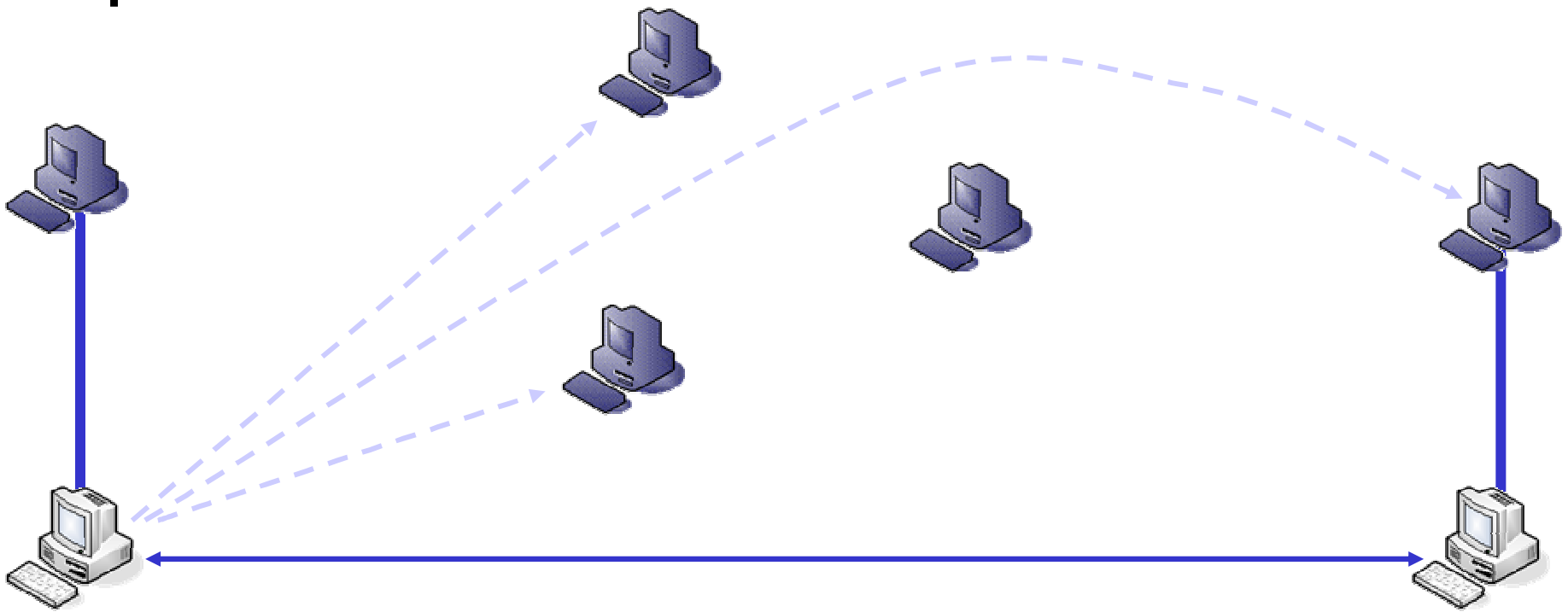
Search function

- **Procedure performed when a user wants to add someone to his buddy's list and communicate for the first time**

- **Search is performed using username as key**
  - **possible since names are unique**
  - **this is why there is the need for central servers**

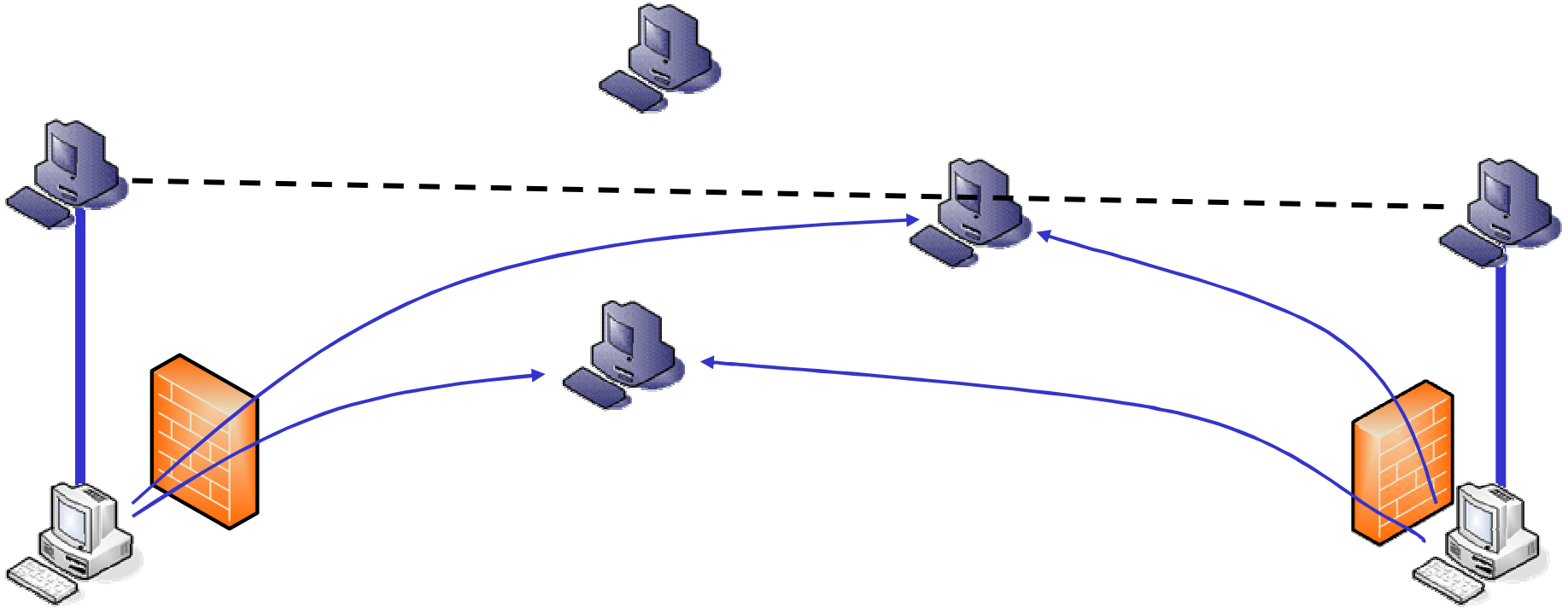
Search procedure

- **User A exchanges info with its SN and gather 3 SNs addresses**
- **A query the 3 SNs via UDP asking if they know the public IP of B**
- **Once A gets the address of B authorization exchange is performed**



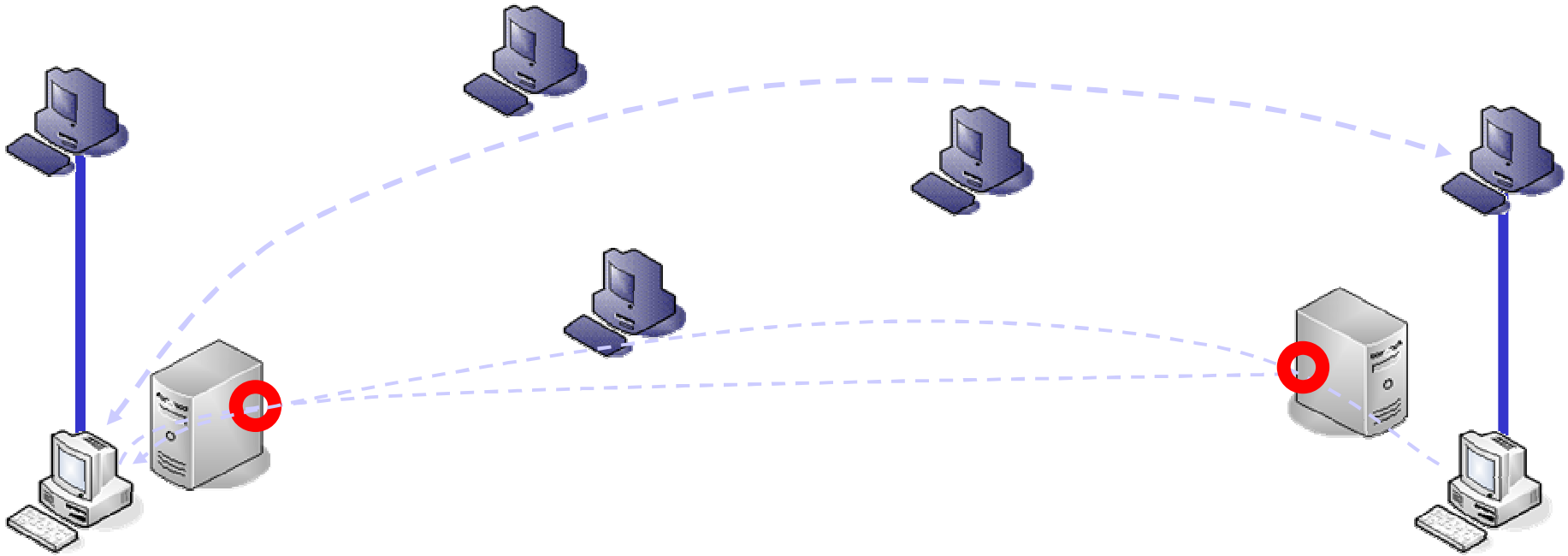
Search: Firewall blocks UDP

- **Firewall blocks UDP**
  - **preventing direct connection w/ the SNs or another user**
  - **the SN of A communicate to B (via his SN) the address of A**
- **Both A and B establish TCP connections with the same 2 SN to exchange authorization**



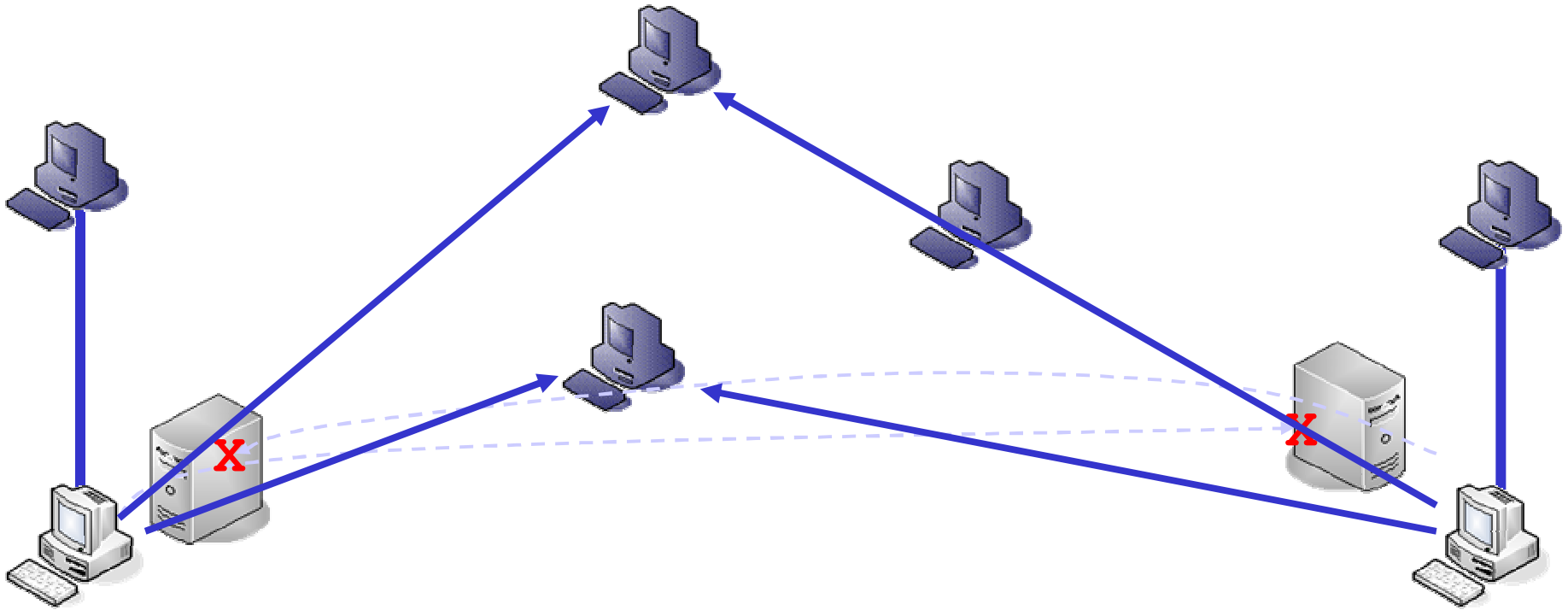
Search: Port restricted NAT

- Once user A gather the address of SN of B, sends a UDP query containing his external address. SN of B replies with user B external address.
- User A send an UDP datagram to user B external address in order to create a mapping in his NAT, anyway packet will be filtered by NAT of B
- User B does the same but this datagram reaches user A
- Once exchanged authorization a TCP connection via 2 SNs as relay is established, as depicted in previous slide



Search: Symmetric NAT

- **Clients try the technique depicted for Port restricted NAT**
  - **but it fails due to symmetric NAT behvior**
- **Clients exchange authorization via TCP using 2 SNs as relay**

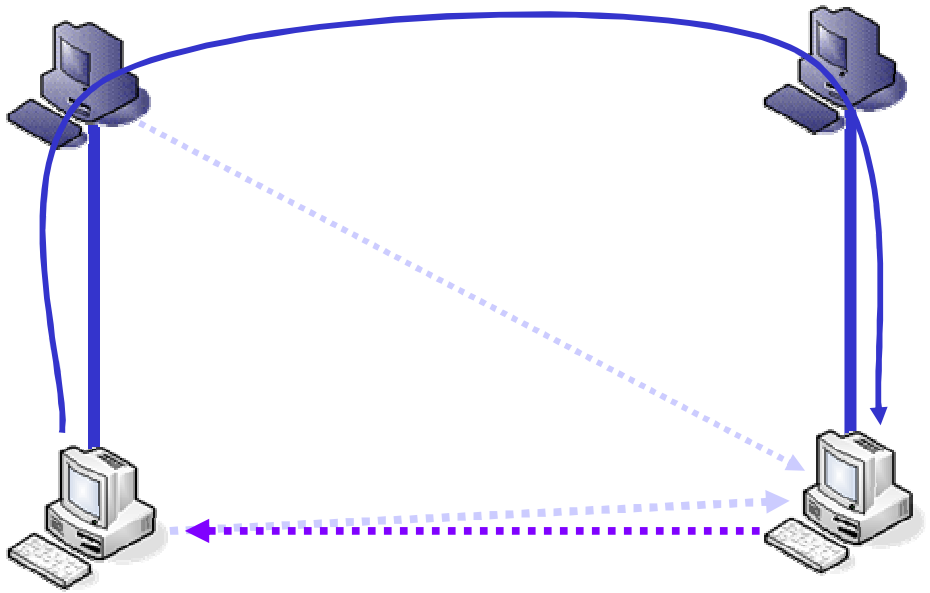


Buddy list signaling

- **Buddy list is a list of “friend” users**
- **Skype allow a user to know if buddies are online/offline**
  - **overlay network informs buddies when user change status**

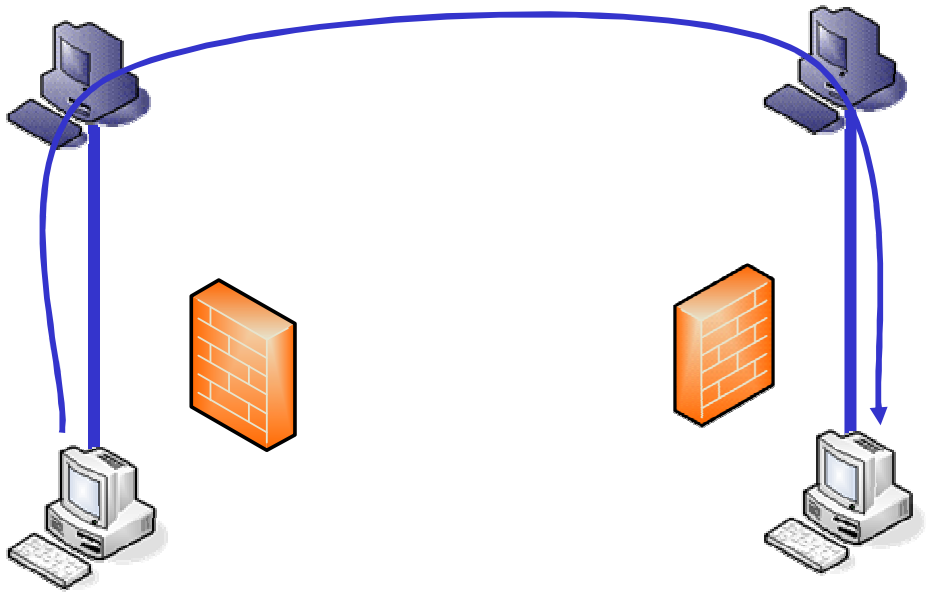
Buddy List signaling procedure

- **A user going on-line informs his buddies either directly using UDP or via the SNs.**
- **When going off-line, a user tear down the TCP connection with the SN.**
- **The SN informs via UDP the buddies that the user is going off-line**
- **To have a confirmation buddies try to ping the user.**



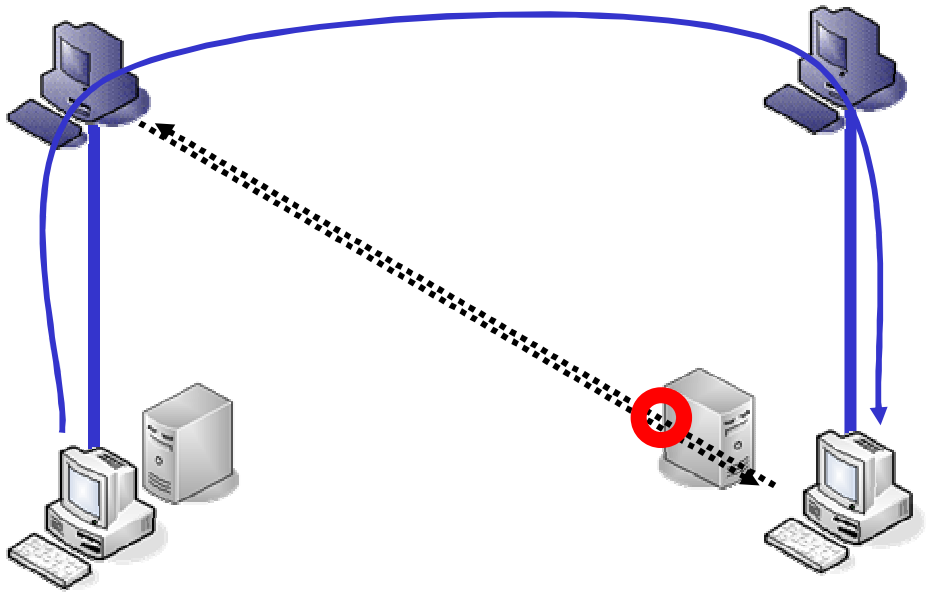
Buddy List signaling: Firewall blocking UDP

- **Since UDP traffic is blocked, on-line/off-line signalling is performed via the SNs**



Buddy List signaling: Port restricted NAT

- On-line/off-line signaling is performed in a way similar to that depicted in previous slide.
- As a difference after the change of status, buddies query the SN of the user for confirmation.

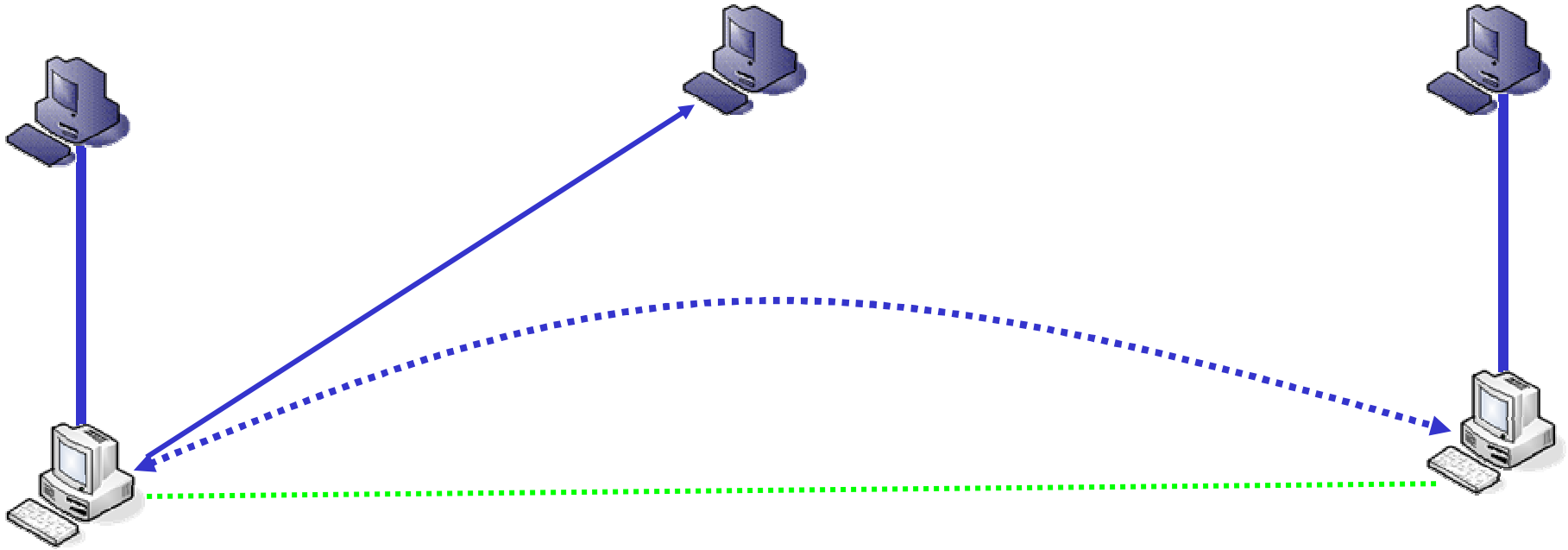


Call establishment function

- **Signaling performed using TCP connection**
  - **overlay network used only if otherwise impossible**
- **Media carried over UDP when possible**
  - **in case relay servers are used**

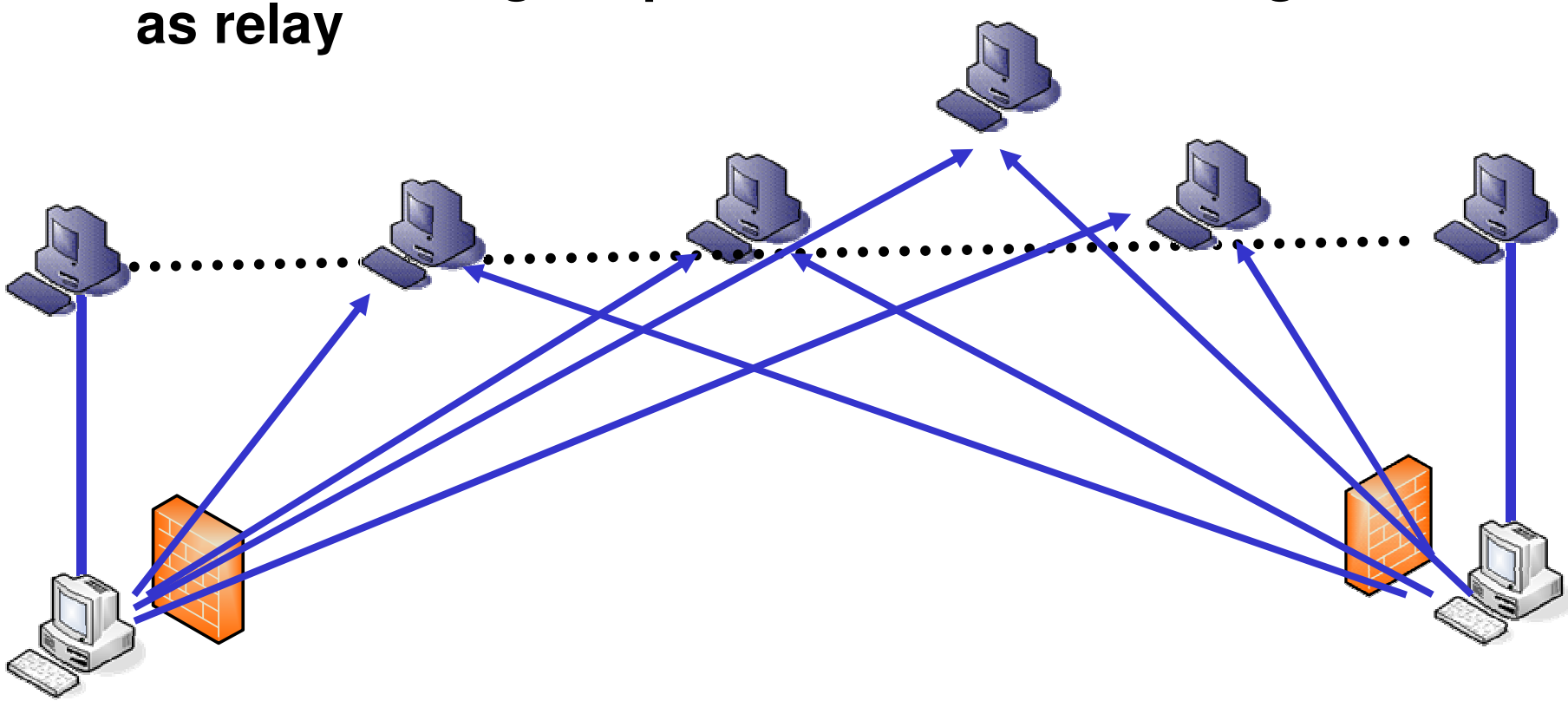
Call establishment procedure

- **User A wants to call user B, so he query some SNs for user B address.**
- **Once he gets user B address they exchange signaling over TCP**
- **Voice traffic carried via UDP**



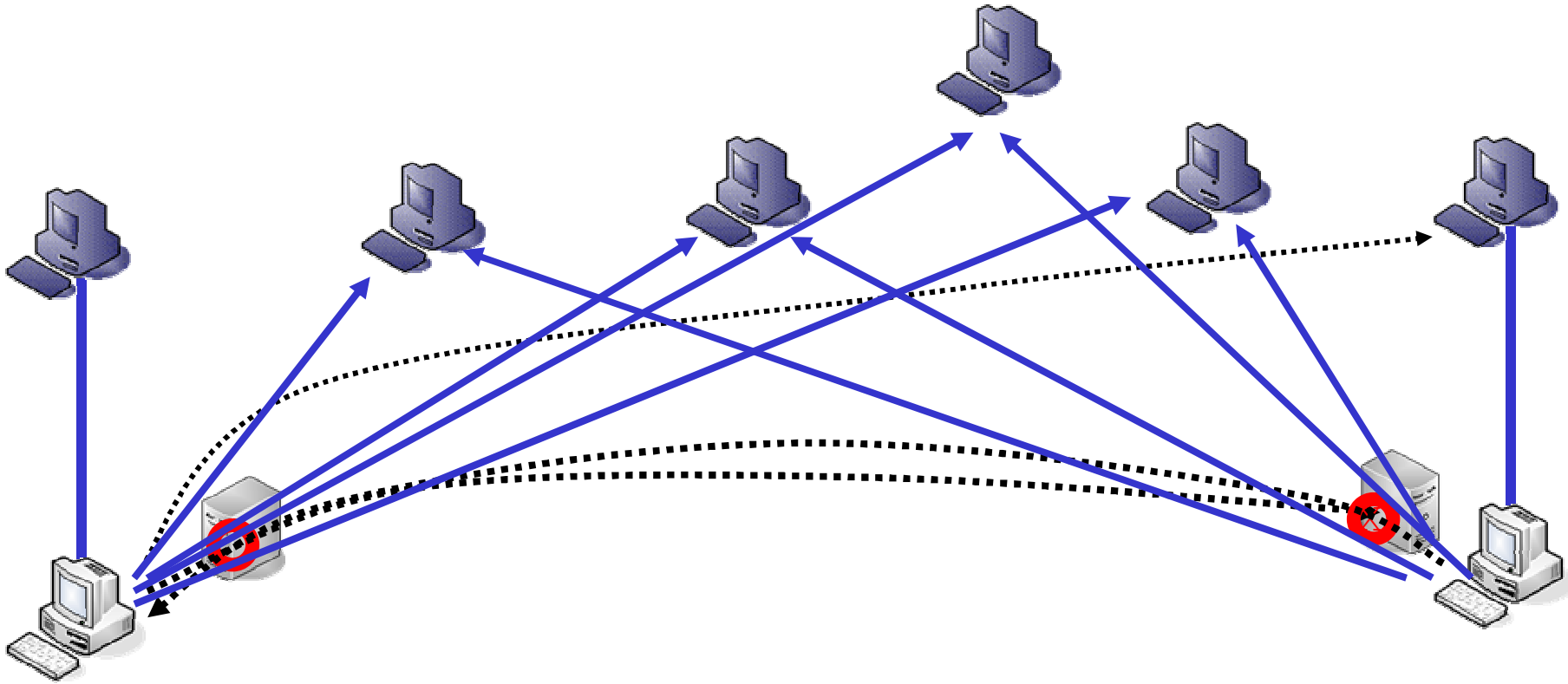
Call establishment: firewall blocks UDP

- **Signaling exchanges are performed by the SNs on behalf of the users**
- **Media exchange is performed via TCP using 4 SNs as relay**



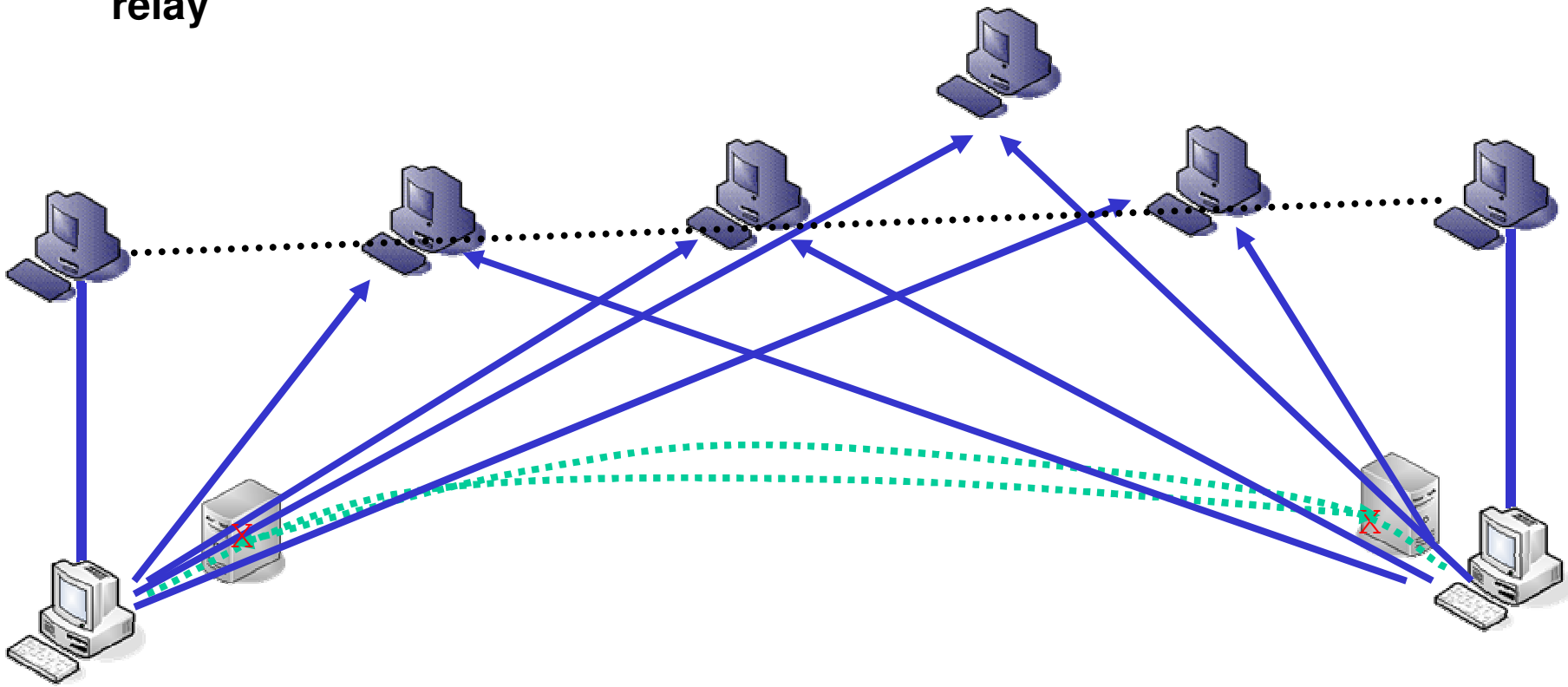
Call establishment: Port restricted NAT

- Once User A gets the address of the SN responsible for user B he queries for his address. SN informs B that user A wants to call him, and tells external address of B to A.
- A and B establish UDP flow using reverse hole punching
- They also establish TCP connection using 4 SNs as relay



Call establishment: Symmetric NAT

- User A and B communicate their addresses via their SNs
- They try reverse hole punching but it won't work because of NATs restrictions
- To establish the media and signalling channel they will use 4 SNs as relay



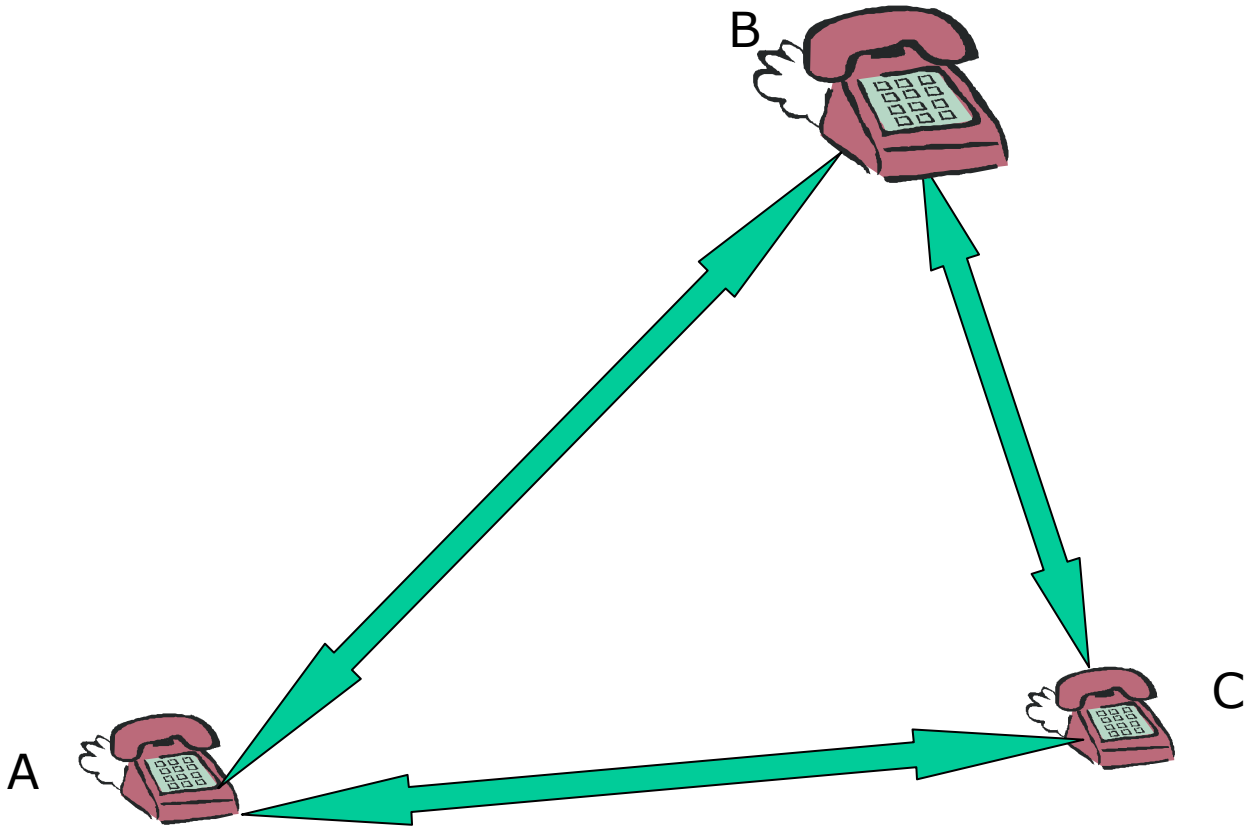
Lesson learned

- Traversal is well possible in many cases without explicit signaling to the middlebox
  - open public access network
  - protected enterprise networks
- Reverse hole punching and tunneling techniques workarounds allow Peer-to-peer communications in almost every scenario
  - Skype only fails completely if firewall blocks TCP but in fact that is a very uncommon case
- Explicit middlebox signaling protocols (like IETF MIDCOM MIB, CheckPoint OPSEC, NEC's SIMCO) are still required for
  - highly protected access network
  - applying security policies by network operator
  - anyway Skype will undermine many of these policies
- Skype tries to use IP network instead of overlay
  - SNs can't assure constant presence
  - avoid overlay congestion

Audio Conference

- Based on traffic mixing in one of the nodes
- Limited to few nodes (5-6)
- Works also with some nodes behind NAT/FW
- The mix node is elected based on it elaboration capabilities, since mixing is CPU intensive
- It does not need to be the conference initiator

Audio Conference: signaling



Audio Conference: audio flows