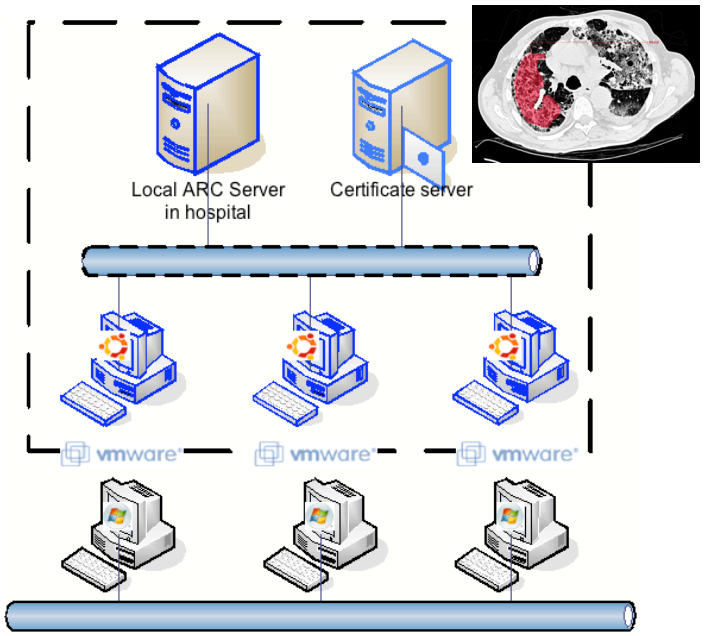
Building a community grid for medical image analysis inside a hospital, a case study



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UNIVERSITÉ DE GENÈVE

HUG
Hôpitaux Universitaires de Genève

KnowARC

Overview

- Motivation: Grid computing for medical image analysis
- Challenges inside hospitals
- Solution guidelines
- An application
- Conclusions

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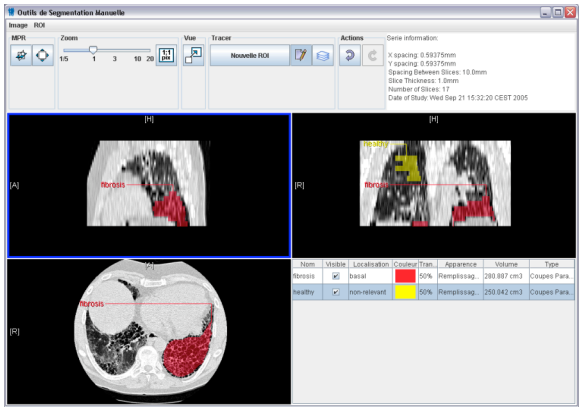
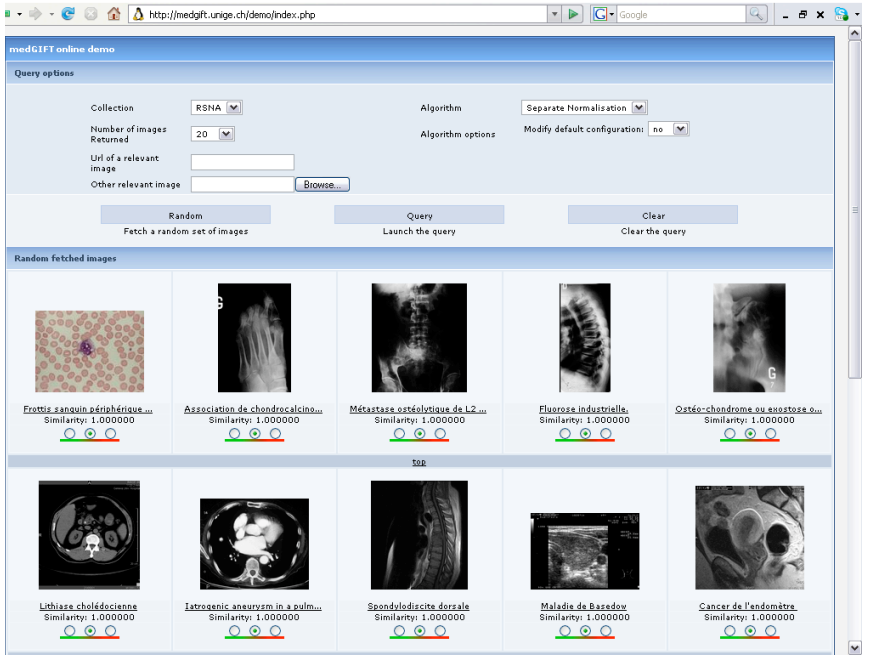
Motivation: Medical image analysis

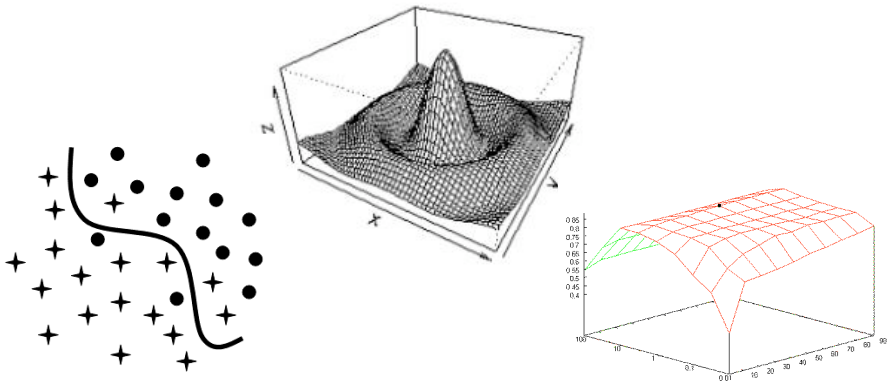
- Computerized medical image analysis provides tools for radiologists inside hospitals
  - Content-based image retrieval (CBIR)
    - Find similar images/cases
  - Computer-aided diagnosis
    - Automatic detection of abnormal patterns
  - ...





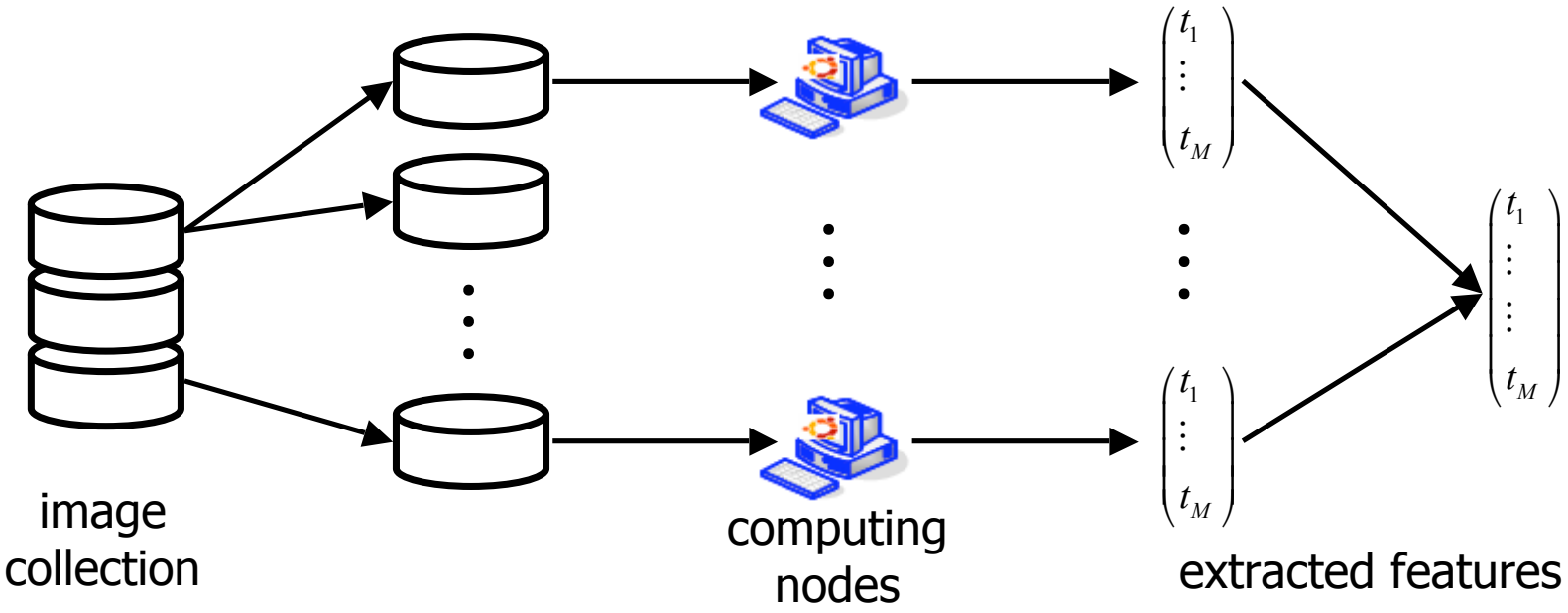
Motivation: Medical image analysis

- Medical image analysis can be computationally intensive:
  - Modern hospitals produce enormous amount of medical images:
    - ~70'000 images/day in Geneva radiology in 2007
  - 2D to 4D high-resolution images
  - Using latest image processing and machine learning algorithms
    - 2D to 4D convolutions
    - High-dimensional feature spaces
    - …



Motivation: Medical image analysis

- Grid computing for medical image analysis:
  - Most of image processing and machine learning algorithms are parallelizable
  - Offline feature extraction for CBIR over large image collections is easy to parallelize:



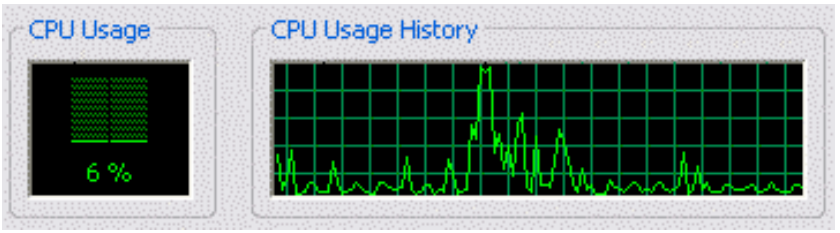
Motivation: Medical image analysis

- Previously: feature extraction for the GNU image finding tool (GIFT) CBIR system was parallelized using external resources provided by the KnowARC project

- Goal: use local resources within hospitals
- Benefits:
  - Policy conformance for handling confidential data
  - Connect resources at different sites within the organisation
  - Interoperability with external resources: one unique interface

Motivation: Medical image analysis

- Local resources at the University Hospitals of Geneva (HUG):
  - No central computing infrastructure for research
  - ~6000 desktop computers
    - Mainly used to access patient records from central databases



⇨ **High potential computing resources**

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Challenges inside hospitals

- Low priority for research compared to clinical routine:
  - Do not exhaust hospitals network resources as people's lives can depend on them
  - Respect data security and confidentiality
  - Use solutions requiring little maintenance for the user
- Main challenges are categorized as:
  - Infrastructures (I)
  - Grid software (G)
  - Political problems (P)

Challenges inside hospitals

- Infrastructures (I)
  - I1: Ports are blocked by a rigid firewall
    - Requirement: do not rely on external resources
  - I2: Research applications and Grid middlewares are mostly running on Linux whereas hospitals desktops have Windows XP
    - Req.: do not assume a Linux environment

Challenges inside hospitals

- Grid software (G)
  - G1: Grid software can be hard to install and maintain
    - Req.: use external expertise and plan time for learning
  - G2: Certificates are difficult to obtain
    - Req.: use own certificates authority if needed
- Political problems (P)
  - P1: Grids are relatively unknown by hospitals ITs: rejection of technology
    - Req.:
      - Involve hospitals IT
      - Create a test bed
      - Create solutions that requires little IT personnel's involvement

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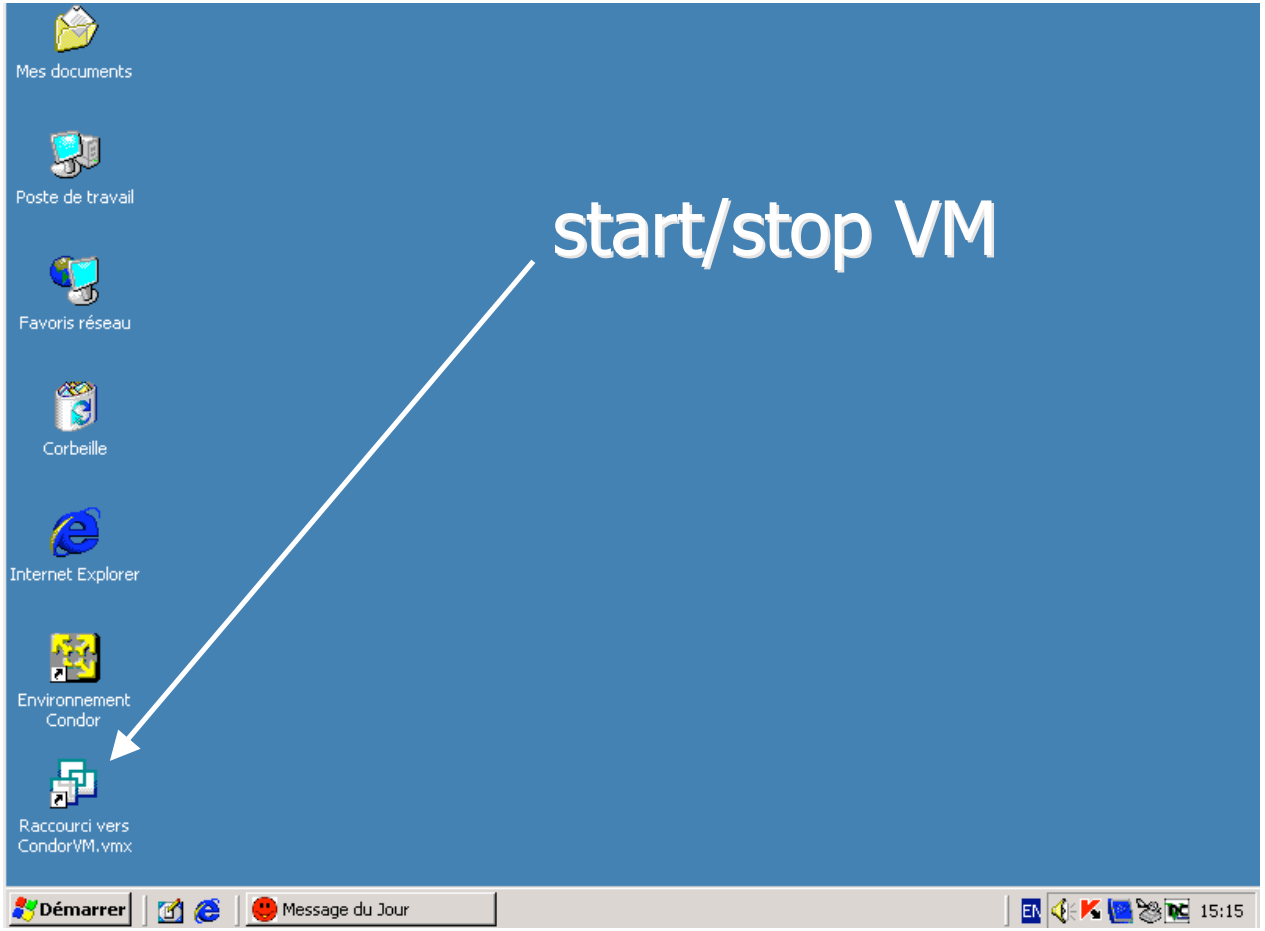
Solutions guidelines

- A test bed was created within the HUG
- Infrastructures (I)
  - A local Grid information system was employed
  - Installation package was created containing a virtual machine (VM) with:
    - Debian Linux and image processing software
    - A local resource management system (LRMS)
  - Installation package was distributed using existing software distribution of the hospitals
  - The user can start/stop the VM when desired

Solutions guidelines

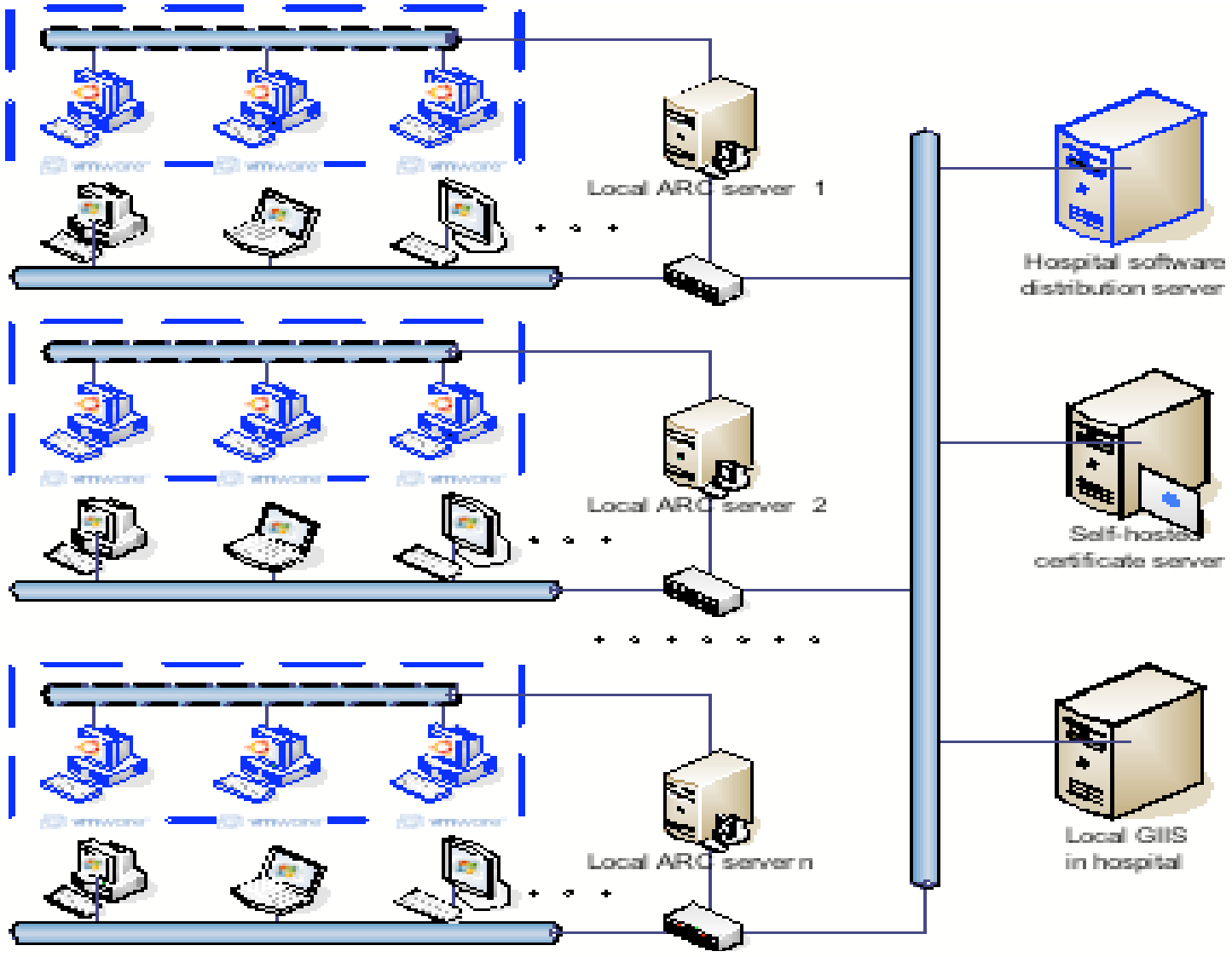
- Screenshot of users's desktop:



Solutions guidelines

- Grid software (G)
  - The Advanced Resource Connector (ARC) Grid middleware and Condor LRMS were used
  - Own certificate authority (CA)
- Political problems (P)
  - A test bed of 20 PCs was created before deploying a larger scale Grid
  - The PCs gain their IP addresses from main hospital area's address pool
    - VM acquire a MAC address at installation, and the DHCP has allocated IP addresses for those

Solution guidelines: setup



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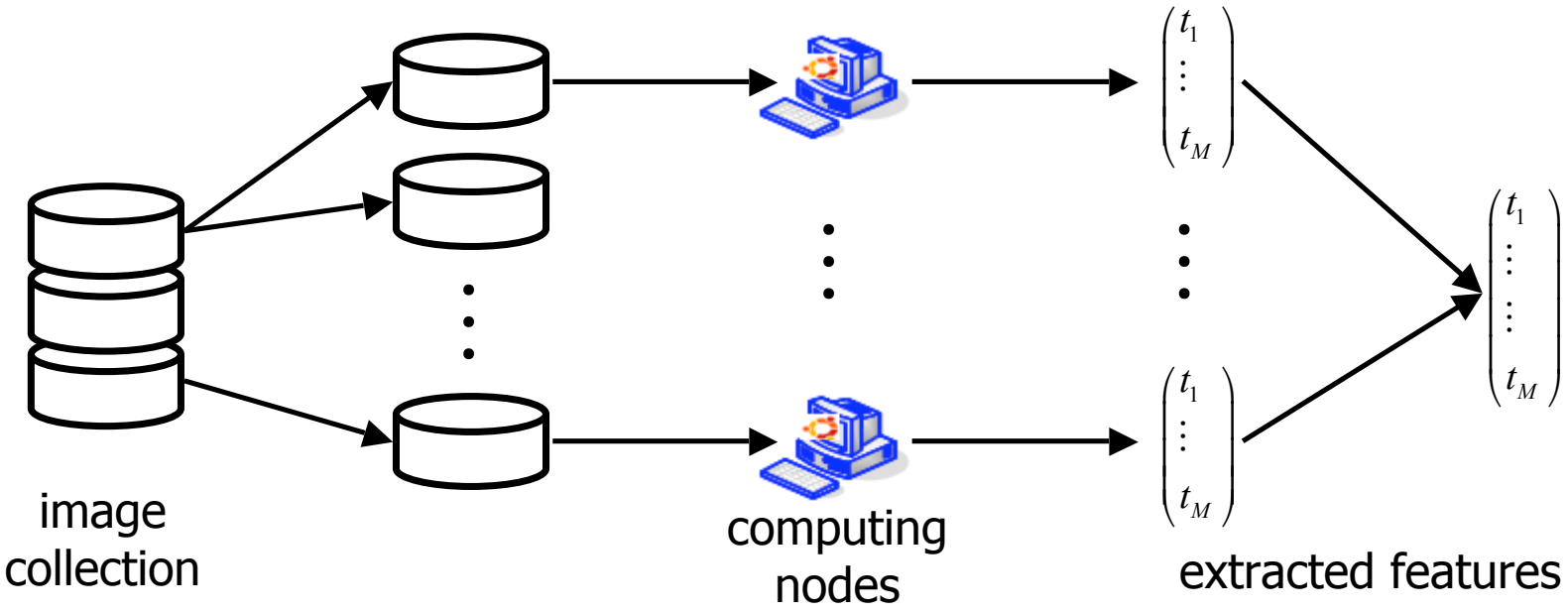
An application

- Offline feature extraction for the GIFT system was parallelized
  - N packages containing images and their processing instructions are sent to computing nodes
  - results are recovered from the nodes



An application

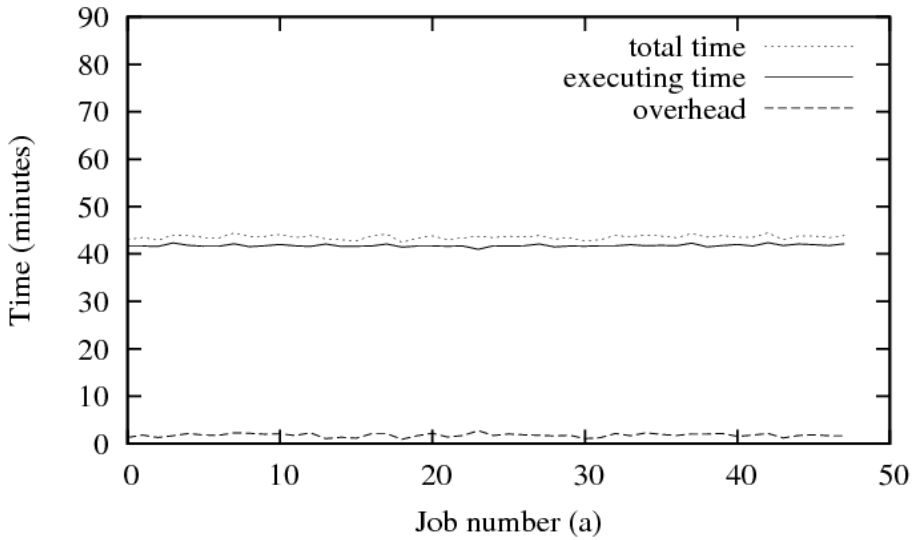
- Comparison of execution times for 50 packages of 1000 images:

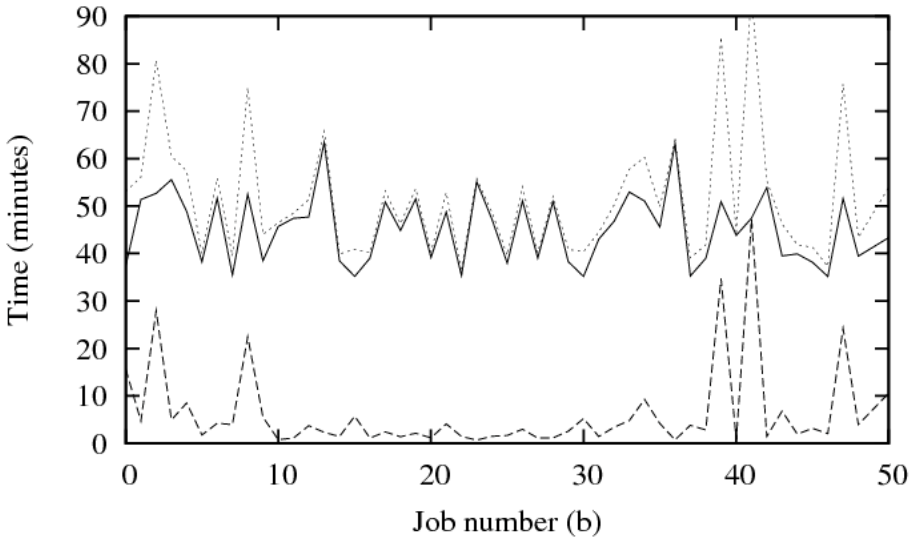
Local server	709 min
37 CPUs remote clusters (KnowARC resources)	537 min
Local cluster, 10 CPUs	240 min

- ✓ Execution time was reduced
- ✓ Though the local cluster had less CPU's, the results were better – less transfer and queue time (no waiting time with local resources)

An application

- Local (a) versus remote (b) execution:





- ✓ Overhead was reduced from 10 min per package to 1 min
- ✓ Higher constancy of the execution times

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Conclusions

- A desktop Grid-like infrastructure was deployed inside the hospitals
- Infrastructures, Grid software and political problems were identified
- Little manual intervention was required because of virtualization and automatic software distribution
- Efficiency was improved compared to using external resources