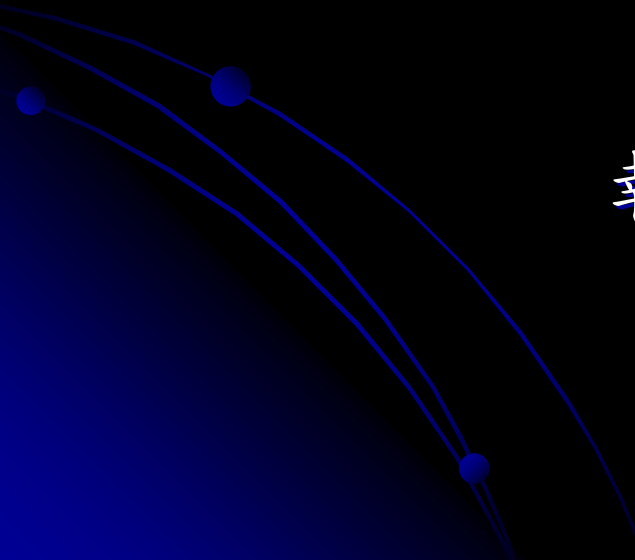
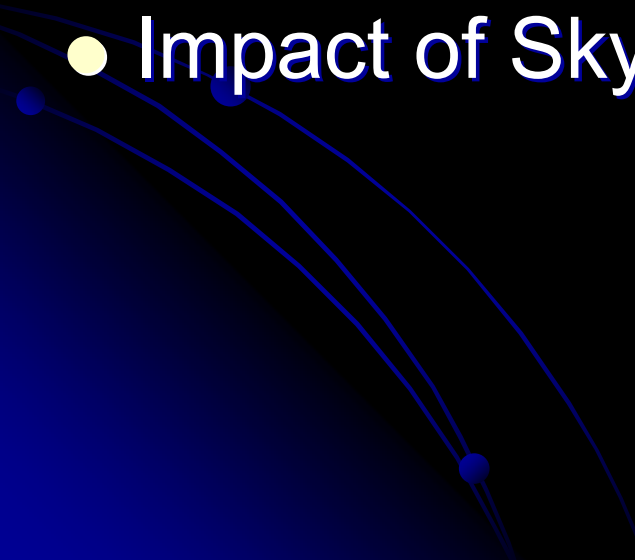


An Analysis of the Skype Peer-to-Peer Internet Telephony Protocol

報告人：唐崇實

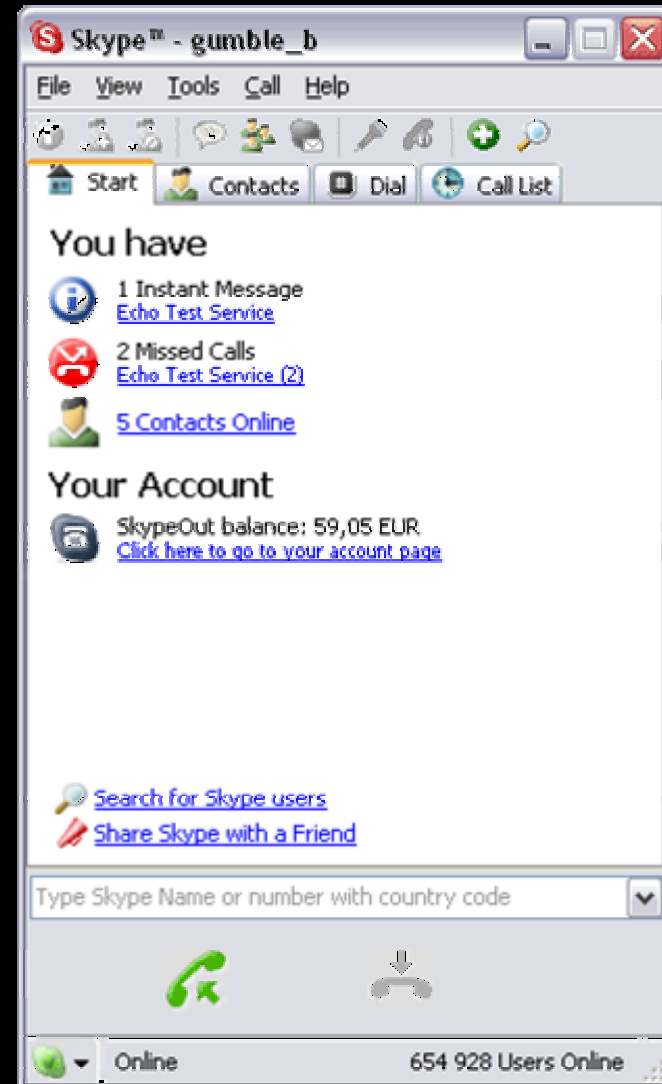


Outline

- Introduction to Skype
 - Skype Features
 - Skype Network and Key Components
 - Skype Functions
 - Impact of Skype
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What is Skype

- A peer-to-peer (P2P) overlay network for VoIP and other applications, developed by Niklas Zennstrom and Janus Friis, who founded KaZaA
- For users, it's an Instant Messaging (IM) software that supports VoIP
- Free on-net VoIP service and a fee-based off-net SkypeOut service that allows calling to PSTN and mobile phone



Usage Status

- More than 38 millions of software download
- More than 7 millions of registered subscribers
- More than 1 million concurrently on-line subscribers,
- More than 2 million on-line subscribers per day
- More than 2.7 billion minutes served: minutes of free Skype-to-Skype calls
- Supported Operating Systems : Windows, Mac OS X, Linux and Pocket PC

Comparison of IM System

	Skype	MSN	Yahoo Messenger
Presence	√	√	√
Chat (IM)	√	√	√
Voice	√	√	√
File transfer	√	√	√
Video		√	√
Others	<ol style="list-style-type: none">1. 圖片顯示2. Voice Conference3. SkypeOut	<ol style="list-style-type: none">1. 圖片顯示2. 手機簡訊3. 即時遊戲4. 網頁資訊	<ol style="list-style-type: none">1. 聊天室2. 收音機3. 手機簡訊4. 網頁資訊

Compared with VoIP Software

- Products which have a true cost-saving advantage over standard telephones do not have comparable quality.
- Call-completion rates are very low due to firewalls and the use of Network Address Translation (which renders over 50% of residential computers unable to communicate with traditional VoIP software).
- The User Interface is typically bloated and requires substantial configuration and technical skills.

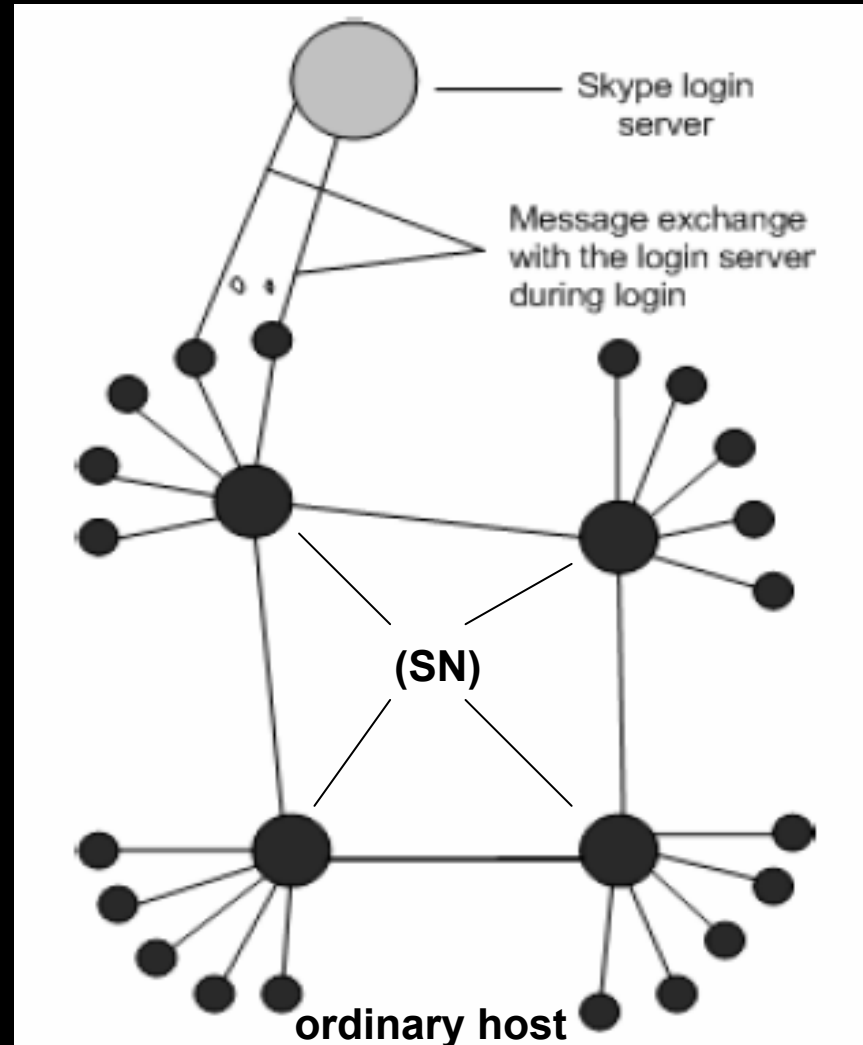
Softphone MOS Measurement

- Compare Skype with other SIP-based softphones, measure the voice quality in MOS

Softphone	Channel A (NB)				Channel B (PC)			
	Min.	Mean	Max.	Std-dev	Min.	Mean	Max.	Std-dev
Skype	3.31	3.51	3.69	0.14	3.36	4.06	4.27	0.33
SJPhone	2.18	2.83	3.18	0.25	3.54	3.84	4.13	0.16
X-Lite	2.36	3.04	3.52	0.36	4.34	4.36	4.37	0.01

Skype Network

- Any node with a public IP address having sufficient CPU, memory and network bandwidth is a candidate to become a super node
- An ordinary host must connect to a super node and must register itself with the Skype login server



Key Components of Skype (1/2)

- Ports

- A Skype client (SC) opens a TCP and a UDP listening port configured in its connection dialog box

- Host Cache (HC)

- A list of super node IP address and port pairs that SC builds and refreshes regularly
- A SC stores HC in the Windows registry

- Codecs

- A wideband codec allowing frequencies between 50-8K Hz, which is Implemented by Global IP Sound

Key Components of Skype (2/2)

- Buddy List
 - Skype stores buddy information in Windows registry
 - Buddy list is digitally signed and encrypted, local to machine and not on a central server
- Encryption
 - Skype uses 256-bit AES encryption
 - Skype uses 1536 to 2048 bit RSA to negotiate symmetric AES keys
- NAT and Firewall
 - SC uses a variation of the STUN and TURN protocols to determine the type of NAT and firewall

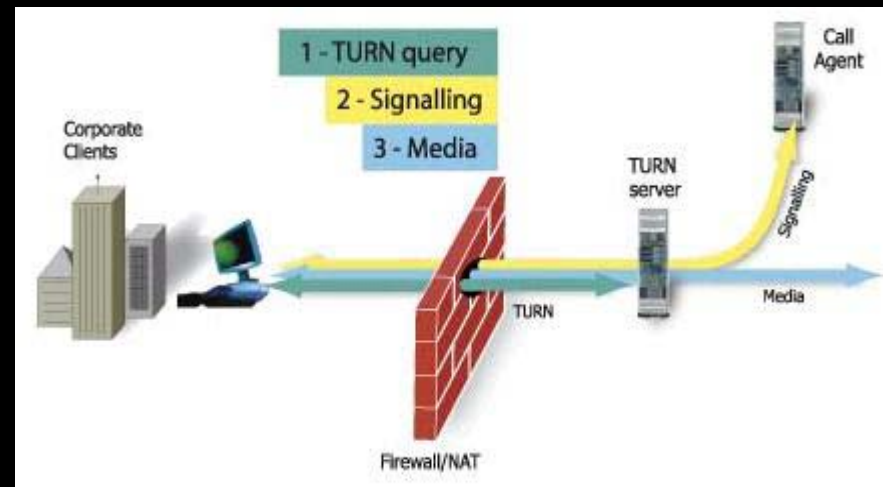
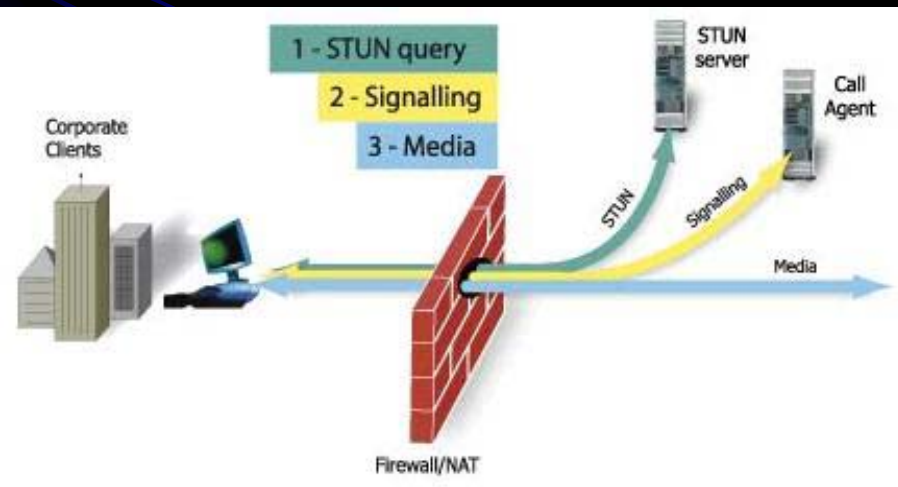
STUN and TURN

- STUN:

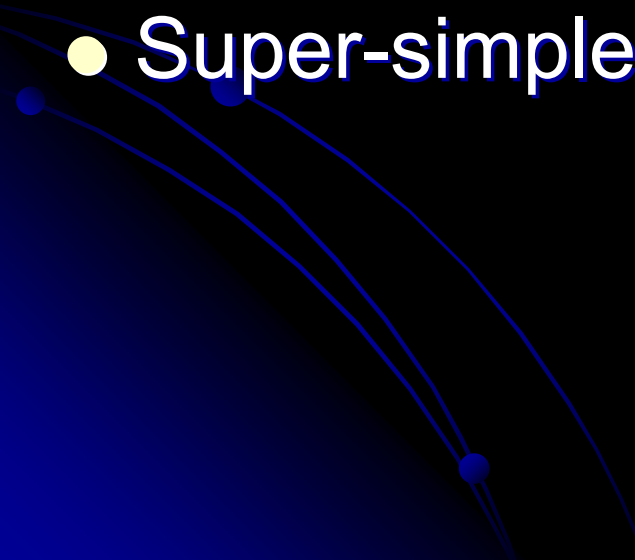
- Simple Traversal of UDP through NAT
- Doesn't work through symmetric NAT

- TURN:

- Traversal Using Relay NAT
- Increase latency and packet loss



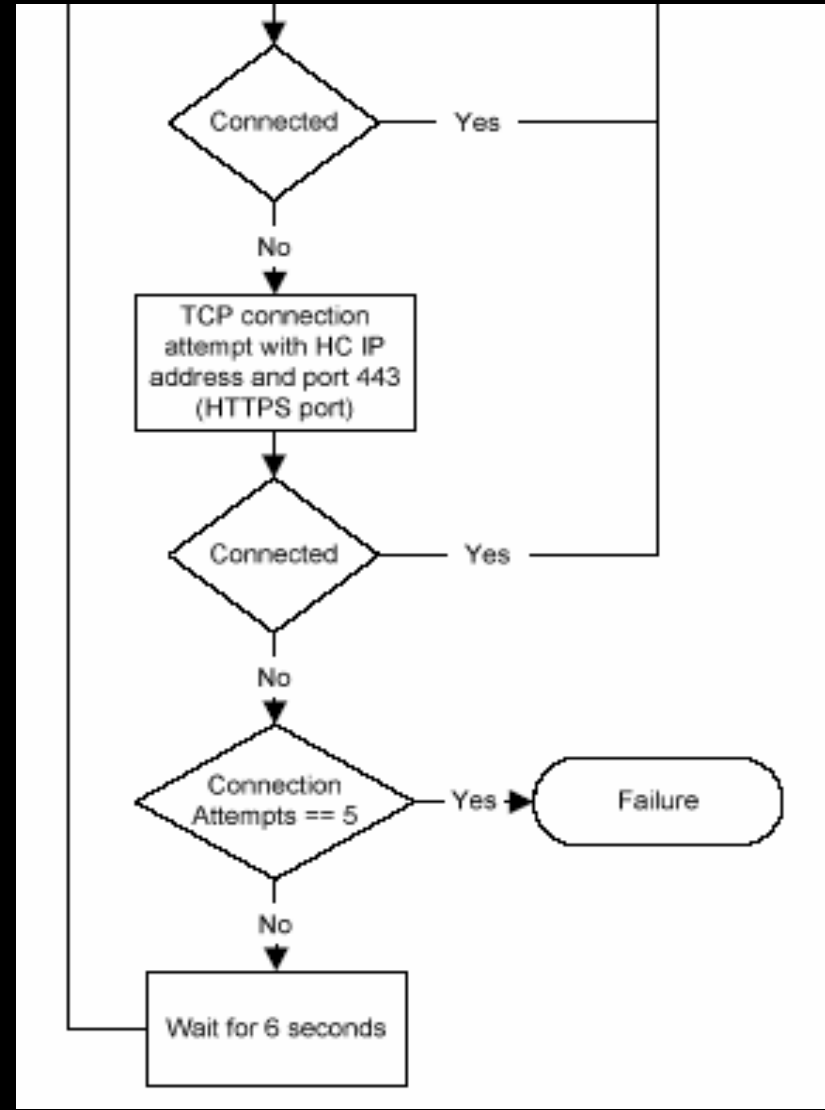
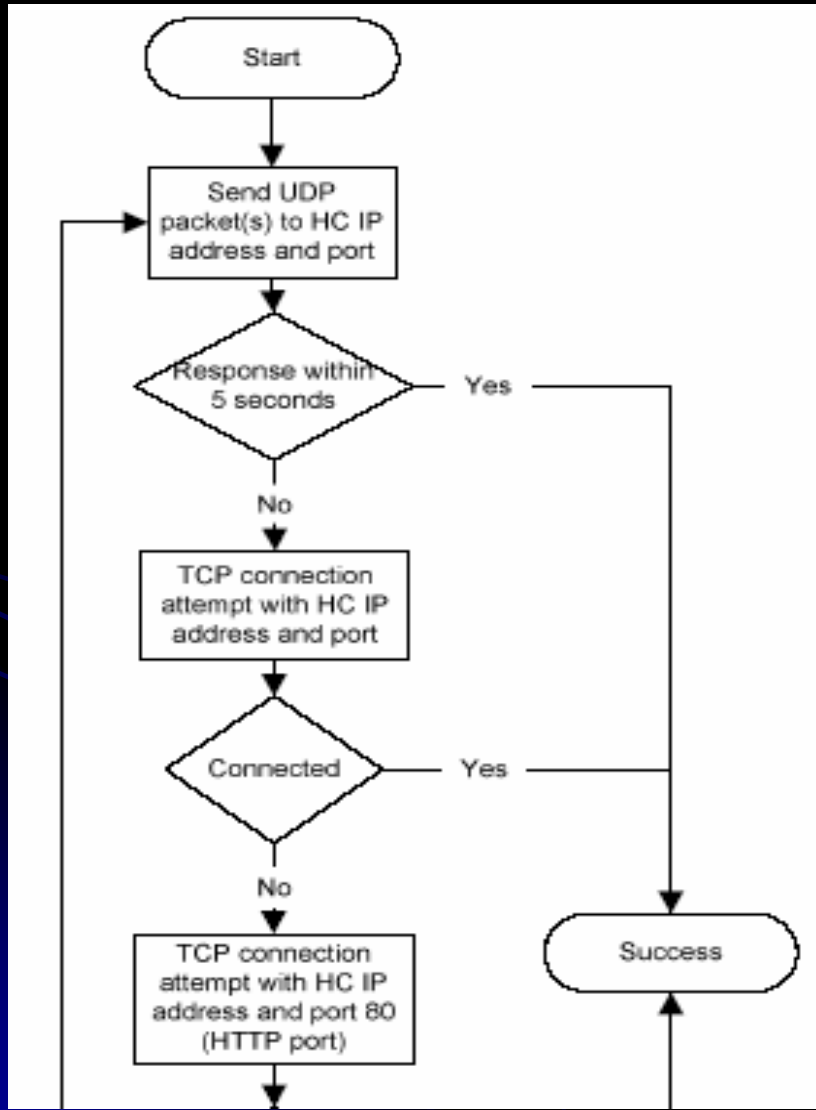
Techniques used in Skype

- Firewall and NAT traversal
 - Global decentralized user directory
 - Intelligent routing
 - Security
 - Super-simple UI
- 

Login

- During login process, a SC
 - Authenticates its user name and password with the login server
 - Advertises its presence to other peers and its buddies
 - Determines the type of NAT and firewall it is behind
 - Discover online Skype nodes with public IP addresses
- Login server is the only central component in the Skype network

Skype Login Algorithm



Skype Login Process (1/3)

- After installation and first time startup, HC was observed empty
- Bootstrap Super Nodes:
 - After login for the first time after installation, HC was initialized with seven IP:port pairs
- Bootstrap IP:port information is either
 - Hard coded in SC;
 - Encrypted and not directly visible in Skype Windows registry; or
 - A one-time process to contact bootstrap node

Skype Login Process (2/3)

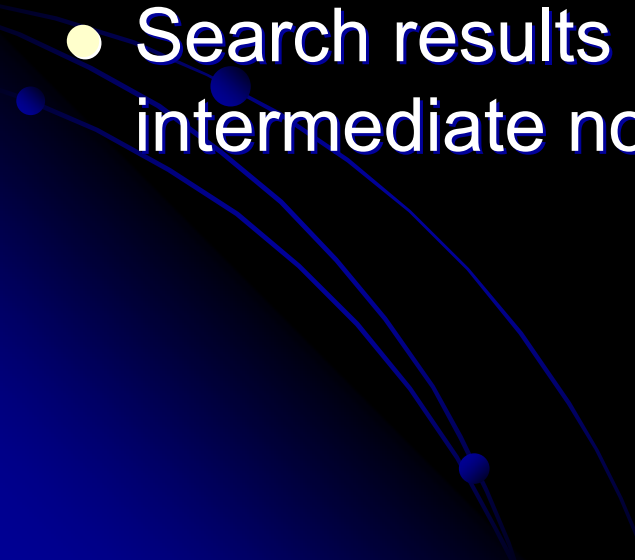
- **First-time Login Process**
 - SC sends UDP packets to some bootstrap SNs
 - SC establishes a TCP connection with the bootstrap SNs that respond
 - SC perhaps acquires the address of login server from SNs
 - SC establishes a TCP connection with login server, exchanges authentication information
- **Subsequent Login Process**
 - Similar to the first-time login process
 - SC uses login algorithm to determine at least one available peer and establishes a TCP connection
 - HC was periodically updated with new peers' IP:port

Skype Login Process (3/3)

- Comparison of three network setups
 - Exp A: Both Skype users with public IP addresses
 - Exp B: One Skype user behind port-restricted NAT
 - Exp C: Both Skype users behind a port-restricted NAT and UDP-restricted firewall
- Message flows for first-time login process
 - Exp A and Exp B are roughly the same,
 - Exp C only exchange info over TCP

	Total Data Exchanged	Login Process Time
Exp A	About 9 KB	3~7 seconds
Exp B	About 10 KB	3~7 seconds
Exp C	About 8.5 KB	About 34 seconds

User Search

- Skype uses Global Index technology to search for a user
 - Skype claims that search is distributed and is guaranteed to find a user if it exists and has logged in during last 72 hours
 - Search results are observed to be cached at intermediate nodes
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Call Establishment and Teardown

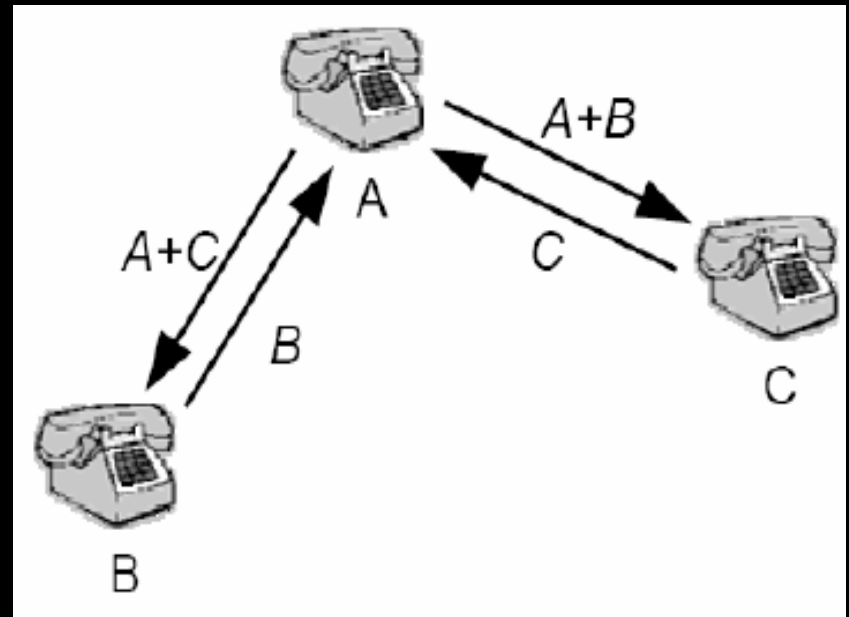
- Call signaling is always carried over TCP
- For user not present in buddy list, call placement is equal to user search plus call signaling
- If caller is behind port-restricted NAT and callee is on public IP, signaling and media flow through an online Skype node which forwards signaling to callee over TCP and routes media over UDP
- If both users are behind port-restricted NAT and UDP-restricted firewall, both caller and callee SCs exchange signaling over TCP with another online Skype node, which also forwards media between caller and callee.

Media Transfer and Codec

- Bandwidth usage: 3~16 Kbytes/s
- Skype allows peers to hold a call. To ensure UDP binding, a SC sends three UDP packets per second to the call peer on average
- No silence suppression is supported in Skype
- The min. and max. audible frequencies Skype codecs allow to pass through are 50 Hz and 8000 Hz
- Uplink and downlink bandwidth of 2 KB/s each is necessary for reasonable call quality

Conferencing

- A acts as a mixer, mixing its own packets with those of B and sending to C and vice versa
- For a three party conference, Skype does not do full mesh conferencing
- The most powerful machine will be elected as conference host and mixer
- Two-way call: 36 kb/s
Three-way call: 54 kb/s



Impact of Skype

- Impact on fixed-line operator
 - Skype will introduce SkypIN
- Impact on mobile phone operator
 - Skype will be imbedded in Wi-Fi/mobile phone
 - WLAN is now limited by
 - Not many Wi-Fi phone models
 - Wi-Fi phone's high price
 - Battery life
 - Not enough hot-spots

Impact of Skype

- Skype has shown, or at least has suggested, the following:
 - Signaling, the most unique property of traditional phone systems, can now be accomplished effortlessly with self-organizing P2P networks
 - P2P overlay networks can scale up to handle large-scale connection-oriented real-time services such as voice
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