We find

that there is *very little churn* in the supernode network, and

that supernodes demonstrate *diurnal behavior* causing median

session times of several hours. Further, we \_nd that *session*

*lengths are heavy-tailed* and are not exponentially distributed.

the number of Skype supernodes

is more stable than the number of online Skype users.

with peak

usage during normalworking hours and signi\_cantly reduced

usage (40.50%) at night. In addition, there are weekly vari­

ations with 20% fewer users online on weekends than on

weekdays. The maximum number of users online was 3:9

million on Wednesday, Sep. 28 around 11am EST. In com­

parison, of the 6000 randomly­selected supernodes pinged,

only 2078 responded to pings at least once during our trace,

and between 30.40% of them are online

While client population varies by over 40% on any given

day, supernode population is more stable and varies by under

25%.

Combined with the lower weekend­usage from

the previous graph, there is evidence to conclude that Skype

usage, at least for those nodes that become supernodes, is

correlated with normal working hours. This is different

from P2P \_le­sharing networks where users download \_les in

batches that are processed over days, sometimes weeks

As has been observed widely for interactive appli­

cations like telnet, web, and email [20, 9], node arrivals in

Skype are concentrated towards the morning, while depar­

tures are concentrated towards the evening (

Skype uses spare network and computing resources of hun­

dreds of thousands of supernodes, and little additional infras­

tructure to handle calls, as compared to traditional telephone

companies and wireless carriers who rely on expensive, ded­

icated, circuit­switched infrastructure.

*Supernode bandwidth consumption.* Figure 4 shows that our

Skype supernode uses very little bandwidth most of the time.

The bandwidth used by our supernode is plotted for 30 second

intervals. Fifty­percent of the time, our supernode consumes

less than 205 bps.

*VoIP silence suppression.* We also observe that Skype does

not use silence suppression and sources 33 packets per sec­

ond for all VoIP connections regardless of speech charac­

teristics. Clearly using this simple technique could reduce

client bandwidth consumption. It would also reduce supern­

ode bandwidth because calls that cannot be completed in a

direct peer­to­peer fashion are relayed via a supernode.

Skype calls *last longer* than calls in traditional telephone

networks, and that \_les transferred are *smaller* than in \_le­

sharing networks.

The supernode is engaged in relaying data 9.6% of the

time. This value is smaller than we expected; it is explained

by Skype's use of NAT traversal that successfully establishes

direct VoIP/\_le­transfer sessions through many NATs. For

relayed data, the supernode uses 60 kbps in the median

In addition to the network bandwidth,

our supernode consumed negligible additional processing

power, memory and storage as compared to an ordinary node.

inter­arrival time of relayed VoIP

sessions and \_le­transfer sessions may be Poisson.

the

median Skype call lasted 2m 50s, while the average was

12m 53s. The longest relayed call lasted for 3h 26m. The

average call duration is much higher than the 3­minute aver­

age for traditional telephone calls

VoIP is free, while phone calls are charged.

The median \_le­transfer size is 346 kB (Figure 5(c)). The

size is similar to documents, presentations and photos, and

is much smaller than audio or video \_les in \_le­sharing net­

works

Stability of the su­

pernode population tends to mitigate churn in the network.

Supernodes typically use little bandwidth even though they

relay VoIP and \_le­transfer traf\_c in certain cases.