Through the Looking-Glass: the technology behind the UK Mirror Service

http://www.mirrorservice.org/

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Introduction

What is UKMS?

- Fast local copies (mirrors) of popular Internet resources for the UK academic community
- Some approximate numbers for September 2004:
  - 201 mirrored sites
  - 4 million files
  - 6 terabytes of disk space
  - 0.4 terabytes of data shipped per day
  - Average bandwidth usage 42Mbit/sec (peaking at 100Mbit/sec)
  - 120,000 distinct user IP addresses per month
  - 28% outgoing traffic is to UK academic users on JANET
  - 100% availability from 1999 to 2004

What we carry

- Open Source software (the vast majority)
  e.g. Debian GNU/Linux, OpenOffice.org
- Academic sites
  e.g. Project Gutenberg, Duke Papyrus Archive
- Some commercial software
  e.g. MATLAB, Netscape
- Legacy content (HENSA/Micros, etc.)
- Official mirror site for many mirrors

History

1987 netlib mirror at UKC; access by email
(18 years later, we still mirror netlib)

1992 UKC gets first Internet link;
ISSC-funded HENSA/Unix at UKC, HENSA/Micros at Lancaster
(`hensa.ac.uk`)

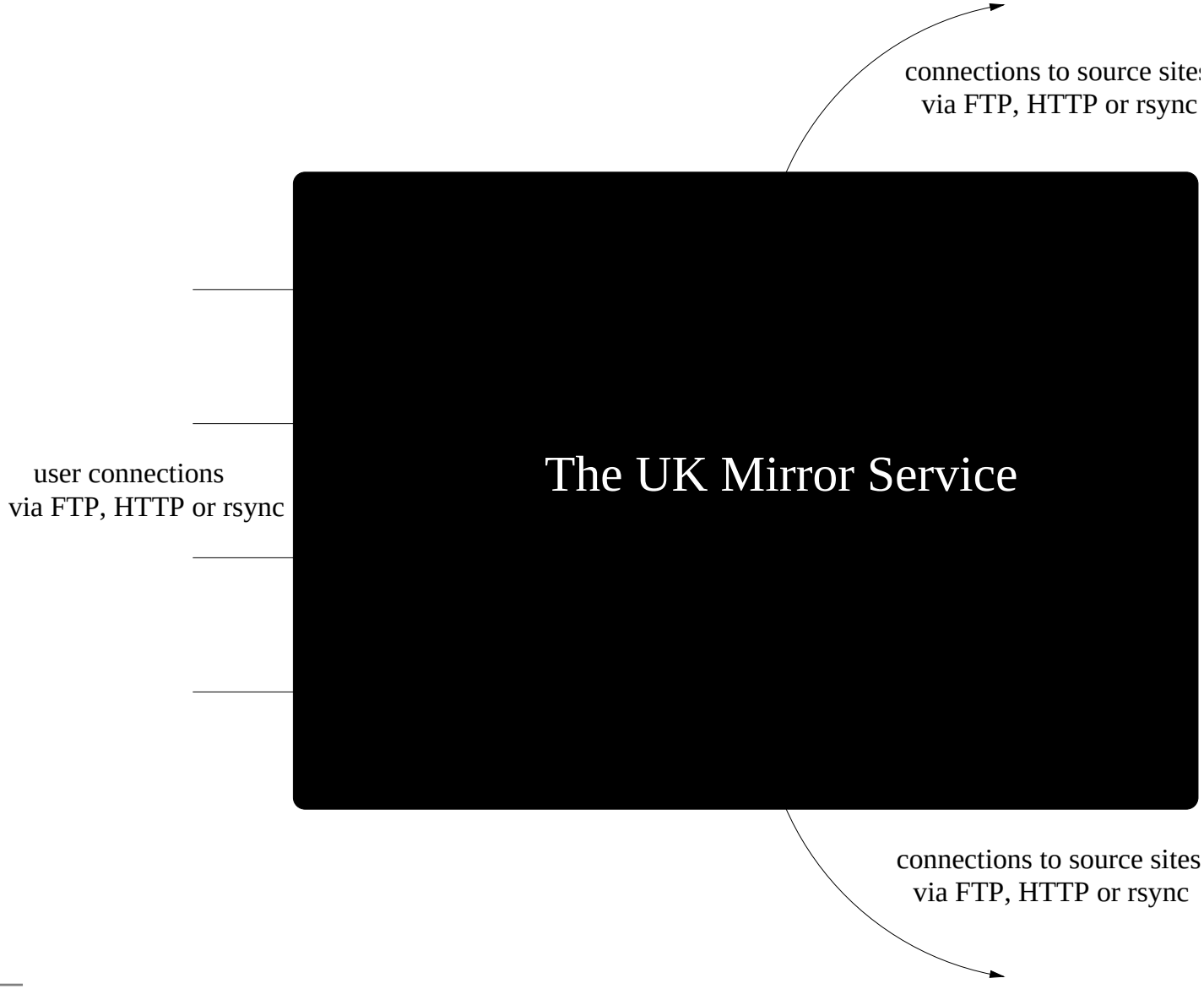
1999 HENSA merges to become the JISC-funded UK Mirror Service with staff at UKC and Lancaster
(`mirror.ac.uk`)

2003 Added third UKMS site at Reading C-POP

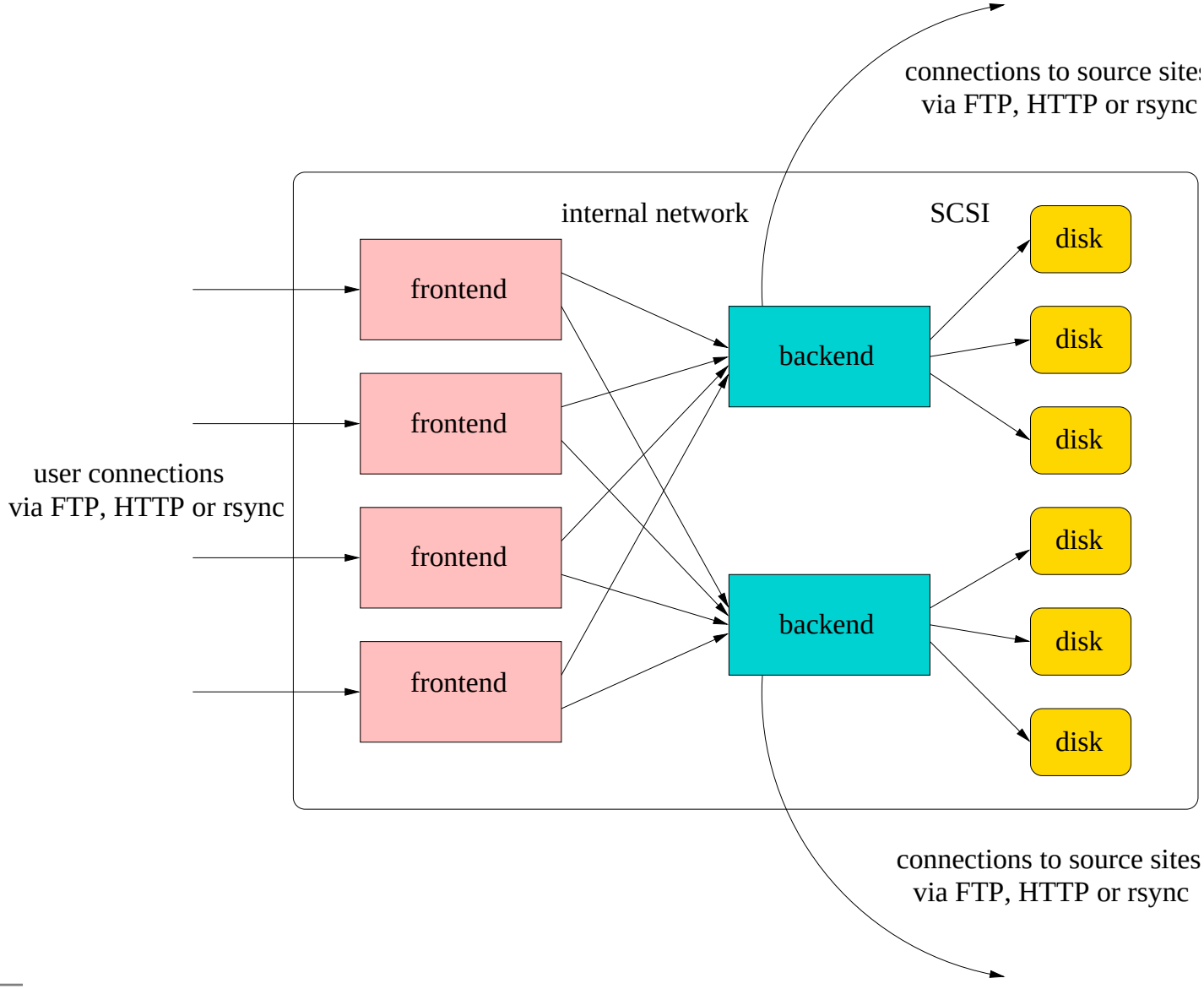
2004 JISC contract expires;
UK Mirror Service now operates from UKC Computer Science
(`mirrorservice.org`)

Architecture

From the outside



Removing the lid



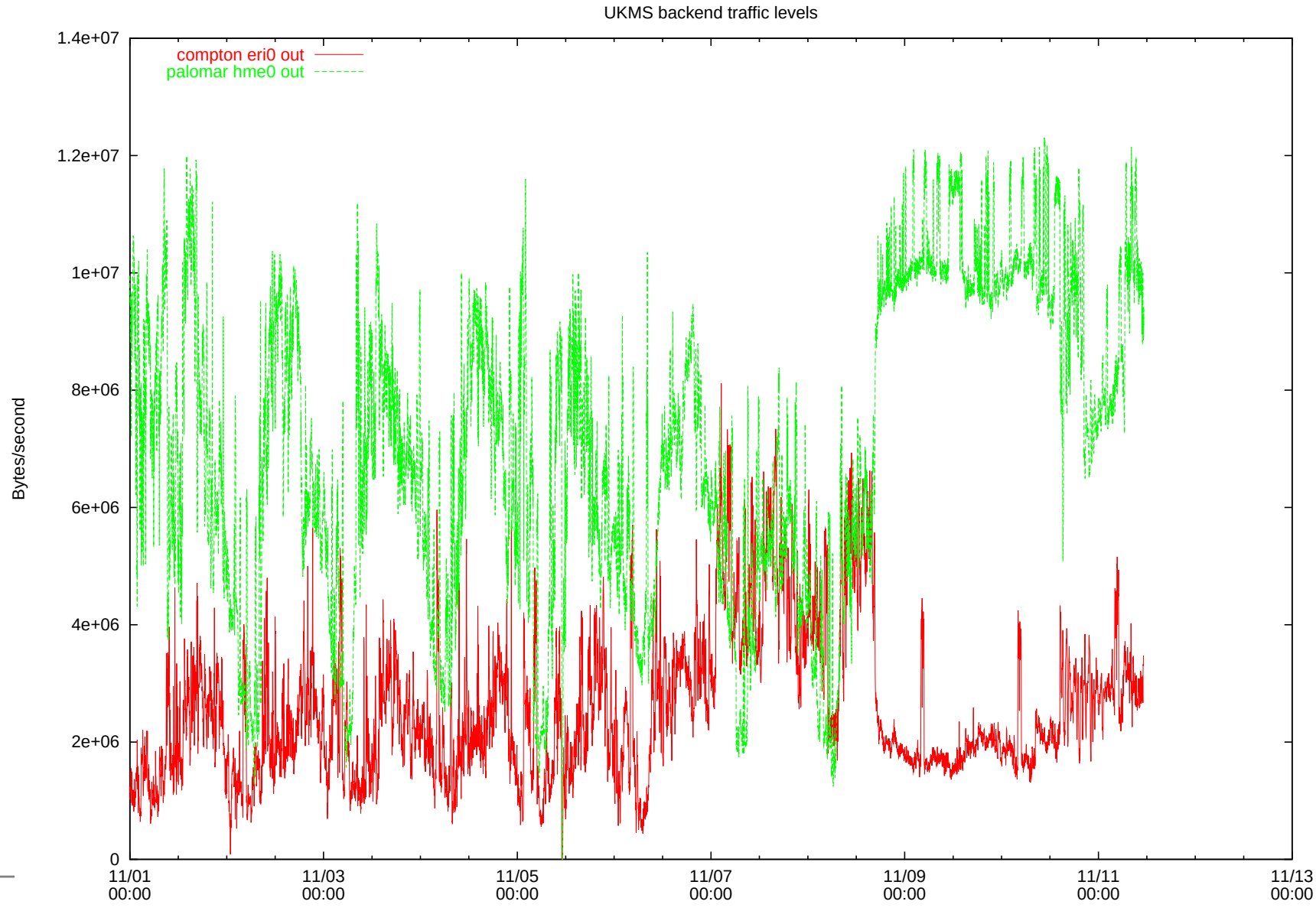
Explaining the roles

- Frontend and backend hosts
- Users make FTP, HTTP or rsync connections to a randomly-selected frontend host (DNS round-robin entries)
- Frontends act as smart caching proxies to reduce load on backends and disks
- Frontends fetch the data from the backends
- Backends have disks attached, each with several mirrors on
- Backends periodically fetch data from source sites to disks

Hardware at UKC

- 4× Sun V120s as frontends
- A V120 as “slow” backend with disk arrays:
  - a 400-gigabyte Sun 3300
  - a 4-terabyte Transtec (cheap!)
- A Sun E450 as “fast” backend with Sun A1000 disk arrays:
  - 2× 160-gigabyte
  - 2× 280-gigabyte
  - 2× 400-gigabyte

A fortnight in the life

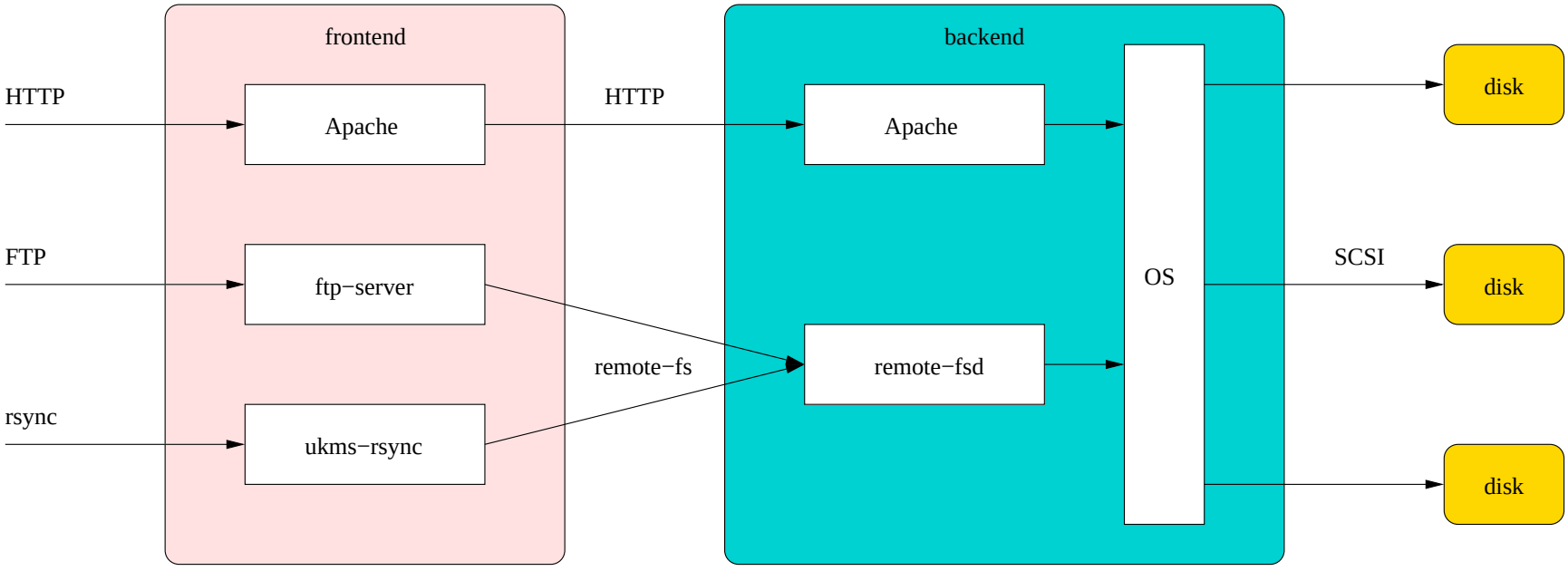


Serving content

Serving in general

- Making a directory on a backend disk available to users
- Must support a standard directory layout across all protocols
- Must transparently select the right backend for different mirrors
- Must minimise the backend load where possible
- Must respect the source site’s presentation instructions

Zooming in. . .


frontend
backend
HTTP
Apache
HTTP
Apache
disk
FTP
ftp−server
SCSI
OS
disk
remote−fs
remote−fsd
rsync
ukms−rsync
disk

An aside: CFTP

- A C++ library and a set of tools
- Used by nearly every part of the UKMS software
- The result of a late-90s UKC research project
- Provides a virtual Unix-like filesystem tree with mountable filesystems
  - **posix-fs** connects to a real local directory
  - **ftp-fs** connects to another FTP server
  - **remote-fs** connects to a directory on another host (using its own protocol)

Serving content with FTP

- **ftp-server** is a custom FTP server based on CFTP
- Limit on the number of concurrent connections to each frontend (client should try next FE if full)
- Can generate tar archives on the fly
- The FTP server exports the CFTP virtual filesystem
- Each mirror is mounted using **remote-fs** from the appropriate backend in the right place under /sites/
- **remote-fsd** server runs on backends

Serving content with rsync

- **ukms-rsync** is a patched version of the stock rsync server
- Uses **libqfs**, a C interface to the CFTP virtual filesystem (looks like Unix system calls)
- Uses nearly the same config for CFTP as the FTP server

CFTP frontend caching

- Initial approach used existing CFTP cache – not good enough!
- Final-year project implemented a better cache filesystem for CFTP
- Cooperative data and metadata caching between all FTP/rsync processes on a frontend
- Tested on real logs – 30 gigabyte data cache reduced data pulled from backend by 50%

Serving content with HTTP

- We use the **Apache** web server (twice)
- Frontend Apache acts as a caching proxy, forwarding requests on to the appropriate backends
- Apache's cache behaves poorly for large files, though, so we redirect requests for CD images to the FTP server
- Most virtual hosts handled directly by frontends
- "Special" virtual hosts handled on backends using extra ports
- Doesn't use CFTP yet, but we're working on it

The browser

- Generates our web interface under /sites/
- A (C!) CGI program that runs on backends
- Supports browsing and extracting from archive files
- Displays likely README files and mirror descriptions

The search engine

- Uses a separate machine and a huge PostgreSQL database
- Indexing scripts examine newly-mirrored data
- Web frontend does queries against the database
- Much more complex than it sounds – good searching is difficult!

Mirroring

Mirroring in general

- Making a local directory look like one on the source site
- May need to exclude some content, or add extra content
- Need to cope with source site being down
- Need to update search engine
- Need to copy mirrored content to other UKMS sites

FTP mirroring with syncfs

- **syncfs** is a general mirroring tool based on CFTP
- Uses **ls-lR** files if available on source site
- Can use multiple connections
- Can resume partial downloads
- Updates mirroring status files (hidden from users)
- Lots of special behaviour to deal with broken FTP servers

Peer mirroring

- syncfs mirroring technique using two UKMS sites (UKC and Lancs)
- Both UKMS sites connect to source site
- One mirrors in alphabetical order, the other in reverse alphabetical order
- Each checks the other UKMS site to see whether it's got the file they want before going to the source site
- On average, each pulls half the content from the source site
- Works when one UKMS site is down too!

Web mirroring

- Actually a general term for anything that's not FTP
- Wrapper around off-the-shelf tools
  - **rsync** for rsync mirroring
  - **pavuk** for HTTP mirroring
  - **tucopy** for Tucows mirrors
- Has workarounds for broken tools
  - Detect empty files and remirror
  - Fix up bad links in HTML
  - Detect "stuck" mirroring processes and restart
- Push mirroring via a modified writable rsync server

Tying it all together

Metaconf

- Configuring all our software by hand would be impractical
- Metaconf takes descriptions of mirrors in a standard format (MDF)
- Provides a uniform interface that scripts can use to get at the descriptions
- Generates per-site configuration files for software that can’t use the Perl interface
- Copes with remapping disks when faults occur

MDF

- An application of RDF (yes, the Semantic Web is useful!)
- An MDF file describes a single mirror:
  - The name, description and classification of the mirror
  - The logical disk upon which it's stored
  - The host that performs mirroring
  - How and when to mirror it (including any special options)
  - How it can be accessed (protocols, virtual hosts)

What we've learnt

. . . about mirroring

- Source sites are usually broken
  - The most important source sites are always overloaded
  - With FTP listings, anything that can go wrong will
- . . . but FTP is still the best protocol for mirroring
  - HTTP mirroring is basically guesswork
  - rsync works badly for very large mirrors
- Off-the-shelf mirroring software is unreliable
- Source site maintainers don’t have the time to listen to mirror maintainers

. . . about serving

- Client software is usually broken
  - “Download accelerators”
  - Incorrect HTTP Redirect handling
  - Large file handling (Fedora DVDs)
- Malicious users exist
- Overzealous indexing bots also exist
- Frontend caching is a really good idea

. . . about protocol design

- FTP has some serious problems
  - Poor takeup of standardised directory listings
  - The whole active/passive mess – NAT/firewall unfriendly
- HTTP has some serious problems
  - No directory listings (WebDAV isn't there yet)
  - It's not good for mirroring
- rsync has some serious problems
  - Huge latency when transferring initial tree
  - Random failures during transfers
  - Backwards compatibility makes code messy
- All protocols suck!

. . . about software design

- Don’t! Big design up front doesn’t work for us
- Our most reliable systems are those that have evolved slowly
- Clear code is easier to modify than a well-documented mess
- Use the right language for the job
- Simple file formats are best
- Being self-healing is useful
- Version control software is invaluable

Future plans

Making our software Open Source

- UKC owns copyright on most of the code
- Need to tidy up build systems and package for release
- Patches to existing software (rsync) are easier
- Package as “Mirror Service In A Box” for others to use

Reducing cost

- Sun kit is reliable but (very!) expensive
- PCs and SATA disks are cheap (free in some cases) and fast
- Our plan is:
  - 6 PCs, each with 4 300-gigabyte SATA disks
  - Mirrored pairs of machines for redundancy
  - Each machine is both a frontend and a backend
- We aren't the only people who've noticed this – Google and archive.org take the same approach on a much larger scale!

The End

Any questions?

Find us at:
http://www.mirrorservice.org/