Communication Systems
Network Applications - Online Services

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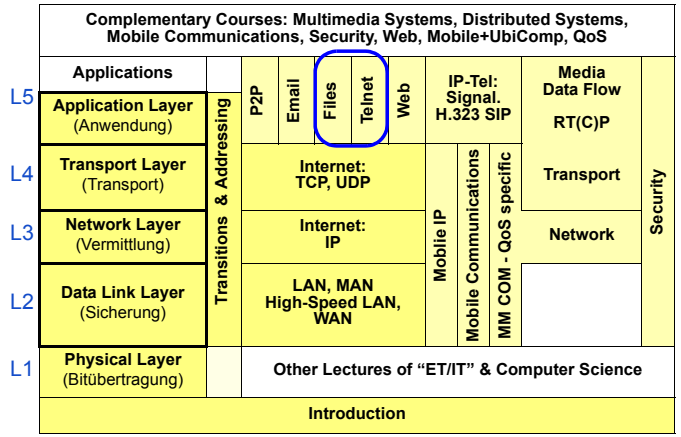
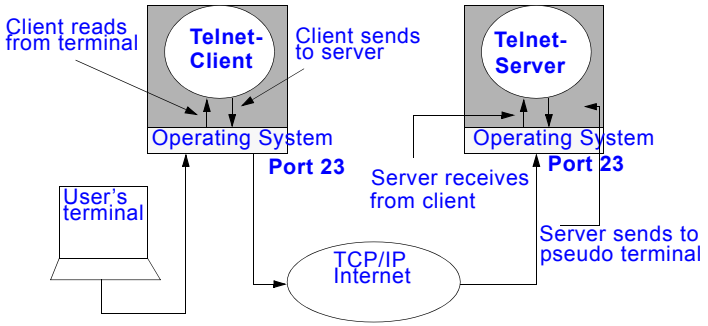
Scope



Overview

1. Remote Login: Telnet



Functionality:

- **remote login**
- **"Network Virtual Terminal"**
- **full screen, i.e. scrolling but no graphics capability**
- **simple terminal protocol**
- **permits negotiations of options (e.g. data transfer: binary or ASCII)**

Remote Login: Telnet (2)

Implementation

- based on TCP connection between client and server
- uses Port 23
- RFC 854: Telnet protocol specification
  J. Postel, J.K. Reynolds. May-01-1983 and supplements

Telnet: example

```
$ telnet login01.kom.e-technik.tu-darmstadt.de
Trying 130.83.245.97...
Connected to login01.kom.e-technik.tu-darmstadt.de.
Escape character is '^]'.
Technische Universitaet Darmstadt
Multimedia Kommunikation - KOM

login: <userid>
Password: ...
[<userid>] ~ $
```

But Telnet is insecure:

- clear text password

Hence, nowadays mainly switched off and replaced by ssh

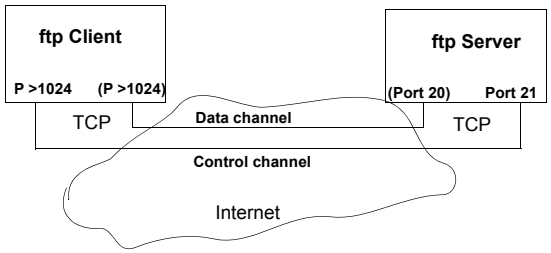
```
...
telnet: Unable to connect to remote host: Connection refused
```


2. Data Transfer - File Transfer Protocol (ftp)

File Transfer allows for

- file transfer
  - send (put, mput)
  - receive (get, mget)
- file transfer in
  - binary
  - textual mode (ascii)
- file manipulation
  - delete (del)
  - rename
- directory operations
  - print working directory (pwd),
  - list directory's contents (ls, dir)
  - create /remove directories (mkdir, rmdir)
  - change directory (cd)
- user identification or "anonymous ftp"
  - of an account/name (user)
  - identification (password)
- additional possibilites (help, etc.)

File Transfer - File Transfer Protocol (2)



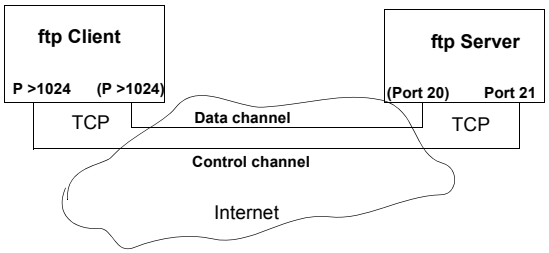
Functionality

- uses TCP for data communication
- ftp client runs as a programm within the user's address space

Some Remarks

- no integration into local file system
  - i.e. no transparency
- does not use a spooler

Data Transfer - File Transfer Protocol (ftp) (3)



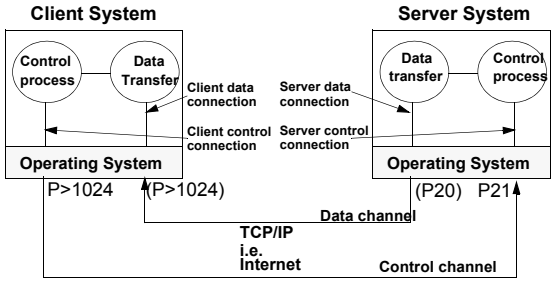
Commands

- transmitted as a 4-character sequence plus options
- e.g. PASS xyz

Response

- sequence consisting of 3 numbers
- first number indicates error status
  - 1,2,3: no error
  - 4,5: error

Data Transfer - File Transfer Protocol (ftp) (4)



TCP control connection

- **exists while the systems interact**
- **therefore can also execute other functions during data transfer**
  - because of 2 connections

TCP data channel

- **for data transfer and data of directory listings (multiline response)**
- **reconnects and disconnects for each data transfer**
- **connection set-up is done in reverse direction**

2.1 Example of an ftp Session (User's Perspective)

```
$ftp
   ftp>
ftp> open ftp.kom.tu-darmstadt.de
   Connected to conga.kom.e-technik.tu-darmstadt.de.
   220 conga.kom.e-technik.tu-darmstadt.de FTP server
   (Version wu-2.4.2-academ[BETA-12](1) Wed Mar 5
   12:37:21 EST 1997) ready.
   Name (ftp:janedoe):

Name (ftp:janedoe): anonymous
   331 Guest login ok, send your complete e-mail address
   as password.
   Password:

Password: **my-passwort e-mail-Adr not-displayed**
   230-******************************************
   230-Welcome to KOM's FTP-Server!
   230 Guest login ok, access restrictions apply.
   ftp>
```


Example of an ftp Session (User's Perspective) (2)

```
ftp> ls
   200 PORT command successful.
   150 Opening ASCII mode data connection for file list.
   pub
   priv
   incoming

   226 Transfer complete.
   21 bytes received in 0.017 seconds (1.2 Kbytes/s)
   ftp>

ftp> pwd
   257 "/" is current directory.
   ftp>
```


Example of an ftp Session (User's Perspective) (3)

```
ftp> get
   (remote-file)
(remote-file) pub/index.html
   (local-file)
(local-file) i.tmp
   200 PORT command successful.
   150 Opening ASCII mode data connection for pub/
   index.html (1339 bytes).
   226 Transfer complete.
   local: i.tmp remote: pub/index.html
   1375 bytes received in 1.6 seconds (0.86 Kbytes/s)
   ftp>
ftp> close
   221 Goodbye.
   ftp>
ftp> quit
   $
```

2.2 Example for ftp Commands (System's Perspective)

Here: telnet has been used to emulate ftp

```
$ telnet conga 21
   Trying 130.83.139.247...
   Connected to conga.kom.e-technik.tu-darmstadt.de.
   Escape character is '^]'.
   220 conga.kom.e-technik.tu-darmstadt.de FTP server
   (Version wu-2.4.2-academ[BETA-12](1) Wed Mar 5
   12:37:21 EST 1997) ready.

USER ftp-guru
   331 Password required for ftp-guru.

PASS 4to1a-kom
   230 User ftp-guru logged in.
PWD
   257 "/home/ftp-guru" is current directory.
```


Example for ftp Commands (System's Perspective) (2)

```
HELP
   214-The following commands are recognized (* =>'s
   unimplemented).
     USER    PORT    STOR    MSAM*   RNTO    NLST    MKD     CDUP
     PASS    PASV    APPE    MRSQ*   ABOR    SITE    XMKD    XCUP
     ACCT*   TYPE    MLFL*   MRCP*   DELE    SYST    RMD     STOU
     SMNT*   STRU    MAIL*   ALLO    CWD     STAT    XRMD    SIZE
     REIN*   MODE    MSND*   REST    XCWD    HELP    PWD     MDTM
     QUIT    RETR    MSOM*   RNFR    LIST    NOOP    XPWD
   214 Direct comments to ftpadmin@kom.tu-darmstadt.de.
```

.. and so on

```
QUIT
   221 Goodbye.
   Connection closed by foreign host.
```


2.3 Additional Information

History

- **First specification**
  - 1971 from M.I.T.
  - RFC 114
- **Variations**
  - 1971 - 1985
  - more than 10 additonal changes and enhancements
- **Present version**
  - by J. Postel (and J.Reynolds)
  - as of Oct. 1985
  - RFC 959

Further details by experiments

- **as telnet session (see above)**
- **with sniffer**
  - e.g. make use of http://www.ethereal.com/
  - and record a simple ftp session

Simple File Transfer: Trivial File Transfer Protocol (TFTP)

Based on the UDP transport protocol

- **simpler**
- **less complex to implement, and less code**

Pure file transfer service

- **e.g. no possibility to view file system on remote system**
- **e.g. no possibility of authentication**

Application

- **e.g. bootstrapping over the network**

3. Network File Systems: nfs and afs/dfs

File Transfer Protokoll
- explicit data request
- explicit commands

Integration into the file system
- implicit data transfer
- benefit: transparency
  - locally and remotely stored data
    - treated the same/similarly
  - all programs use the data by means of read/write accesses

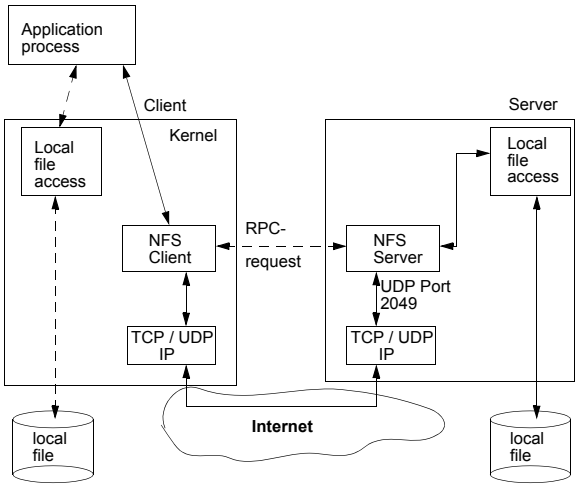
3.1 Network File System (nfs)

Network file system (nfs) for remote access to files in the network
- i.e. access to parts of files (as opposed to ftp)
- transparent access to files in remote file systems

History

1984	announcement
1985	first product presented by SUN
1986	porting for system V - release 2
1986	NFS 3.0: improved yellow pages (localization of files) and PC-NFS
1987	NFS 3.2: file locking
1989	NFS 4.0: encoding
1989	licensed by 260 suppliers

nfs Architecture

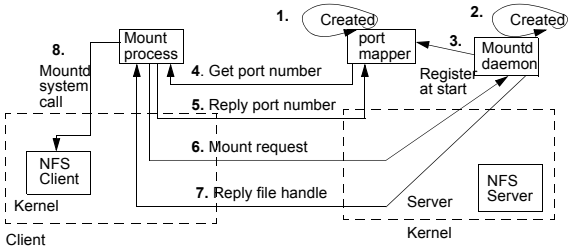


Characteristics

in general
- client-server model
- communication
  - originally only UDP
  - TCP enables nfs over WANs
- no presentation services, only byte stream read and write
- nodes import/export directories
- integrated into the operating system/file system

widespread because
- suitable for heterogeneous networks
- inexpensive
- open system (public specification)
- availability
  - simple to port to new platforms
  - public reference implementation
  - by now standard on almost all UNIX systems
  - component of e.g. UNIX-V-Release-4 since 1989
  - and e.g. PC-NFS for PCs

Implementing nfs: Mount Protocol



NFS
- protocol for file access only (read and write)
- providing remote file access by MOUNT protocol

MOUNT
- connects remote file system with local directory
- whole remote file tree is mounted into local directory
- followed by NFS remote file access just as if accessing local data

Implementing nfs: Mount Protocol (2)

MOUNT and NFS are
- separate protocols
- MOUNT or mountd supply information for NFS or nfsd (e.g. system name and paths)

Mountd and nfsd
- daemons with regard to Unix
- automatically started when the server is booted
- nfsd activates the NFS server code in the operating system

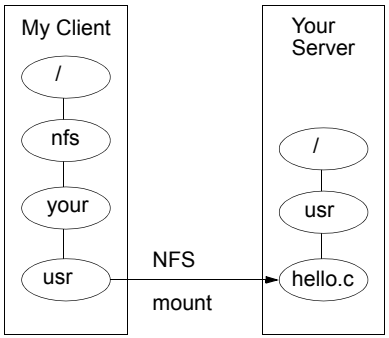
Mount process
- at nfs server
  - a “file handle” (unique file system control block) is generated
- to nfs client
  - the file handle is returned
- nfs client
  - uses file handles when accessing the remote (sub-)directory tree

Implementing nfs: Mount Protocol (3)

Example:

```
mount -t nfs your:/usr /nfs/your/usr
```

- i.e. address
  /nfs/your/usr/hello.c actually is /usr/hello.c



Specific nfs Problems

Security
- general problem
  - link to network always represents a potential security problem
  - Ethernet packets can be easily tapped (intercepted)
- solution
  - with version 4.0: NFS supports encryption
  - only privileged ports (<1024) permit data access
  - similar mechanism for MOUNT
  - comparison of
    - internet address
    - client name with /etc/hosts

Data consistency
- problem:
  - several remote NFS clients have simultaneous write access
- lock manager
  - allows for files to be locked
  - service parallel to NFS (lockd)
  - with NFS version 3.2
  - NOT part of the operating system (e.g. not in SUN-OS)
  - no deadlock recognition

3.2 Andrew File System (AFS or DFS)

Overview
- functionality similar to NFS
- mutual authentication requested when contact is established
  - user TOKENS authenticate communication mutually
  - tokens generated at login
  - stored in the AFS cache manager
- security
  - token always has to be submitted when a service is requested
  - access protection of the AFS file tree
    - through Access Control Lists (ACL's)
  - multi-layered administration privileges

Further development
- AFS 4.0 is called the DISTRIBUTED FILE SYSTEM (DFS)
  - file system component in the
    - Distributed Computing Environment (DCE) of the Open Software Foundation (OSF)
  - not to be confused with the Microsoft DFS system

Authentication in afs through Kerberos

Mutual authentication
- mutual identity proof (user, AFS authentication server)
  - user:
    - has to know the password
  - server:
    - has to decrypt and
    - has to respond to a message which the login process has encrypted with the user password

File access:
- user: AFS cache manager on user workstation checks
  - user identity by using the token
- server: AFS file server checks
  - identity by decrypting the token and
  - by responding with the requested service

In general
- communication partners know "Shared Secret"
  - shared secret in form of an encryption key
- in AFS SIMPLE and COMPLEX MUTUAL AUTHENTICATION
  - depends on the no. of used keys and
  - depends on the no. of participating partners

Simple Mutual Authentication

In general
- usually the first step of authentication during login

Challenge-response process
1. Login program on AFS client workstation
   - sends CHALLENGE MESSAGE
     - with encryption key encoded by login (computed from user password -afs-password)
   - to authentication server (using AFS database server)
2. Authentication server
   - decrypts message with the user password listed in the database
3. Authentication server
   - generates response, which also contains original message
4. Authentication server
   - sends this response encoded with the same key back to the login process
5. Login process
   - decrypts and verifies the response with the original message

Complex Mutual Authentication

1 (step): simple mutual authentication
2: TICKET GRANTER (auth. server comp.) supplies TOKEN to the login process

Token contains
- server ticket Tc
  - confirmation for successful user identity verification
  - Tc is encrypted with server encryption key Ks (shared secret of the AFS server and the auth. server of one cell)
  - thus client cannot decrypt Tc
- session key Kc,s
  - random number issued by the ticket granter
  - shared secret between client and AFS servers
  - Kc,s is part of the tickets (encrypted with the server key) and also unencrypted in the token
- flag for which servers the ticket is valid
- ticket validity period
- complete ticket encrypted with encryption key; the key is known to the login process and to the auth. server

AFS cache manager
- does not know the user password
- does not know the encryption key derived from it
- is used for storing the encrypted ticket and session keys

File Access in AFS

1. **On behalf of the user, the AFS cache manager sends the encrypted ticket and the requested service (encrypted with the session key) to AFS**
2. **The AFS server deciphers the ticket to learn the session key (session key is the shared secret)**
3. **AFS server sends response encrypted with the session key**

Reliability Concept

- **client can recognize session key only**
  - if it was able to decipher the token
- **deciphering only possible**
  - if the user knows the correct password at login
- **AFS server can learn session key only**
  - by deciphering the ticket
- **ticket granter only generates valid ticket**
  - if the identity of the user has been proven.
  - The ticket is encrypted with the server encryption key
- **only ticket granter and AFS server know the server encryption key**
- **critical:**
  - **AFS database server (auth. database, auth. server, ticket granter)**

Access Protection in AFS

Access Protection through Access Control Lists (ACLS's)

- **one ACL per directory**
- **defines file access rights**
  - **lookup** (to display ACL and files)
  - **insert** (to generate directory entries)
  - **delete** (to remove directory entries)
  - **administer** (to change the ACL of a directory)
  - **read** (to reads the file, if the UNIX-Bit r has been set for the owner, analog execution if x has been set)
  - **write** (like to read, if w has been set for owner)
  - **lock** (to set and to remove advisory locks)
- **20 entries per ACL**
  - **user and group name with access rights**
    - one-character abbreviations for access rights
  - **users themselves can**
    - define (up to 20) groups (users or systems)
    - place their own or foreign groups into an ACL