DBW – Databases and Web development

Aims

- Review a number of technologies to handle bioinformatics data:
  - Computer communication, design of web applications, basic database design and optimization.
  - This is NOT a programming course, it is about building applications in an heterogenous scenario

- The final objective is to built a **fully operative application** using the appropriate combination of the techniques reviewed.

Bioinformatics & Internet

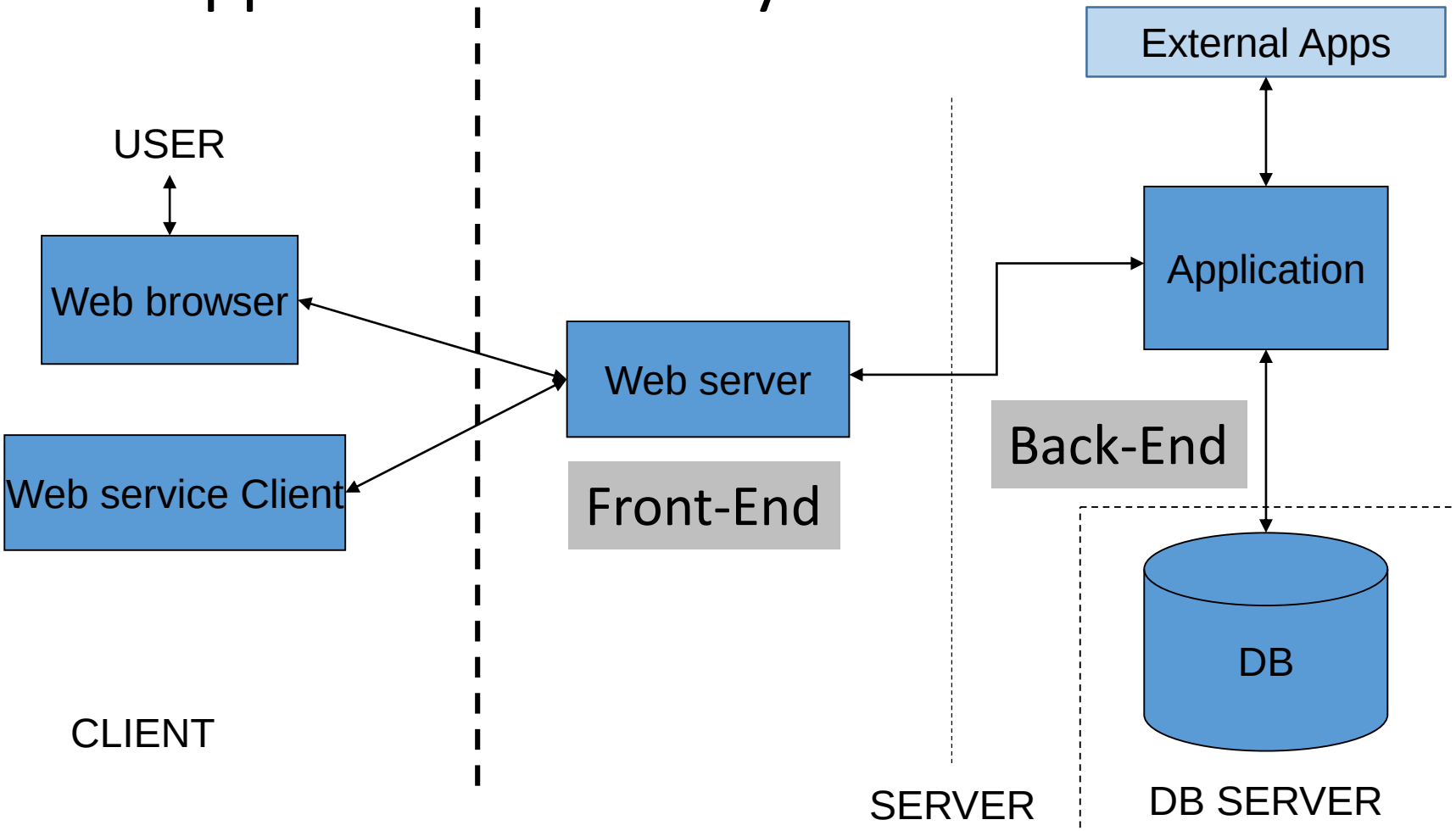
- Tools and data should be available through web

- Ex. Nucleic Acid Research reviews:
  - Database Issue (January) 1170 DBs
  - Web Server Issue (July) 1200 Servers

Web applications by access type

- Web interfaces
  - Provide a user friendly interface (web based) to “human” users
    - Users known how to use the interface
    - There is no need to install software
    - Single operations (no large scale)
    - Must adapt to navigation uses (low latency, synchronous answers,…)
- Web services
  - Provide a programmatic interface (using Web protocols)
  - Intented to interact with software, not humans
    - Well-defined data formats required.
    - Adequated for large scale operations
- Modern applications will normally offer both

Web application anatomy



Web application styles

- Access to data
  - Friendly interface to data repositories
- Web Interfaces to stand-alone software
  - Collect input parameters and redirect output
- Workbenches (e.g. Galaxy)
- On-purpose applications & DBs
- Web services (programmatic access)

MolecularModelingandBioinformatics

New search | Protein Data Bank

PDB local mirror at MMB: 117976 total entries (Proteins: 106948, Nuc. Acids: 2908, Prot-Nuc Complexes 6009, Carboh. 18

PDB Id	
Uniprot Acc.	
Sequence search	Upload File: Examinar... No se ha seleccion Exact match ◉ Protein ○ Nucleic a
Advanced Search:	
Resolution	From 0.0 to Inf
Compound type	☑ Any ☐ carb ☐ nuc ☐ other ☐ prot ☐ prot-
Exp. type	☑ Any ☐ ELECTRON_CRYSTALLOGRAPHY NEUTRON_DIFRACCTION ☐ NMR ☐ SOLID-
Simulation	☐ MoDEL ☐ BigNASim

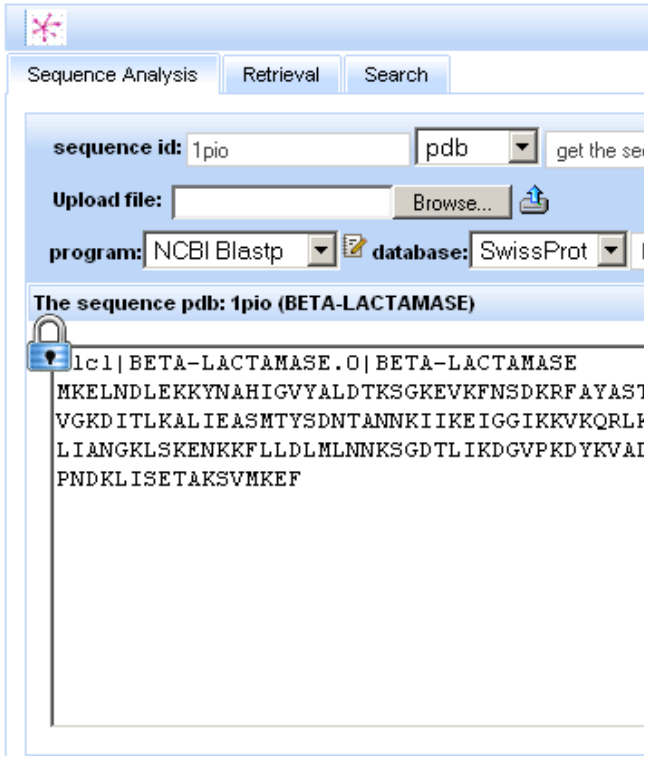
MolecularModelingandBioinformatics

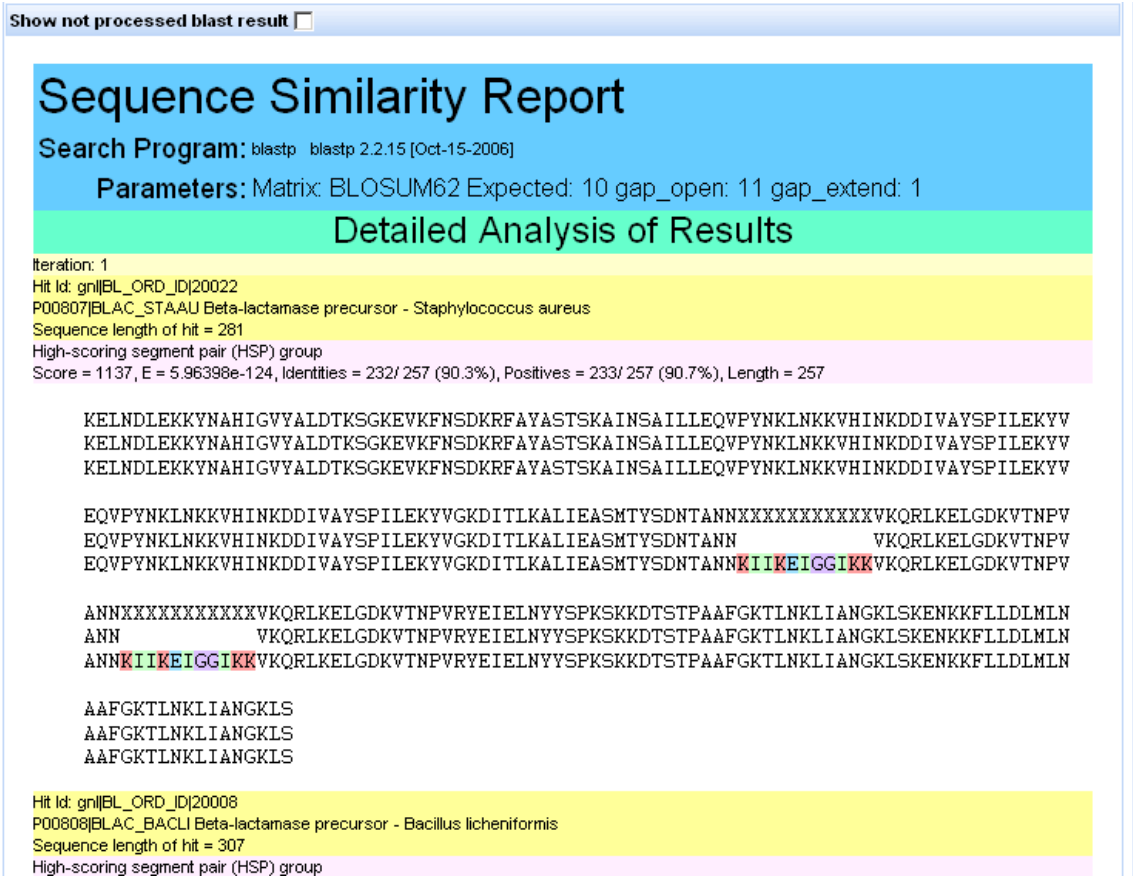
New search | Protein Data Bank

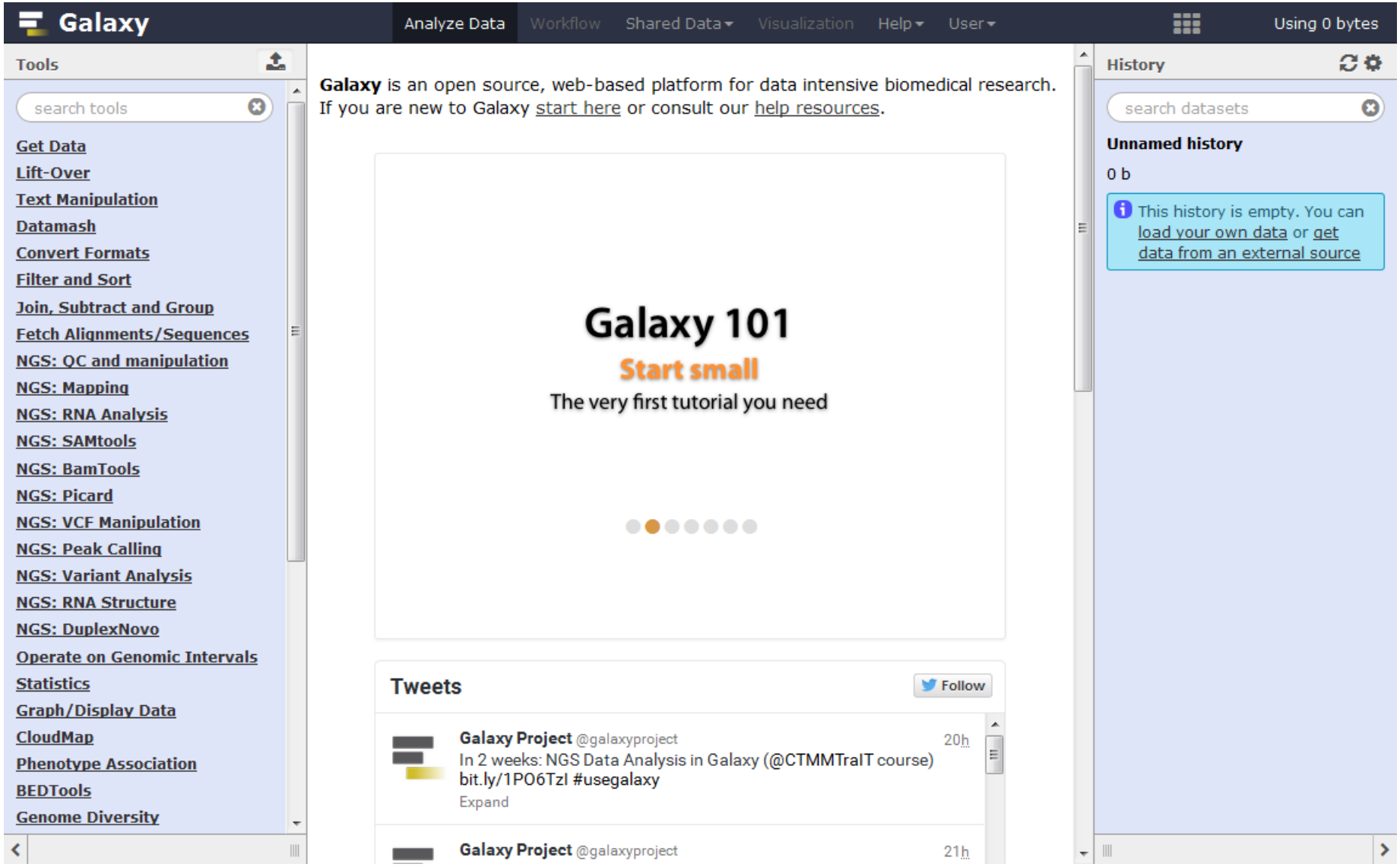
Entry: 2KI5

Classification	Transferase
Type	Prot
Deposition Date	02/12/99
Title	Herpes simplex type-1 thymidine kinase in complex with the drug aciclovir at 1.9a resolution
Source	*Human herpesvirus 1*
Authors list	Batuwangala, T., Bennett, M. S., Champness, J. N., Rutherford, T., Sanderson, M. R., Summers, W. C., Sun, H., Wien, F., Wright, G.
Resolution	1.9
Exp. type	X-RAY DIFFRACTION
Structure:	Asymmetric Unit — PDB File — 3D View BioUnit(s) — 1 — PDB File — 3D View View entry at [PDB]

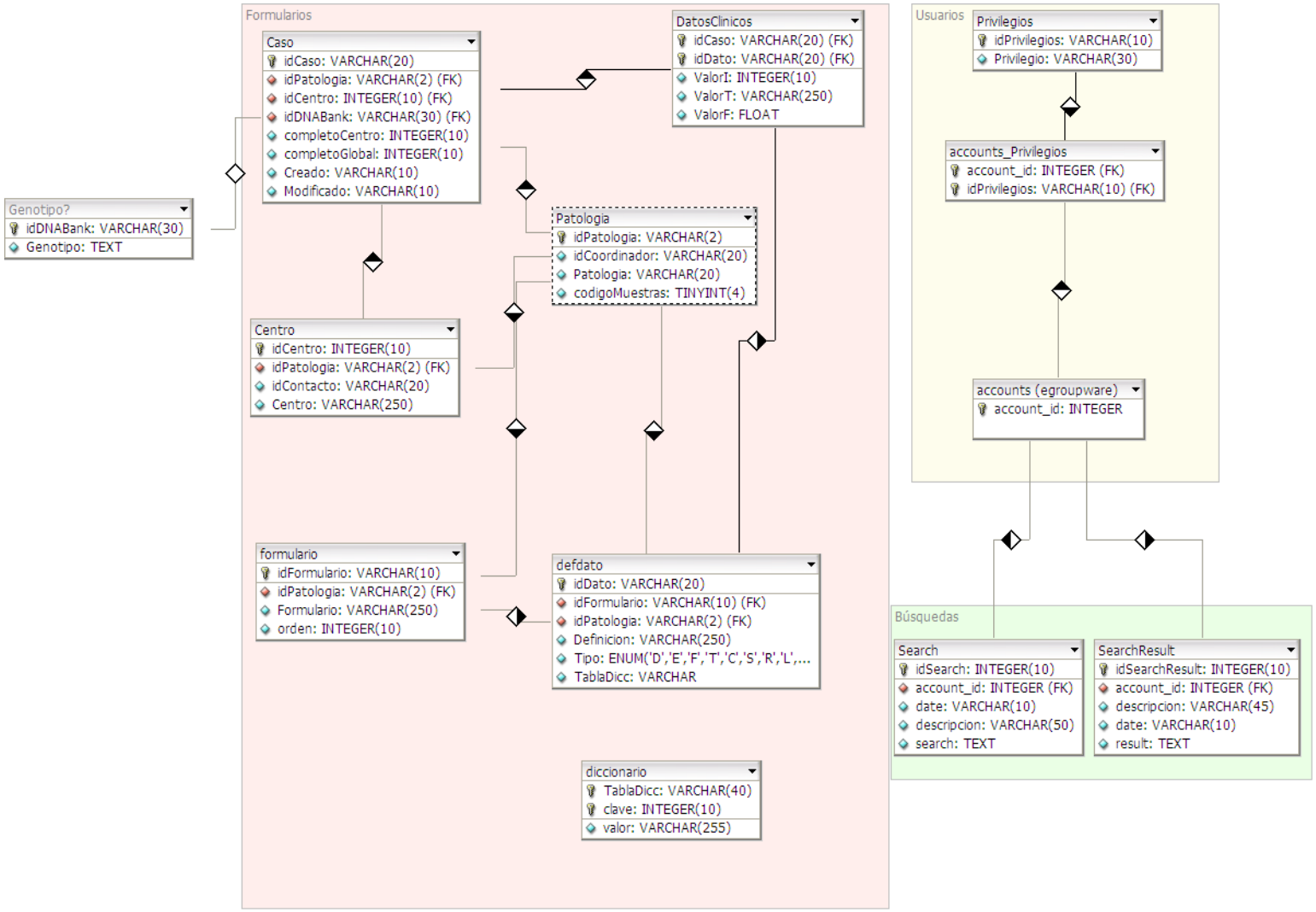
Web interfaces to apps.

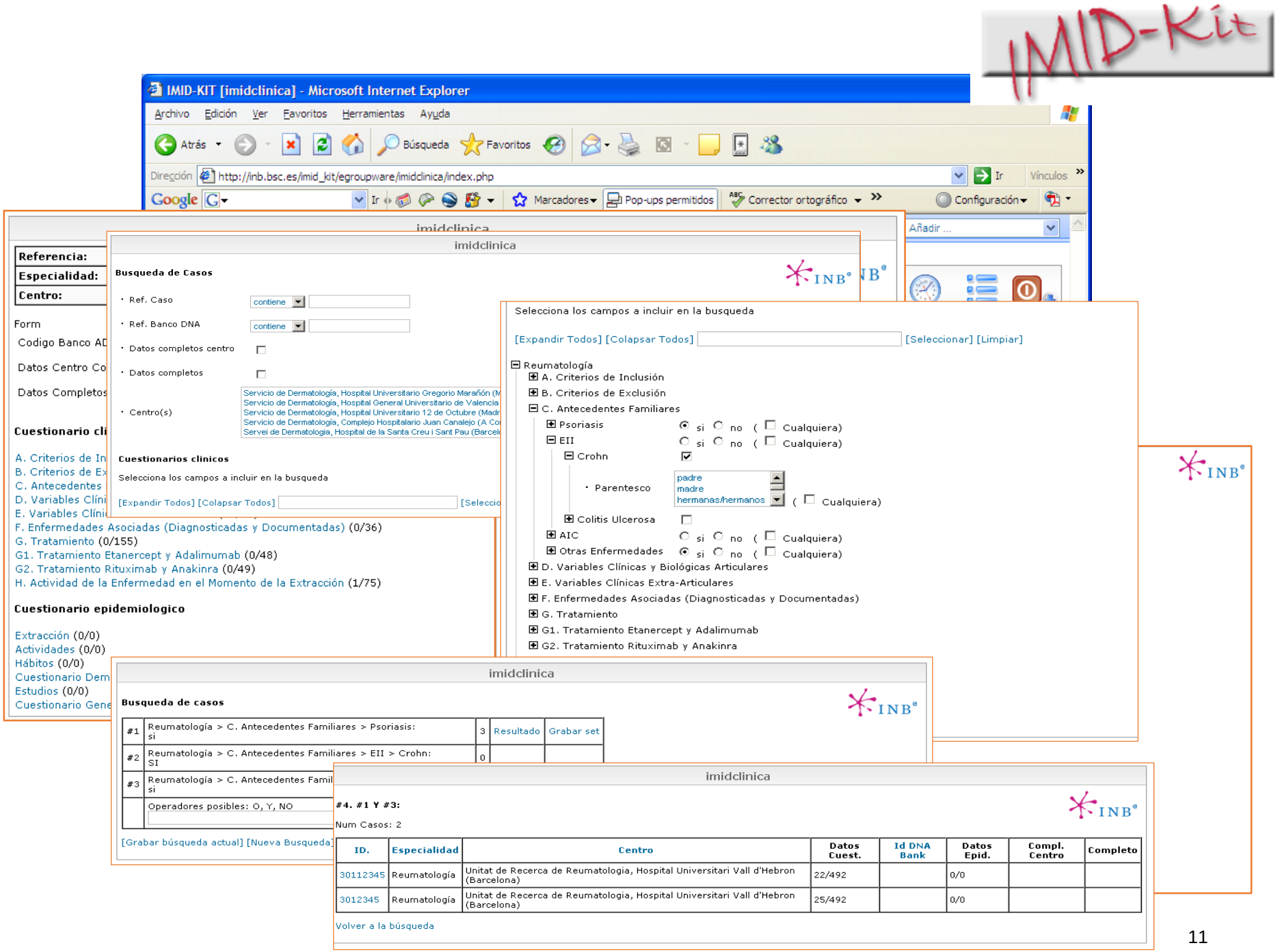





Galaxy
Analyze Data
Workflow
Shared Data
Visualization
Help
User
Using 0 bytes
Tools
search tools
Get Data
Lift-Over
Text Manipulation
Datamash
Convert Formats
Filter and Sort
Join, Subtract and Group
Fetch Alignments/Sequences
NGS: QC and manipulation
NGS: Mapping
NGS: RNA Analysis
NGS: SAMtools
NGS: BamTools
NGS: Picard
NGS: VCF Manipulation
NGS: Peak Calling
NGS: Variant Analysis
NGS: RNA Structure
NGS: DuplexNovo
Operate on Genomic Intervals
Statistics
Graph/Display Data
CloudMap
Phenotype Association
BEDTools
Genome Diversity
Galaxy is an open source, web-based platform for data intensive biomedical research.
If you are new to Galaxy start here or consult our help resources.
Galaxy 101
Start small
The very first tutorial you need
Tweets
Follow
Galaxy Project @galaxyproject 20h
In 2 weeks: NGS Data Analysis in Galaxy (@CTMMTraIT course)
bit.ly/1PO6TzI #usegalaxy
Expand
Galaxy Project @galaxyproject 21h
History
search datasets
Unnamed history
0 b
This history is empty. You can load your own data or get data from an external source

Special purpose applications & DBs




IMID-KIT [imidclinica] - Microsoft Internet Explorer
Archivo Edición Ver Favoritos Herramientas Ayuda
Atrás Búsqueda Favoritos
Dirección http://inb.bsc.es/imid_kit/egroupware/imidclinica/index.php
Ir Vínculos
Google Ir Marcadores Pop-ups permitidos Corrector ortográfico Configuración
imidclinica
Añadir ...
Referencia:
Especialidad:
Centro:
Form
Codigo Banco AD
Datos Centro Co
Datos Completos
Cuestionario cli
A. Criterios de In
B. Criterios de Ex
C. Antecedentes
D. Variables Clíni
E. Variables Clíni
F. Enfermedades Asociadas (Diagnosticadas y Documentadas) (0/36)
G. Tratamiento (0/155)
G1. Tratamiento Etanercept y Adalimumab (0/48)
G2. Tratamiento Rituximab y Anakinra (0/49)
H. Actividad de la Enfermedad en el Momento de la Extracción (1/75)
Cuestionario epidemiologico
Extracción (0/0)
Actividades (0/0)
Hábitos (0/0)
Cuestionario Dem
Estudios (0/0)
Cuestionario Gene
imidclinica
Busqueda de Casos
INB
· Ref. Caso contiene
· Ref. Banco DNA contiene
· Datos completos centro
· Datos completos
· Centro(s)
Servicio de Dermatología, Hospital Universitario Gregorio Marañón (M
Servicio de Dermatología, Hospital General Universitario de Valencia
Servicio de Dermatología, Hospital Universitario 12 de Octubre (Madr
Servicio de Dermatología, Complejo Hospitalario Juan Canalejo (A Co
Servei de Dermatologia, Hospital de la Santa Creu i Sant Pau (Barcel
Cuestionarios clinicos
Selecciona los campos a incluir en la busqueda
[Expandir Todos] [Colapsar Todos] [Seleccio
Selecciona los campos a incluir en la busqueda
[Expandir Todos] [Colapsar Todos] [Seleccionar] [Limpiar]
Reumatología
A. Criterios de Inclusión
B. Criterios de Exclusión
C. Antecedentes Familiares
Psoriasis si no (Cualquiera)
EII si no (Cualquiera)
Crohn
· Parentesco padre madre hermanas/hermanos (Cualquiera)
Colitis Ulcerosa
AIC si no (Cualquiera)
Otras Enfermedades si no (Cualquiera)
D. Variables Clínicas y Biológicas Articulares
E. Variables Clínicas Extra-Articulares
F. Enfermedades Asociadas (Diagnosticadas y Documentadas)
G. Tratamiento
G1. Tratamiento Etanercept y Adalimumab
G2. Tratamiento Rituximab y Anakinra
imidclinica
Busqueda de casos
INB
#1 Reumatología > C. Antecedentes Familiares > Psoriasis: si 3 Resultado Grabar set
#2 Reumatología > C. Antecedentes Familiares > EII > Crohn: SI 0
#3 Reumatología > C. Antecedentes Famil si
Operadores posibles: O, Y, NO
[Grabar búsqueda actual] [Nueva Busqueda]
imidclinica
#4. #1 Y #3:
Num Casos: 2
INB
ID. Especialidad Centro Datos Cuest. Id DNA Bank Datos Epid. Compl. Centro Completo
30112345 Reumatología Unitat de Recerca de Reumatologia, Hospital Universitari Vall d'Hebron (Barcelona) 22/492 0/0
3012345 Reumatología Unitat de Recerca de Reumatologia, Hospital Universitari Vall d'Hebron (Barcelona) 25/492 0/0
Volver a la búsqueda

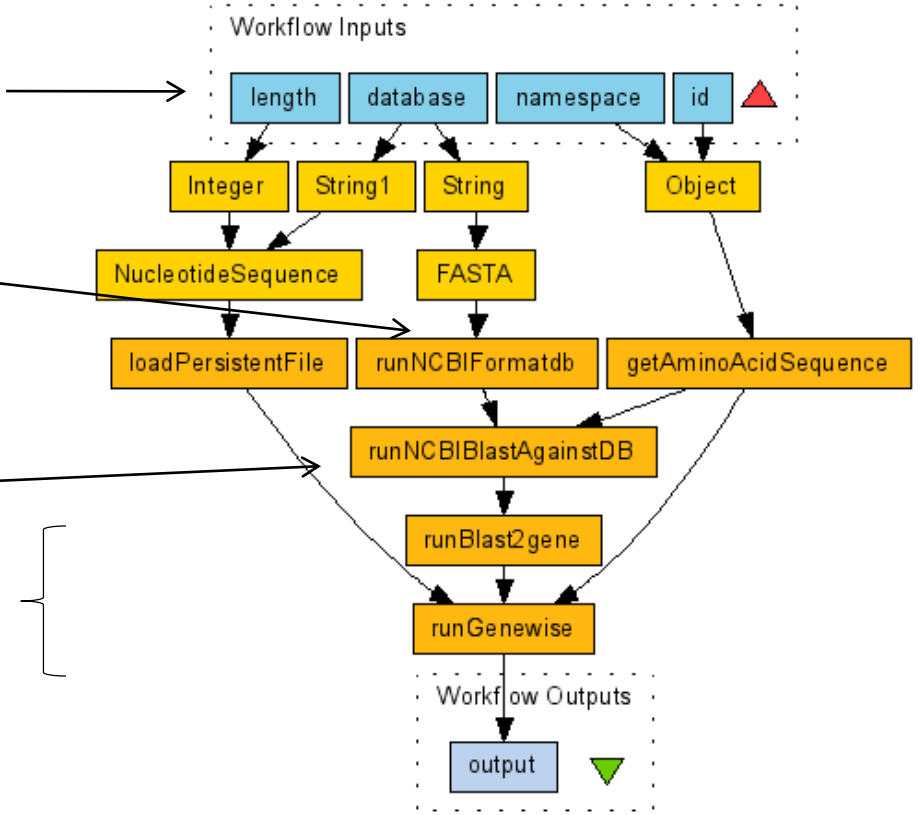
Bioinformatics web-services and workflows

Input: Protein Id and DNA genomic sequence

Building of Blast Database from DNA seq.

BLAST Search

Run GeneWise to detect gene structure

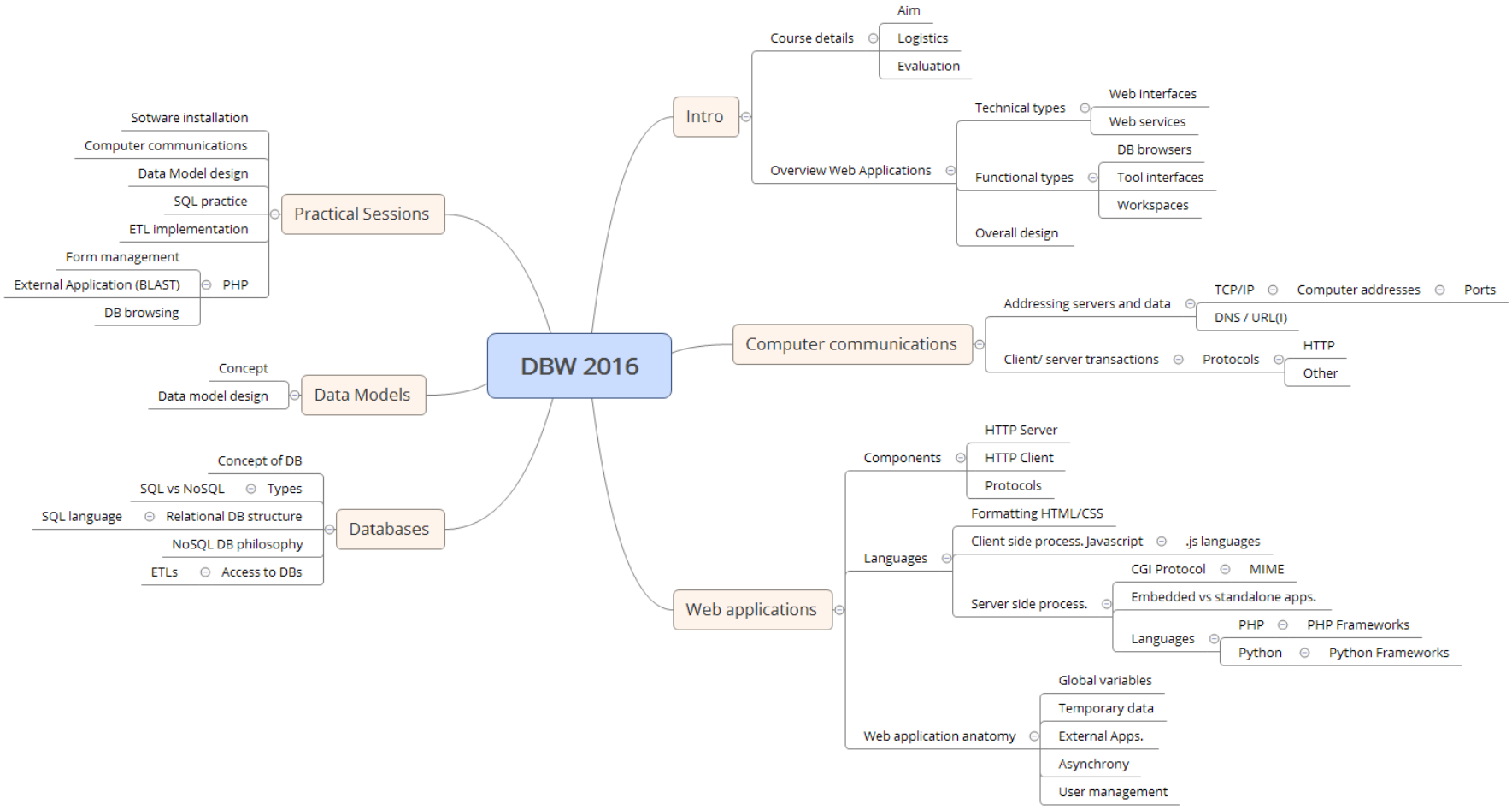


Building a (web) application

1. Define specifications
2. Analyze data and built a data model
3. Decide/prepare Database implementation
4. Build ETL if necessary
5. Define interfaces
6. Define and prepare files/scripts layout
7. Write application code
8. Test, debug, document…

Course logistics

- Web site(s)
  - Course materials:
    - http://mmb.pcb.ub.es/formacio/
  - Personal sites:
    - http://mmb.pcb.ub.es/formacio/~dbwXX
  - SSH Access
    - ssh mmb.pcb.ub.es –p 22021 –l dbwXX
  - Mysql Access (port 13306)
    - DB: DBWXX, same user/password



Subjects overview

Software to install

- Ideally Linux (may need root privileges)
- From Linux distribution
  - Apache Web Server (v. 2.x)
    - With PHP 5.x and mysql support
  - MYSQL server (v. 5.x)
  - MYSQL Workbench or phpMyAdmin
- Netbeans (PHP module) (optional)
- MongoDB (optional)

Evaluation

- Exercices, in-class projects (20%)
- Personal web site (20%)
- Web application project (60%)
  - Progress presentations
  - Fully operative web application using DBs

Evaluation

- Web application project
  - 3-4 people / group
  - Free subject (bioinformatics preferred)
  - Should include DB management, web interface, users management
  - May use fake data if necessary
  - Available at the personal web site
  - Preferred languages: PHP, Perl, Mysql

Evaluation

- Web application project
  - Steps:
    - Initial specification (16 Jan)
    - Data analysis & Database design (21 Jan)
    - Project Demo (6 Feb)
    - Final application (~6 Mar)
- Installed on server
  - mmb.pcb.ub.es/formacio/~dbwXX
    - Account dbwXX . DB DBWXX

Basic computer communication protocols

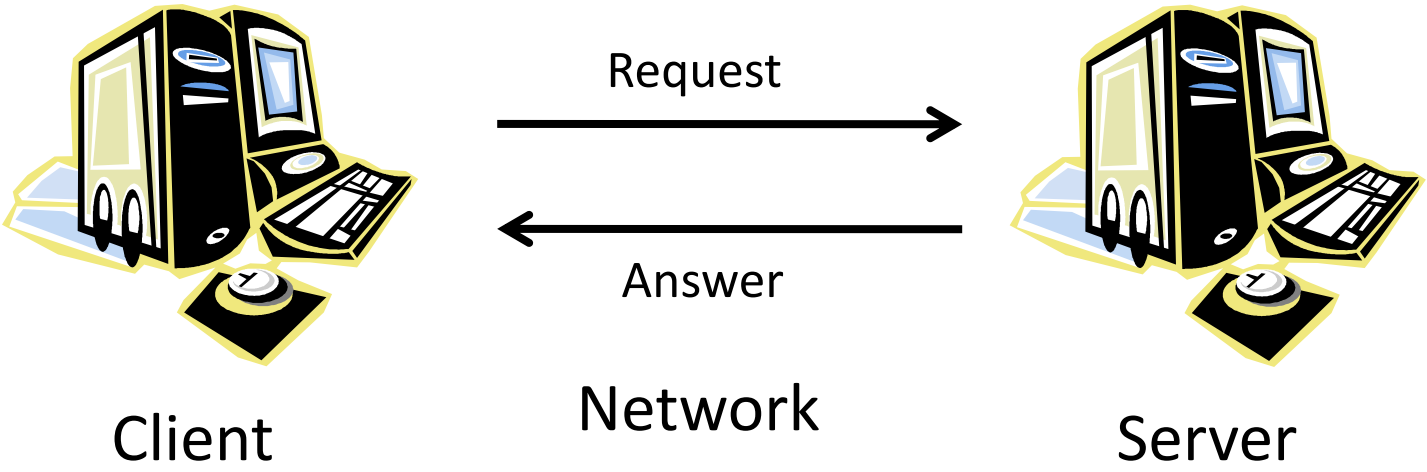
Aim & Outline

- Understand the basic components of computer communication protocols
  - Concepts of client and server
  - Addressing servers and data
    - Computer addresses (MAC Address, IP Address)
    - Ports
    - Resource identification
      - DNS
      - URL/URI concept
  - Client/server transactions
    - HTTP protocol

Present internet

- Huge network of computers using common communication protocols (TCP/IP, HTTP)
- Distributed, no central servers
  - (Well, not really true in bioinformatics)
- Common language: HTML/CSS (XML)
- Content mostly static, but dynamic behaviour is possible through web applications

Components



- Client and Server logic and physical addresses
- Data
- Data meta-information
  - Nature of data
  - Request (what to do)
  - Applications involved (email, web, etc.)

How it works: TCP/IP

- Packet switching
  - Packet switching breaks the signal in small fragments ("packets") each of them containing the complete information about source and destination
    - Packets can share a single communication line
  - Users have the idea of a dedicated line but, in fact, it is not. Of course, the bandwidth is limited.
- Computers connected to internet should have addresses
  - MAC Address: Address of the physical interface
  - IP Address: Address of the computer

IP addresses

- Allow to find destination irrespective of the nature of the network media.
- Each device has a “unique” IP address
- IPv4: 32 bits (4 x 1 byte (0-255) numbers)
  - Max: 2^{32} : aprox 4.3 x 10^{9}
  - P.ex. 161.116.222.59 (mmb.pcb.ub.es)
  - 4 levels are hierarchical
- Some addresses are reserved, and some networks are “local”
- IPv6: 128 bits (16 bytes). Max: 2^{128} (3.4 x 10^{38})

Names *vs* addresses (Domain Name System)

- IP addresses are not easy. Most hosts have also a "name":

  f. ex. www.ncbi.nlm.nih.edu

- Host names have a structure similar to IP addresses: Top domains (.es, .edu, correspond to full class domains and subnets are indicated by prefixes.
  - ub.es (161.116.x.x)
  - bq.ub.es (161.116.154.x)
  - www.bq.ub.es (161.116.154.18)

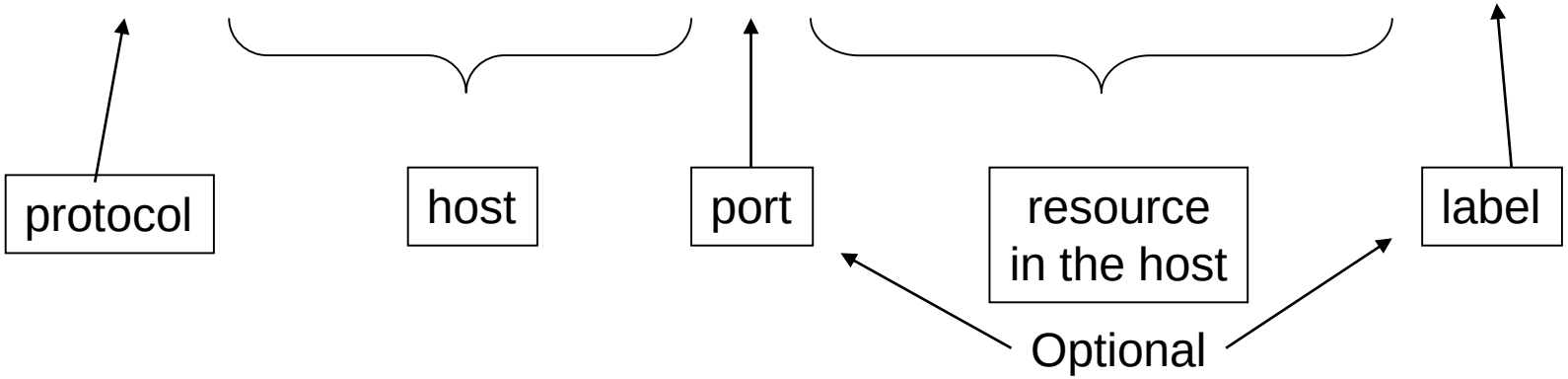
How to address applications in a server: Port ids.

- Each host has **one IP address** but has **several ports** for known services
- Ports are 2-Byte numbers.
  - 0-1023 are "**Well known ports**" (Telnet: 23, FTP: 21, HTTP: 80, ...).
  - 1024-49151 are "**Registered ports**", usually managed by applications (MySQL: 3306)
  - 49,152-65,535 are "**Dynamic and/or private ports**" freely usable.
- Communication to ports triggers the specific application to deal with the data
- However, different ports from official ones can be used to:
  - Hide applications
  - Have more then one server in the same IP address
  - Hide servers in internal networks.

URI/URLs

- Resources must be identified in a way that includes all the necessary details:

http://mmb.pcb.ub.es:80/courses/master.htm#top



Missing parts of the URL are filled by default!!

Client – server communication

- Most Web Applications use HTTP (hypertext transfer protocol), although sometimes FTP, SMTP

- HTTP is a client-server communication protocol
  - Link between client and server is dynamic
  - Usually limited to a single transaction
  - Requests composed by a query operation and a variable set of headers.
  - Answers: headers + data

Client – server communication

- Relevant Operations: GET, POST
  - GET: Simple retrieval, all information/parameters included in the URL
    - Simple queries, static information
    - Required to be used as hypertext links
  - POST: Query defines the resource, but input data follows
    - Input data can be of any type (including binaries, whole files) or size (within limits)
- Relevant HTTP headers
  - Content-type (POST): input data format
  - Content-type (Answer): Data MIME type (text/html, image/jpg, …)
  - Location: Redirects browser
  - Set-cookie: Set a “cookie” on users’ software.

Cookies

- Small information tags sent as HTTP headers and stored in the browser side
  - Are associated with a URL, and are sent back to the server whenever that URL is visited within a expiration date

```
Set-Cookie:
  PHPSESSID=bb56ee648aeac6923e3360a7b8284a6f;
  path=/
```

- Useful to “remember” clients, but some people disables them!