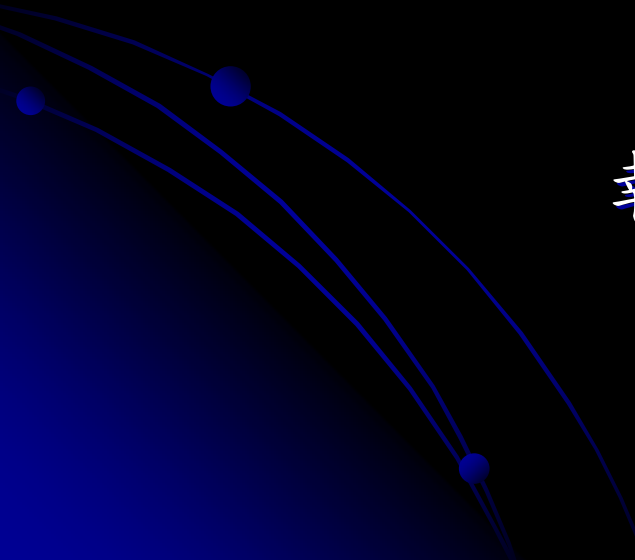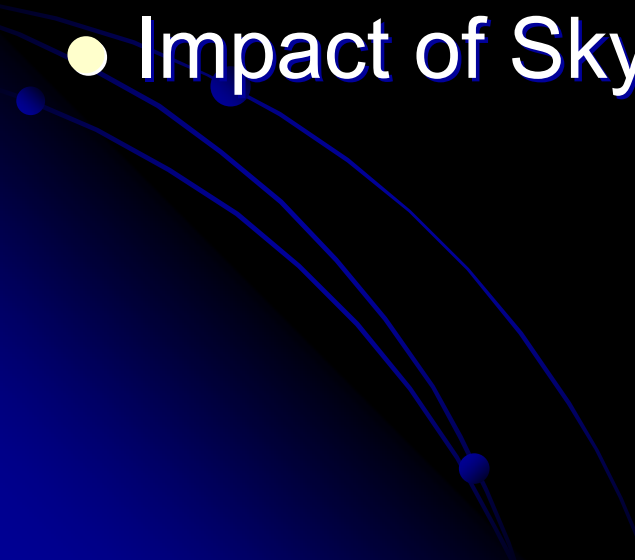# An Analysis of the Skype Peer-to-Peer Internet Telephony Protocol

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Outline

- Introduction to Skype

- Skype Features

- Skype Network and Key Components

- Skype Functions

- Impact of Skype

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
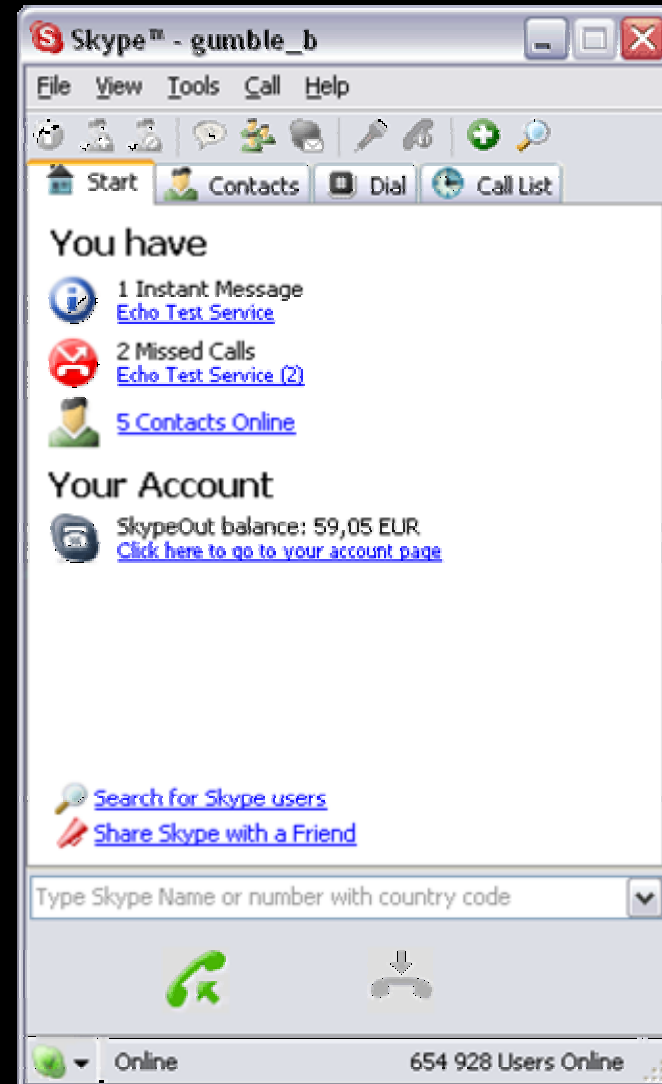
Usage Status

- 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	1. 圖片顯示 2. Voice Conference 3. SkypeOut	1. 圖片顯示 2. 手機簡訊 3. 即時遊戲 4. 網頁資訊	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

Skype login server

Message exchange with the login server during login

(SN)

ordinary host
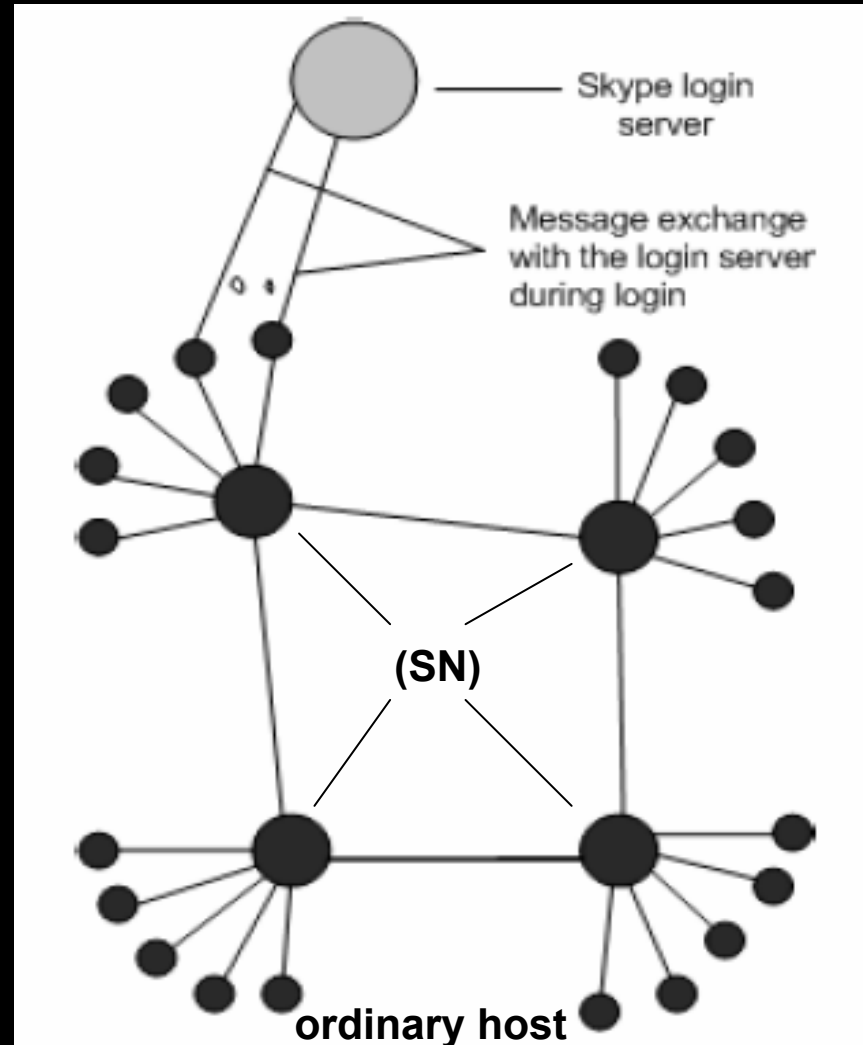
Key Components of Skype (1/2)

- 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
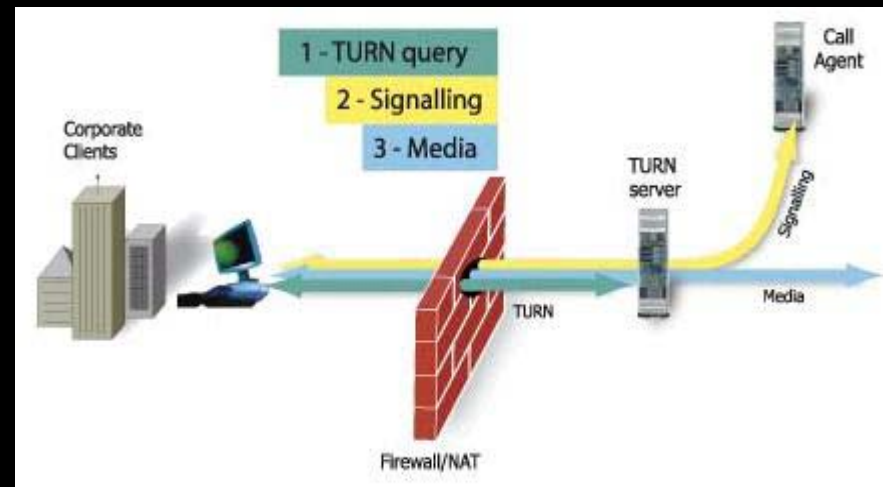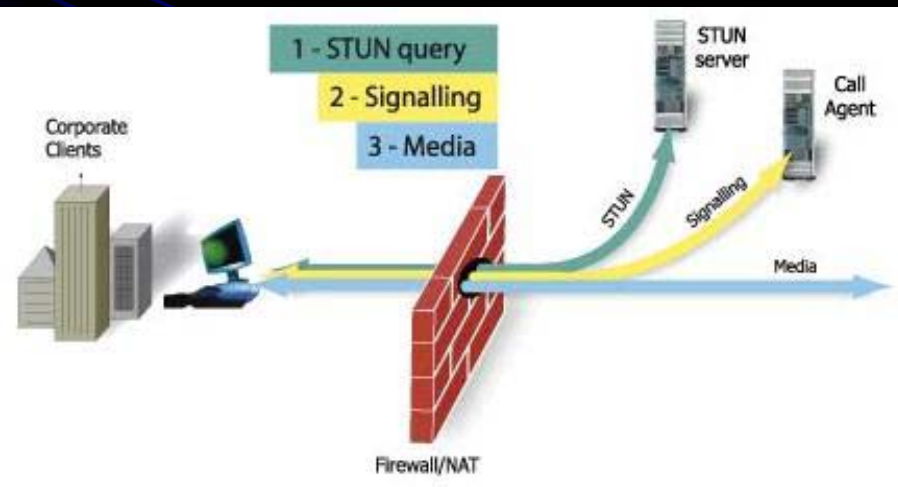 - SC uses a variation of the STUN and TURN protocols to determine the type of NAT and firewall
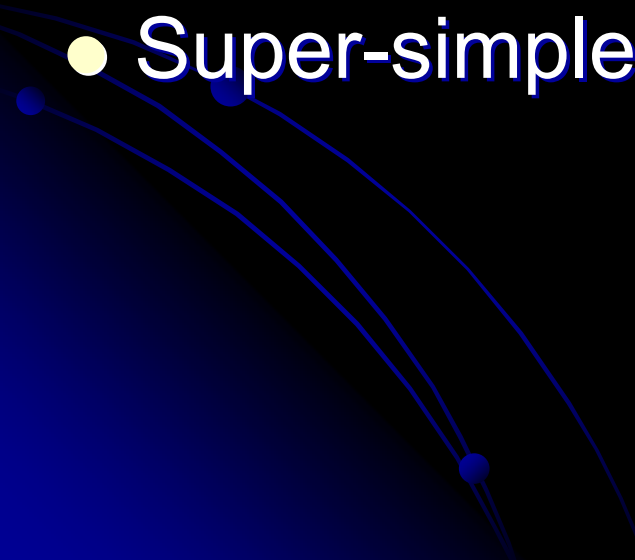
STUN and TURN

- 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
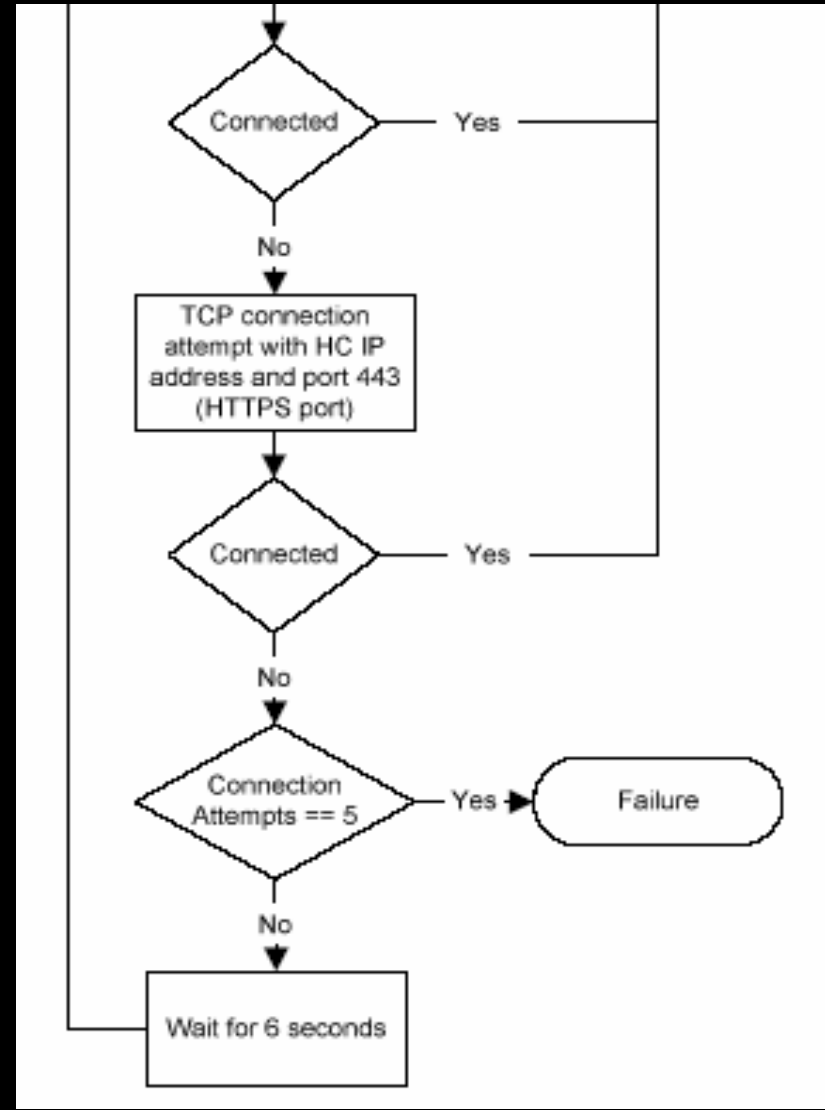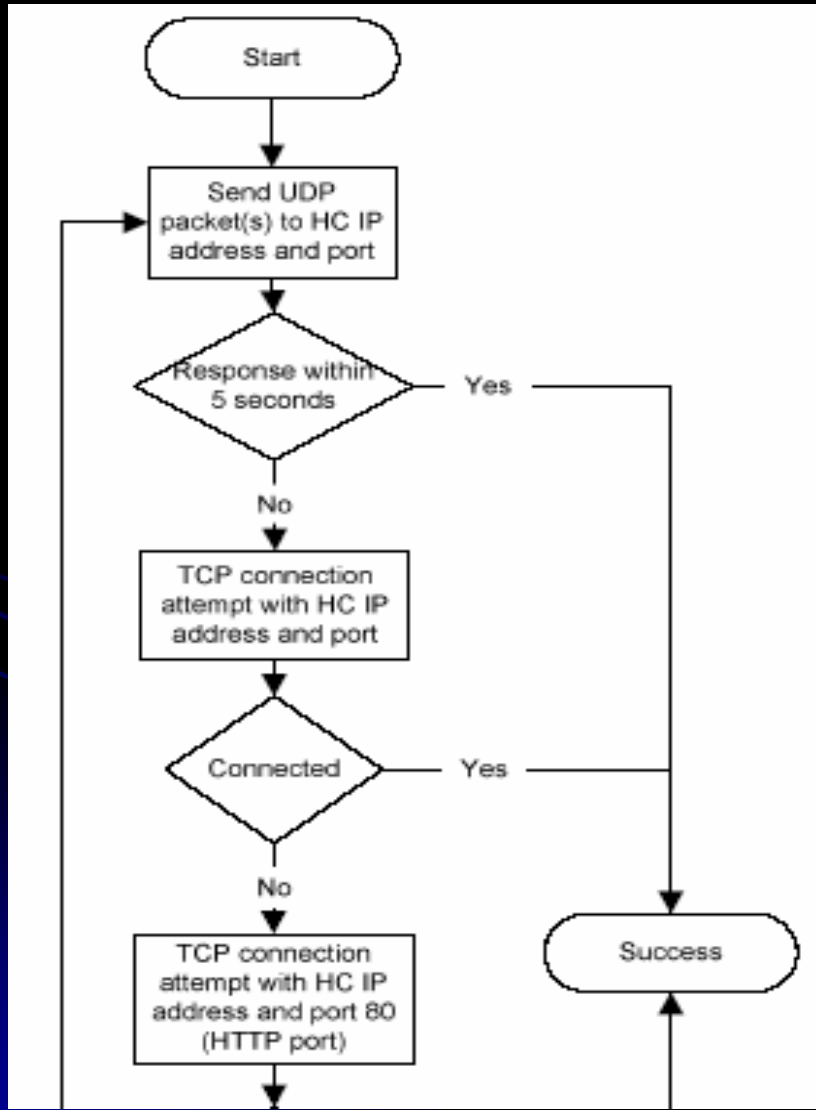
Skype Login Process (1/3)

- 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
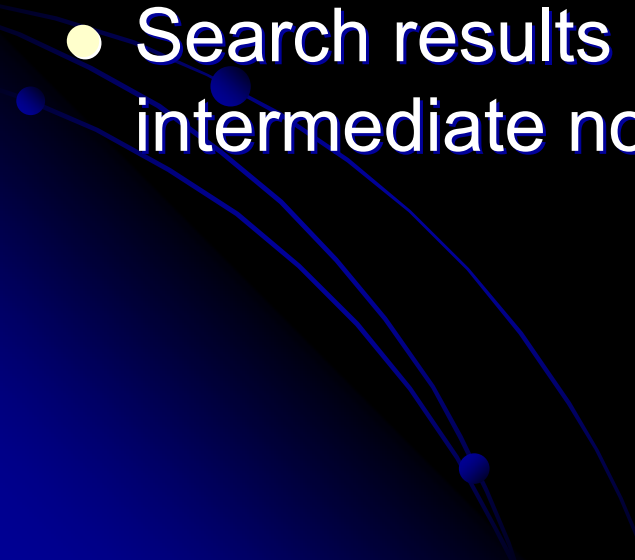
Skype Login Process (2/3)

- 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

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
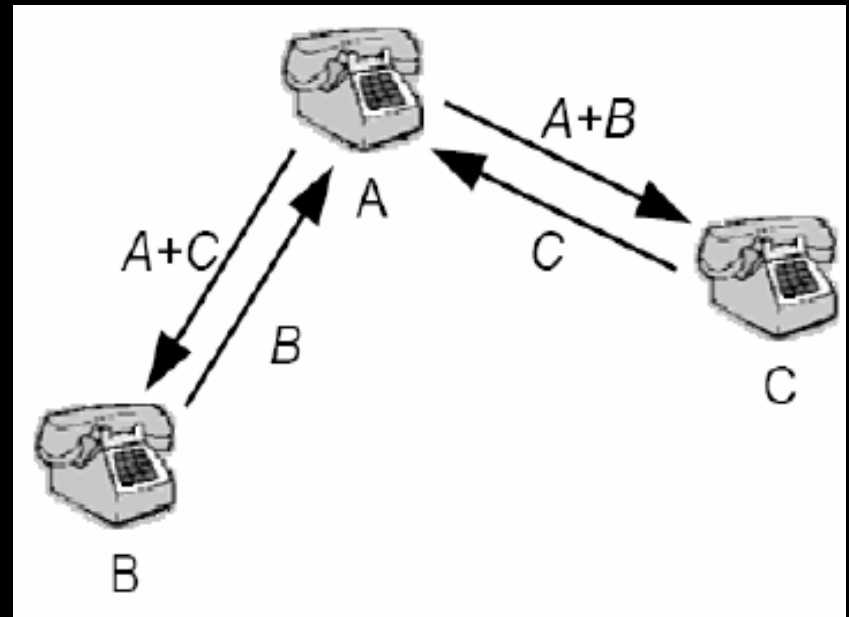
Impact of Skype

- 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