edinburgh data-intensive research

VERCE

DISPEL introduction

Malcolm Atkinson

Malcolm.Atkinson@ed.ac.uk

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NSF PIRE Open Science Data Cloud

workshop

Informatics Forum

Edinburgh

FP7-INFRASTRUCTURES-2011 project# 283543

Outline

- Data Intensive
  - What is it?
  - Why use it?
- DISPEL
  - What is it?
  - Why design it?
  - Is it different?
- A simple example
- Summary and Conclusions

picture from Erica Salmon
Cornish Coast Path
where I call home

Data-Intensive Thinking

Data-Intensive Thinking

epcc

OGSA-DAI

DATA MINING ADMIRE DATA INTEGRATION

Computing over data pedigree!

edinburgh
data-intensive
research

- **Tycho Brahe and Johannes Kepler**

  1546-1601 & 1571-1630

- **Dennis Noble uses Mercury**
  - *The* London University Computer in 1959
  - to demonstrate heart beats as emergent behaviour
  - by simulating two ion channels
  - 2 papers in Nature 1960
    - read "The Music of Life" by Dennis Noble

Gray's Laws of Data Engineering

Jim Gray:

- Scientific computing is revolving around **data**
- Need **scale-out** solution for analysis
- Take the **analysis to the data**!
- Start with "**20 queries**"
- Go from "**working to working**"

From: Alex Szalay, JHU

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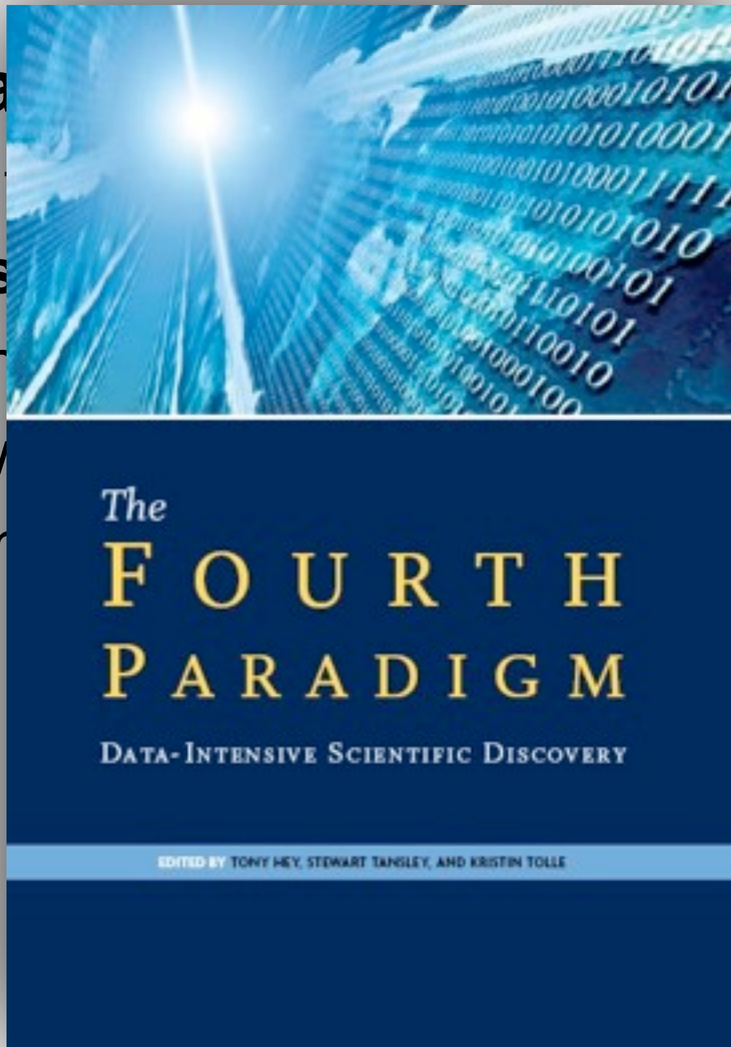

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Defining “Data-Intensive”

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- **Generally**
  - ***A computational task is data-intensive if you have to think hard about an aspect of data handling to make progress***
    - distribution, permissions and rules of use, complexity, heterogeneity, rate of arrival, unstructured or changing structure, long tail of small and scattered instances, size of data, number of users
    - often in combination

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    - often in combination
- **Quantitatively**
  - **The computation's Amdahl numbers are close to 1**
    - CPU operations : bits transferred in or out of memory
    - 1000 CPU operations : 1 I/O operation
  - **Total volumes expensive to store**
  - **Total requests/unit time hard to accommodate**

Data-Intensive Strategies 1

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  - So that you can afford a lot of them
  - Balanced for data-intensive work
  - Treat memory bandwidth as a scarce resource

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- Use directories and indexes to avoid revisiting data randomly

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  - many subtasks at modest rate per task in large numbers
  - NOT tightly coupled parallelism!!!
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- Statistical and quantised accounting

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- **High-level notations for describing methods /composing tasks**
  - *with well-developed optimised transformations before execution*
  - query languages: SQL/AQL, (Xquery &SPARQL), ...
  - workflow languages: Kepler, Pegasus, DISPEL, ...
  - MapReduce: PigLatin, ZigZag, ...

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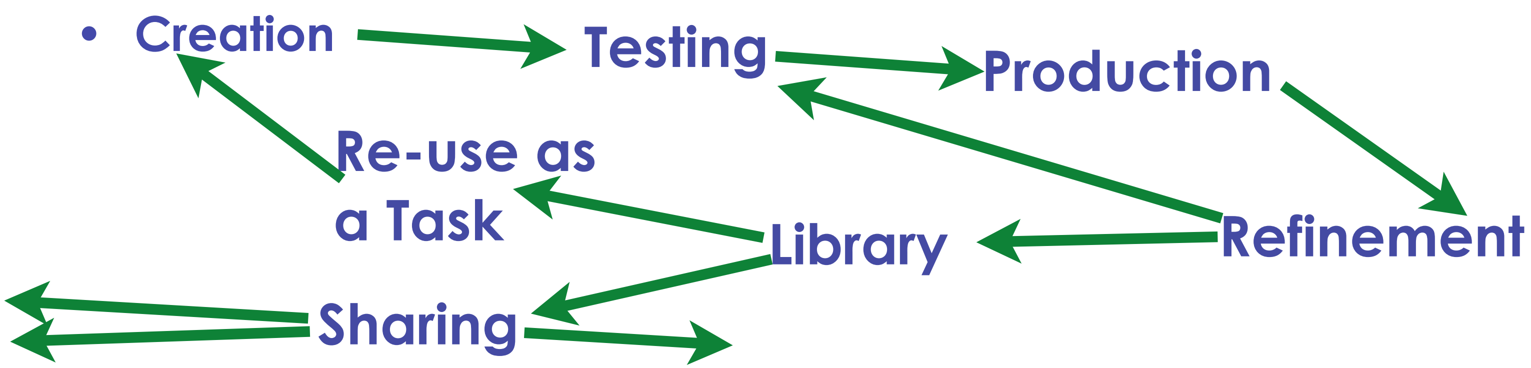
  - your existing code & preferred languages
- **Support for the query & workflow lifetime: new research objects**



Diversity, Urgency, Complexity, …

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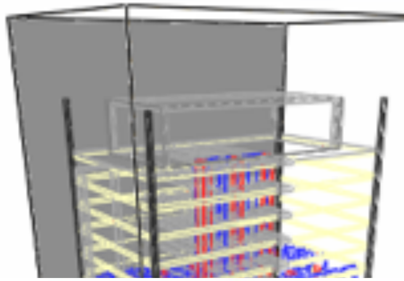

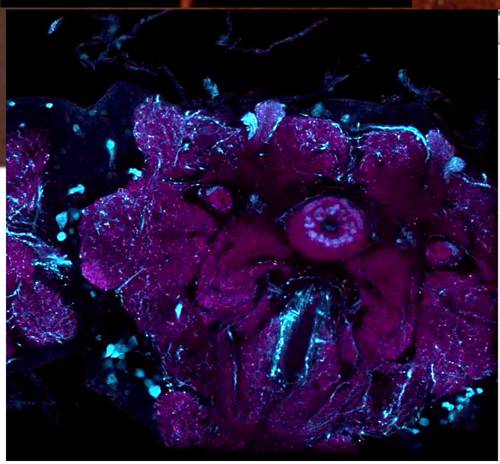

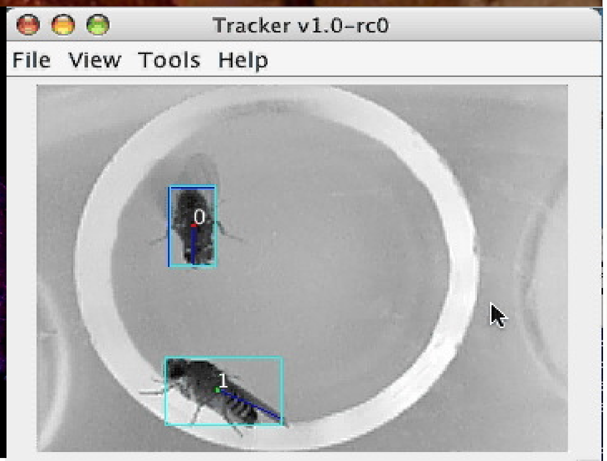

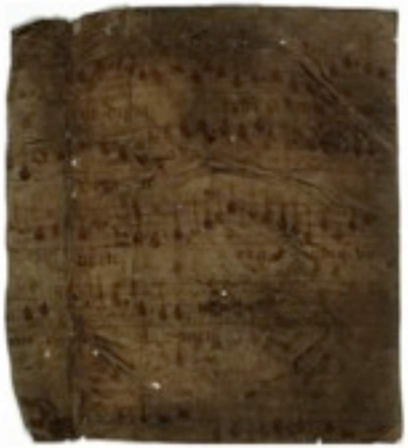

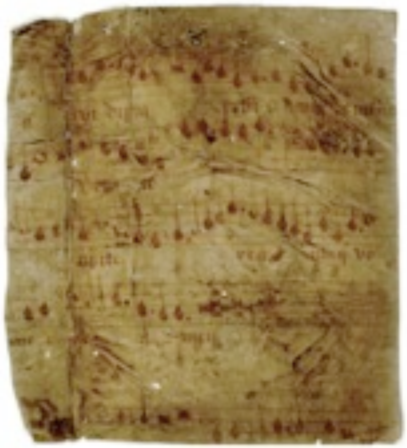

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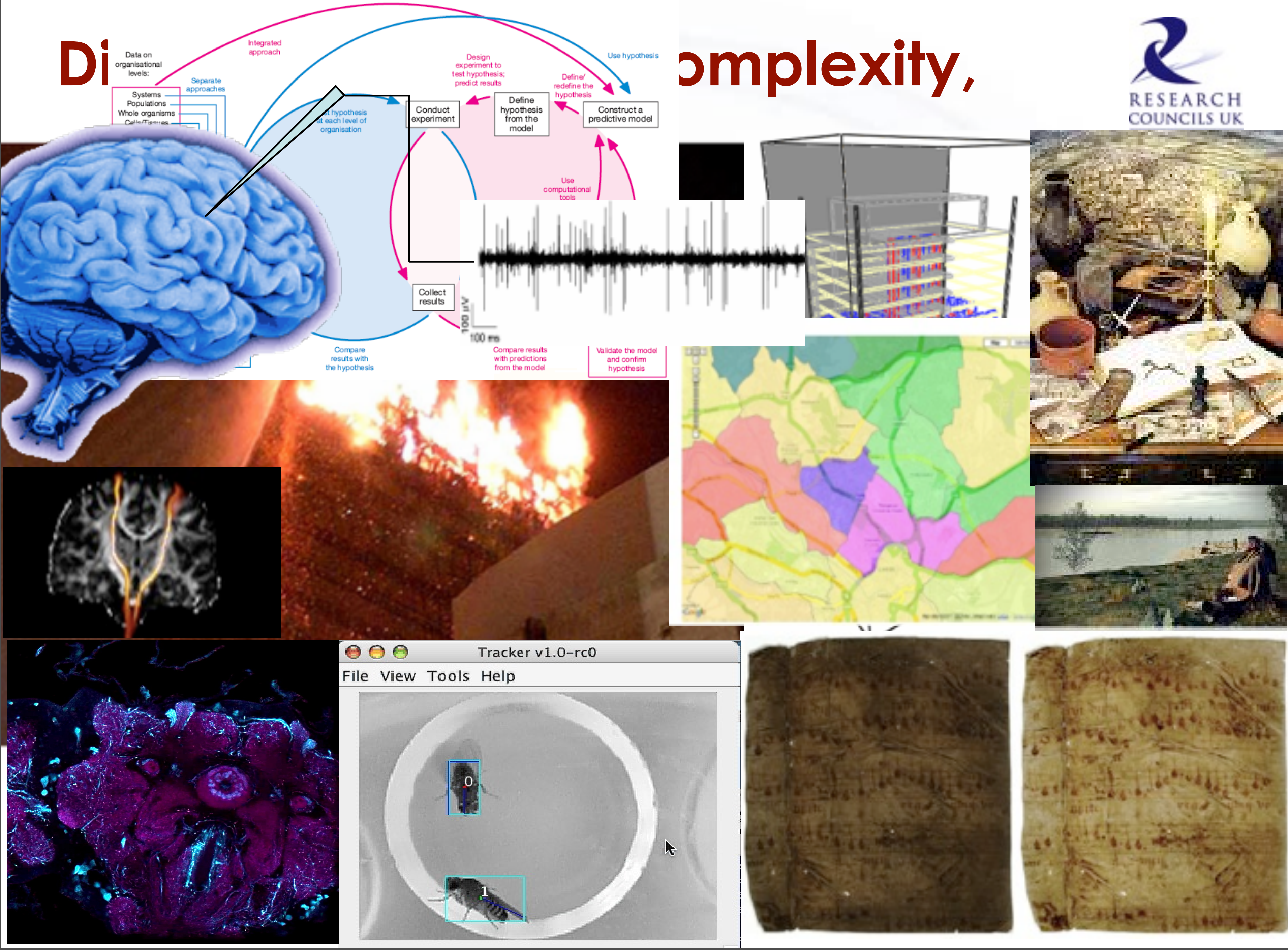

Tuesday, 17 July 12

Datascopes for the naked mind

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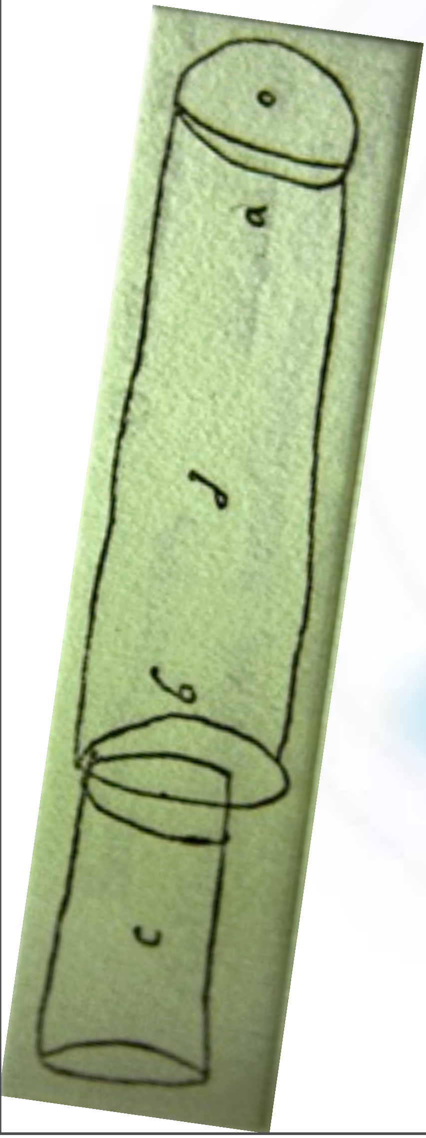

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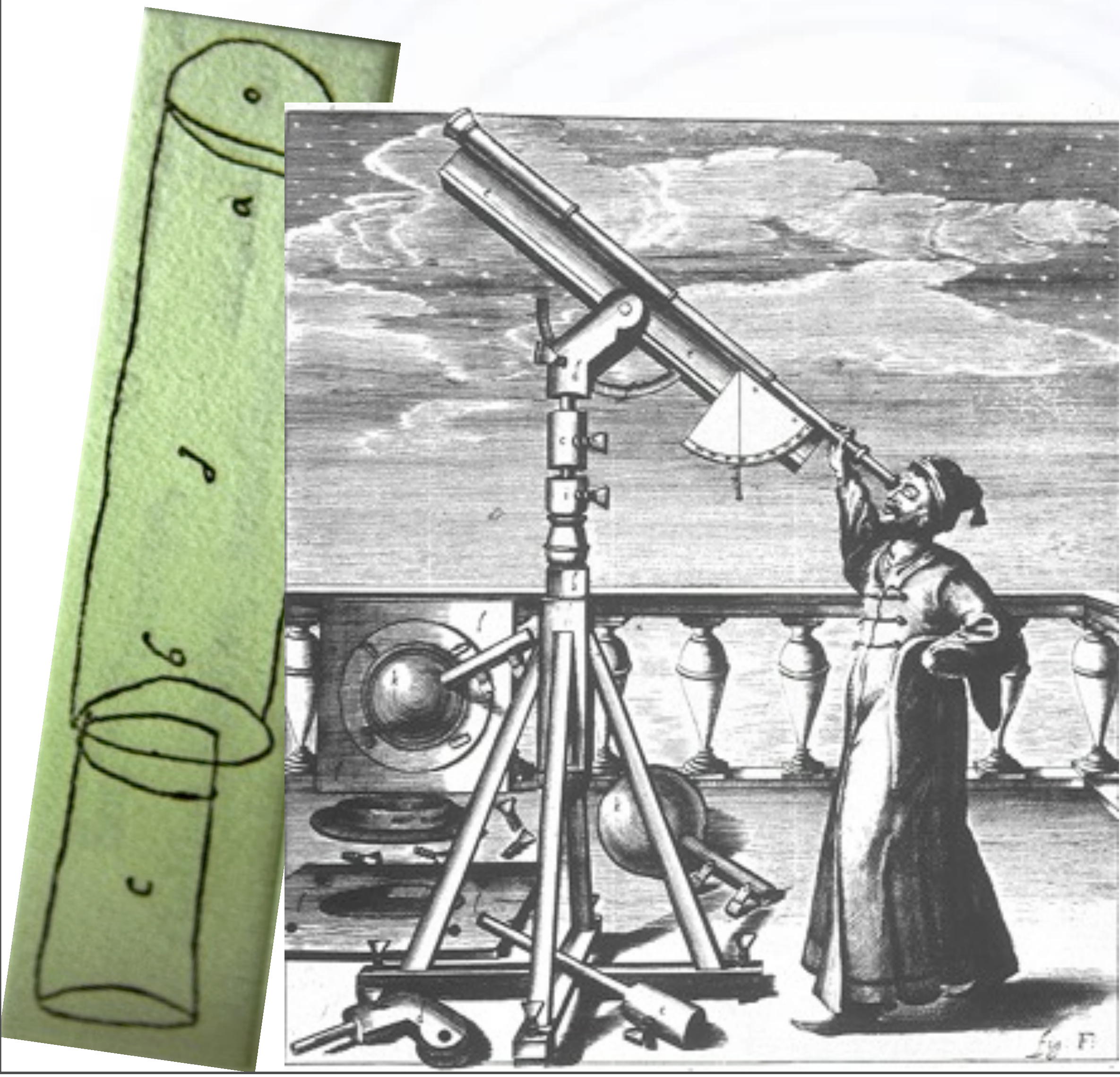

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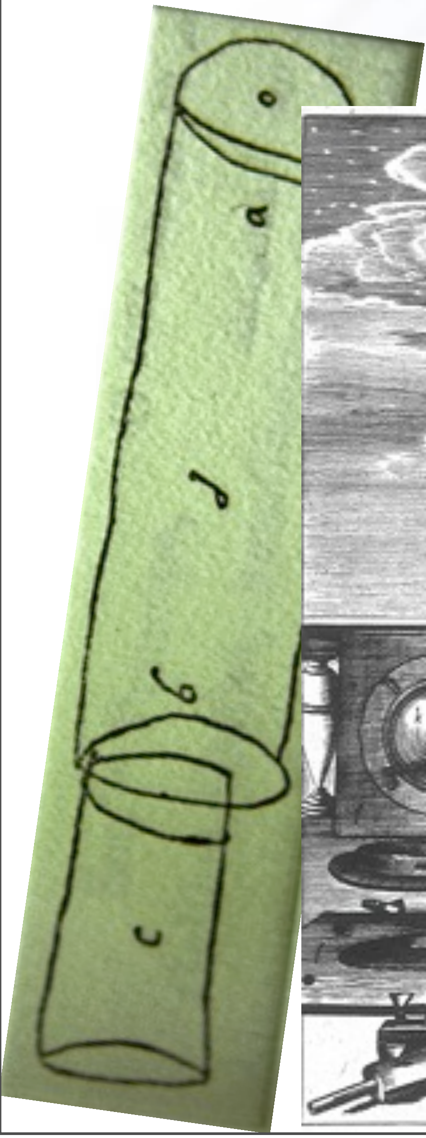

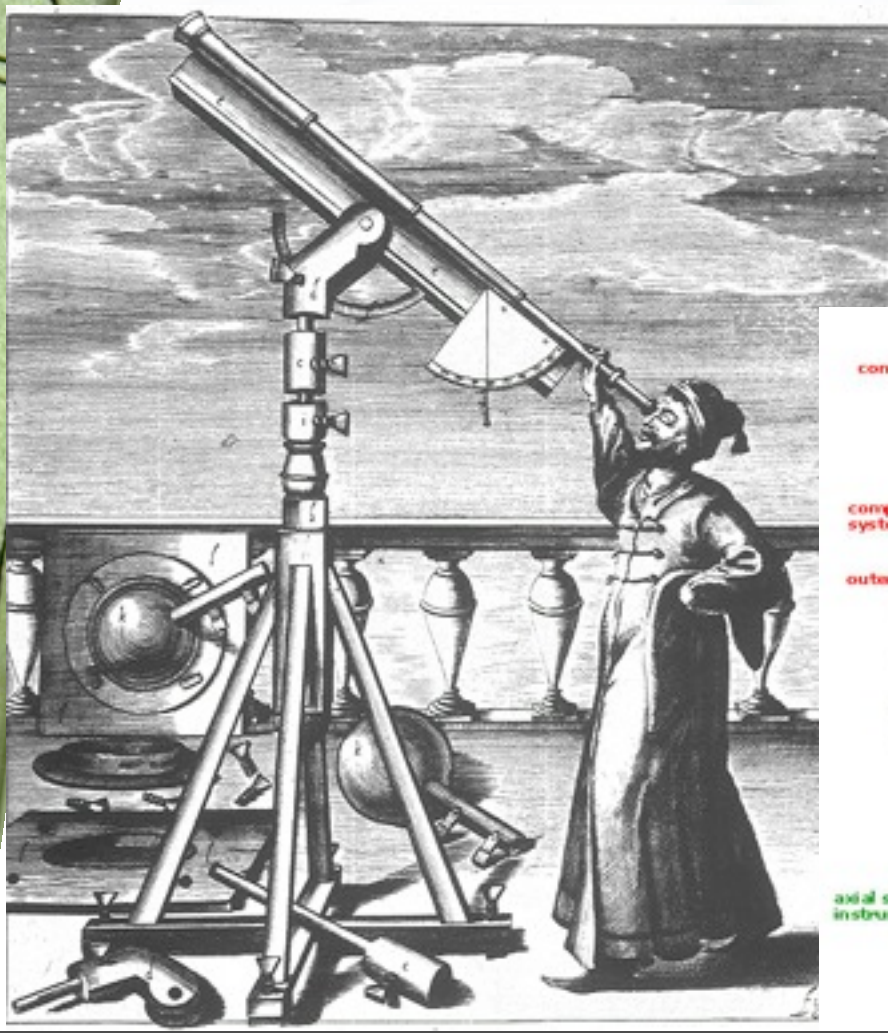

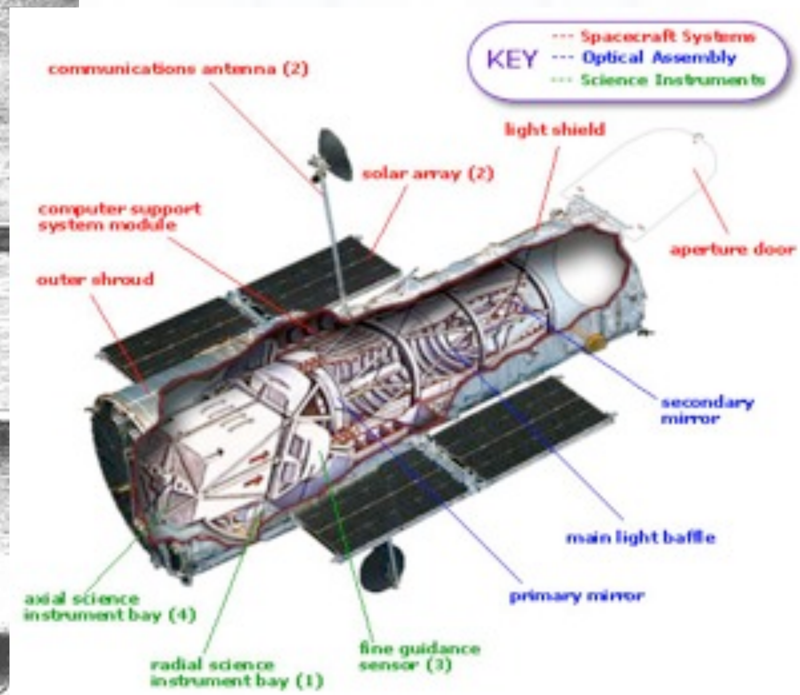

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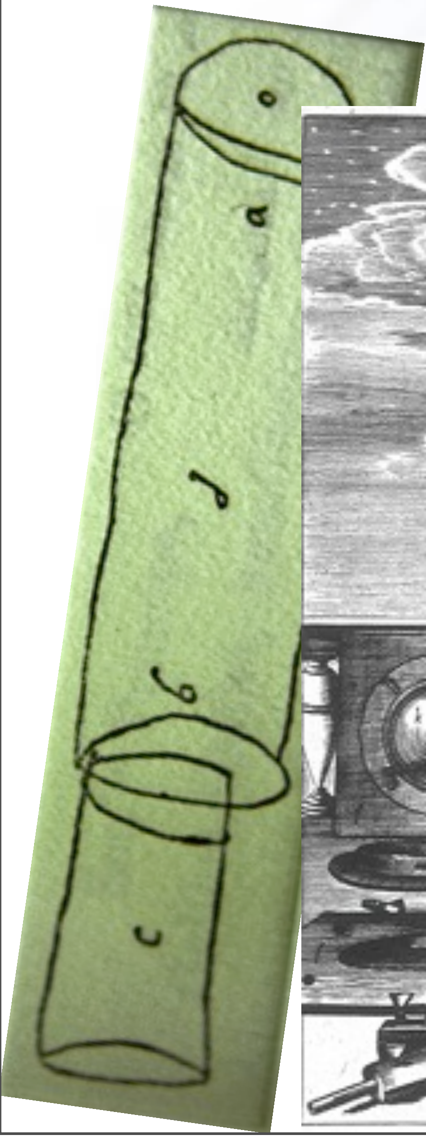

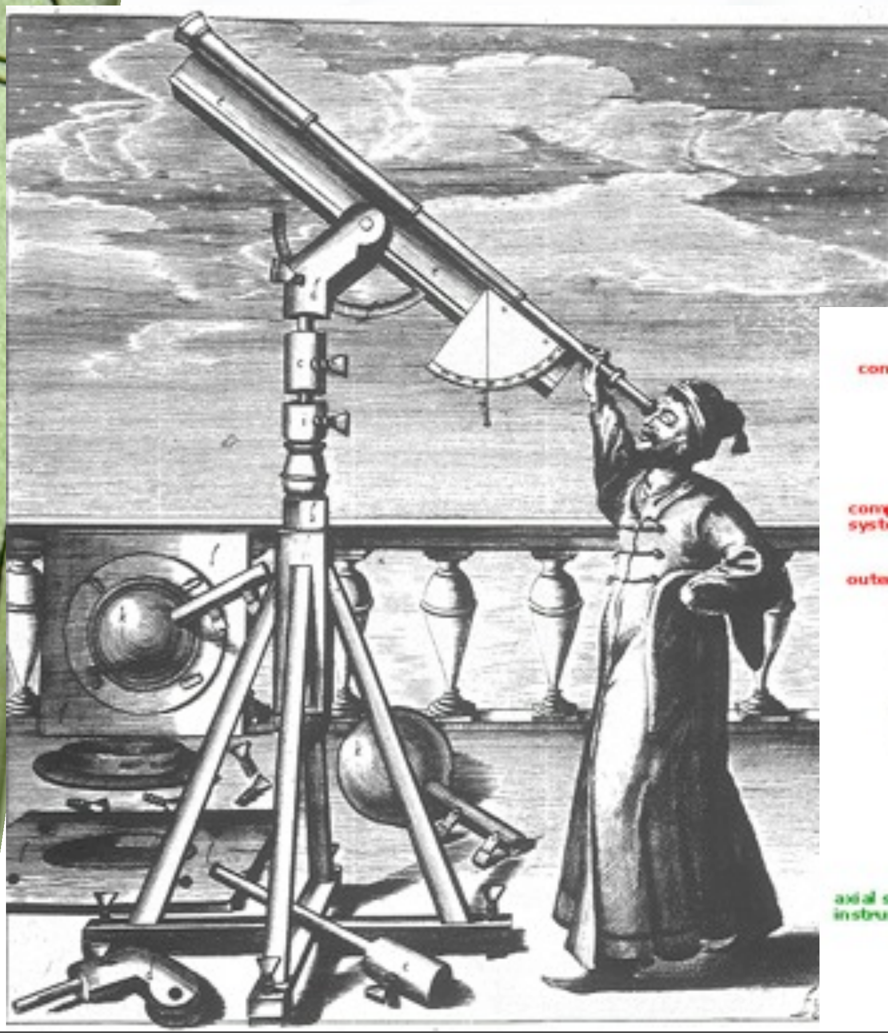

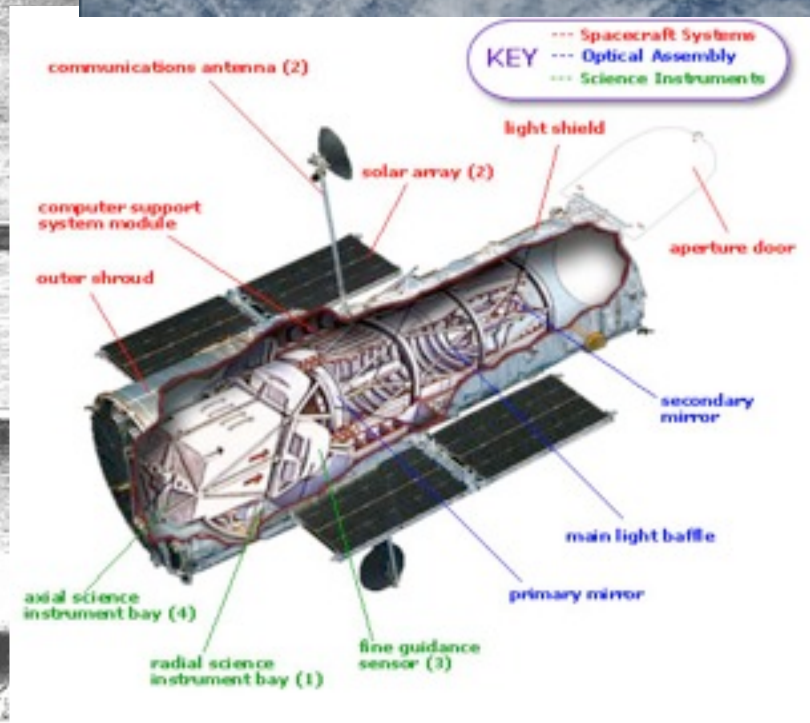

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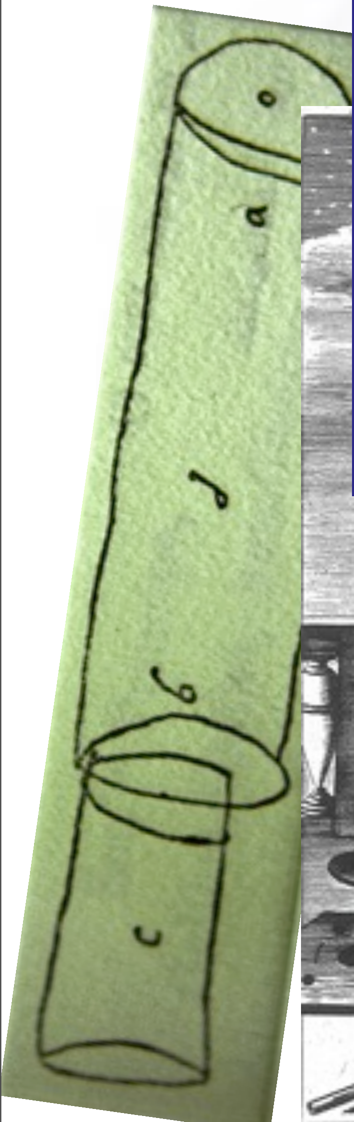

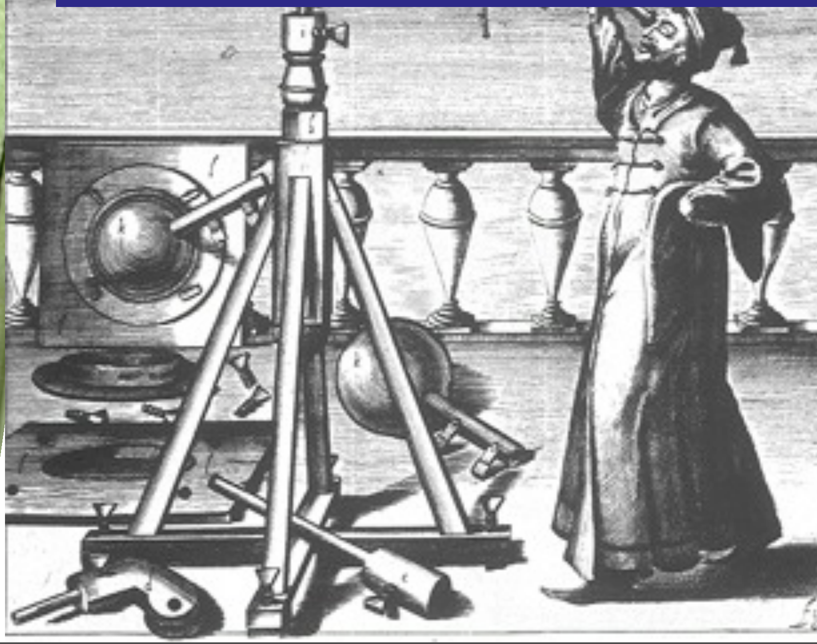

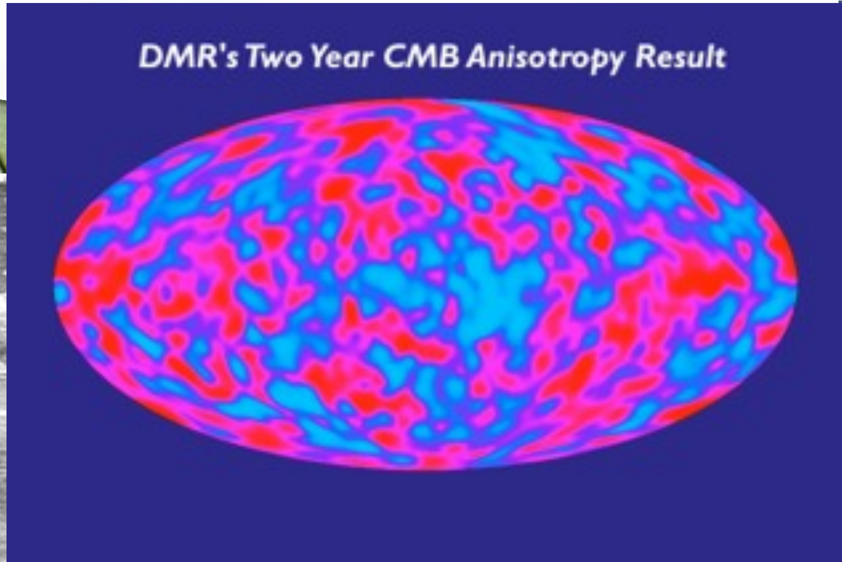

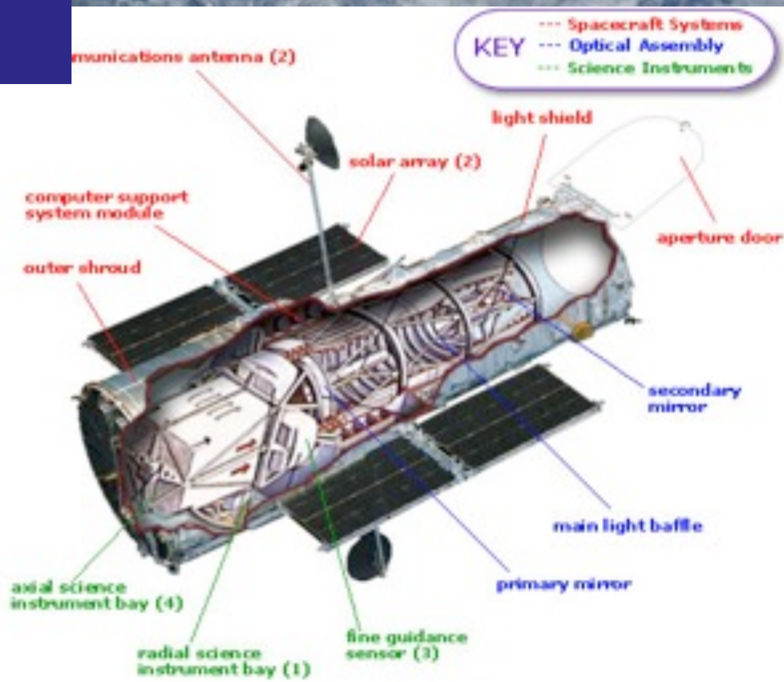

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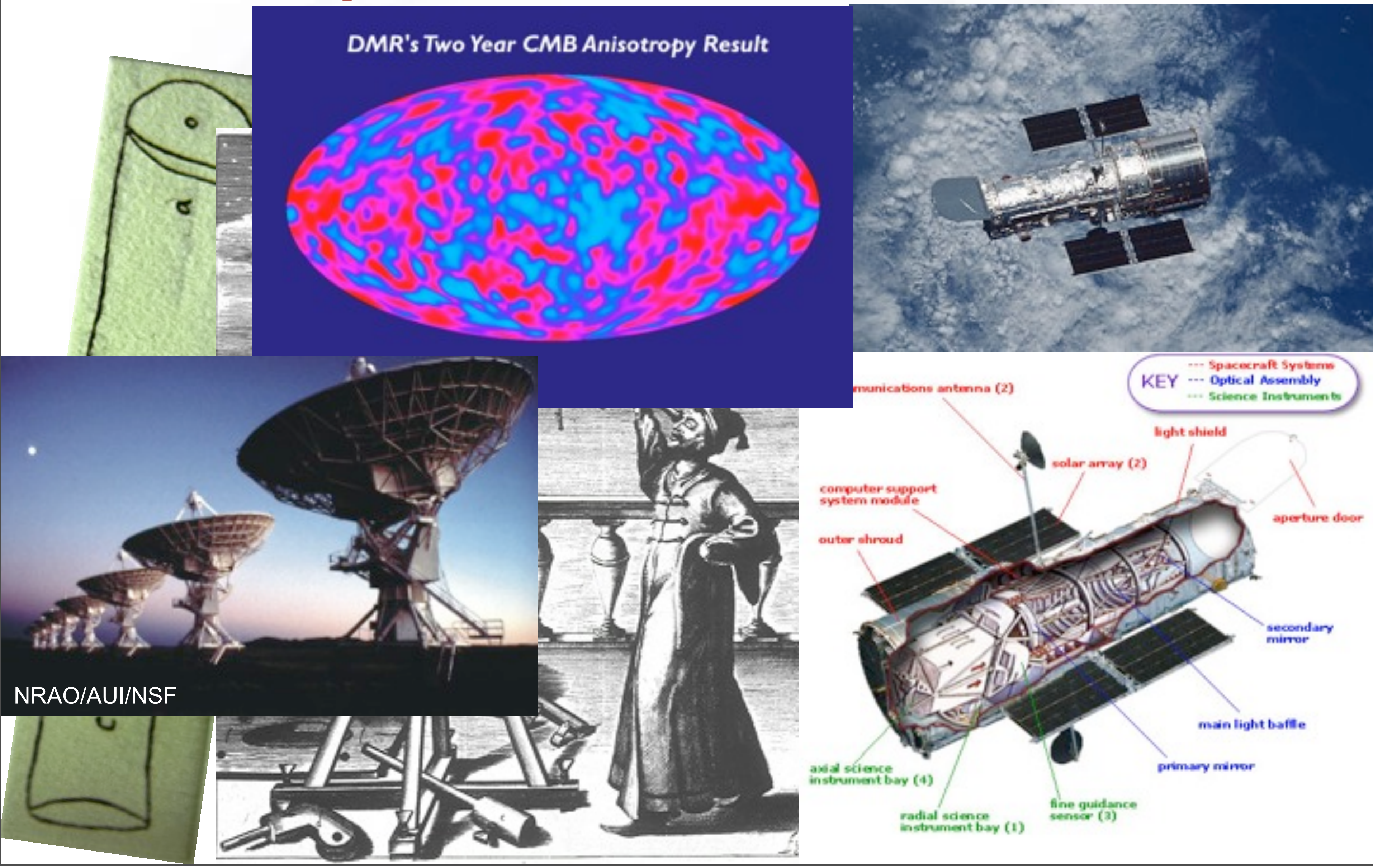

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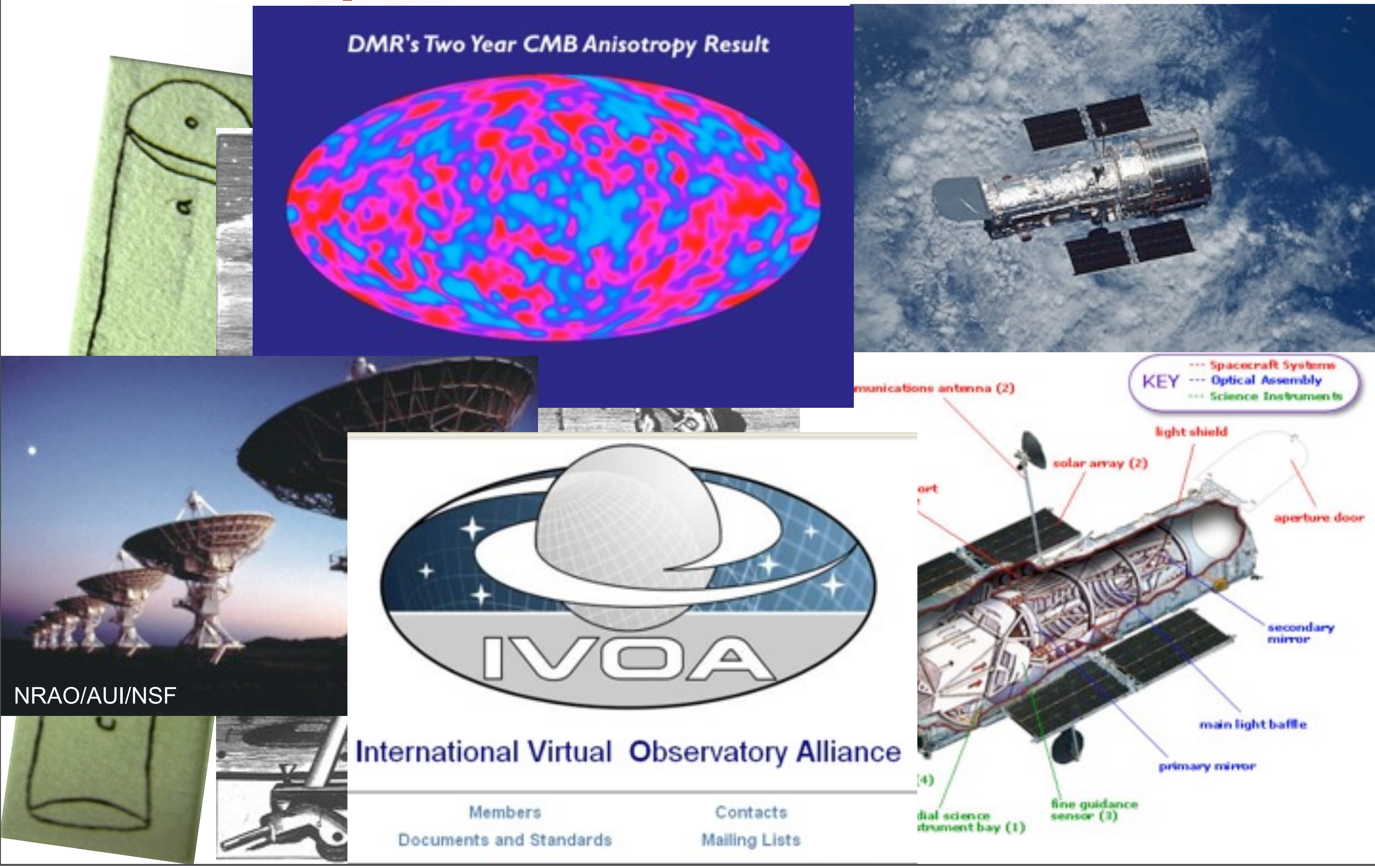

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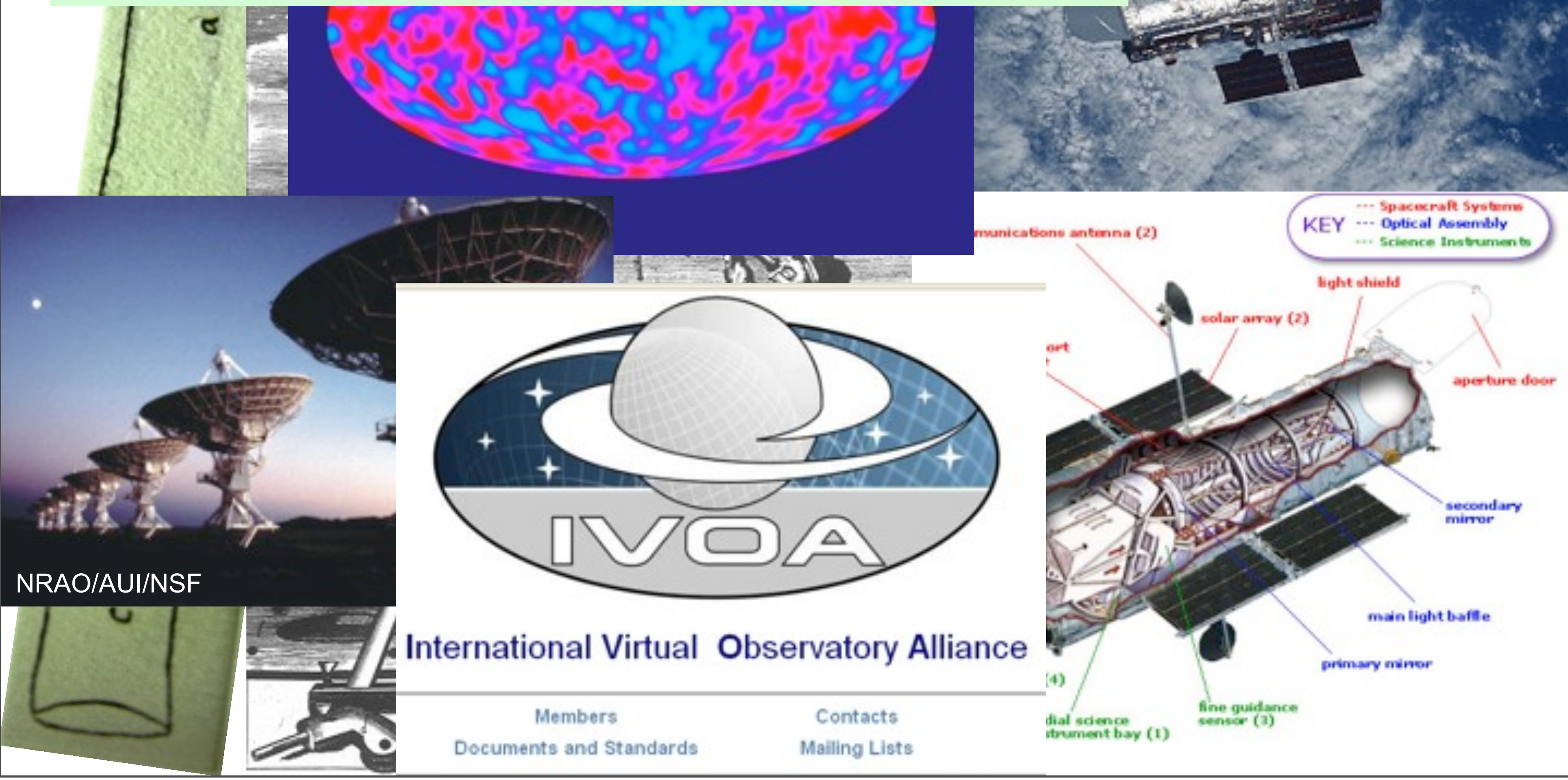
To reveal evidence in data you could never see before



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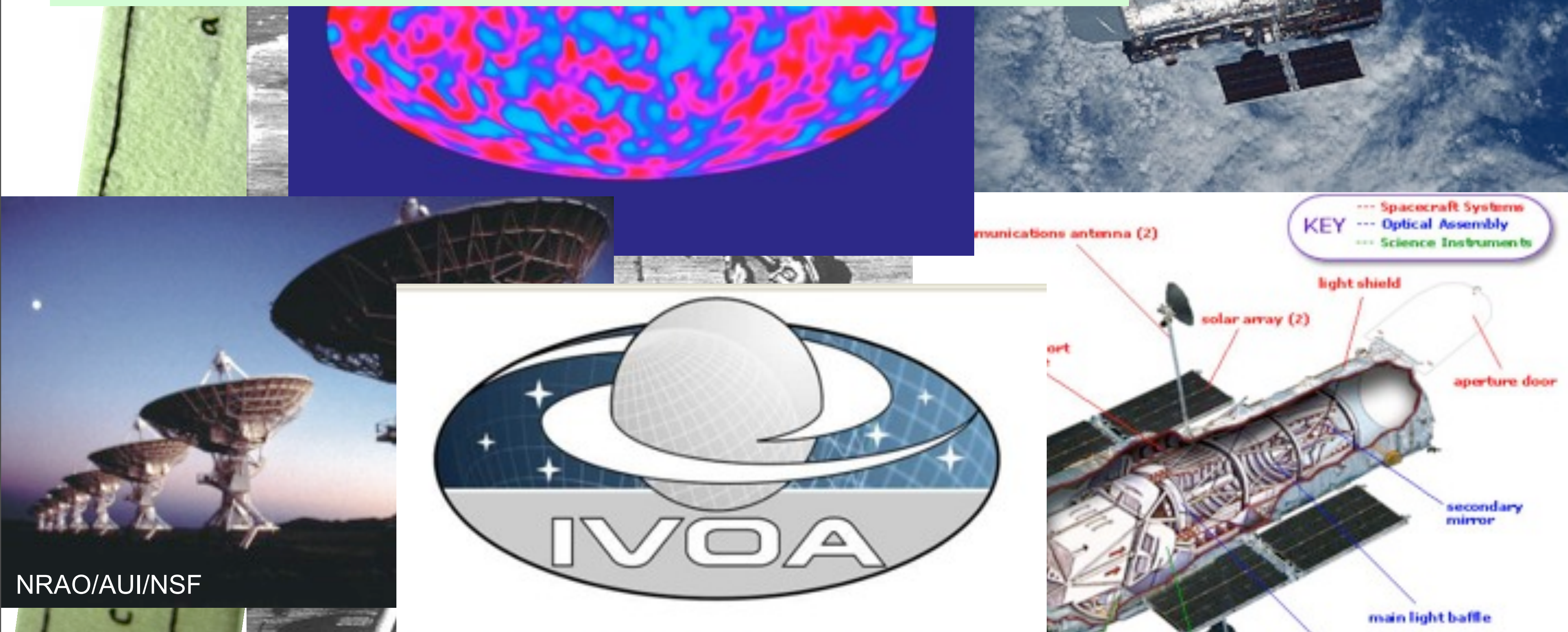
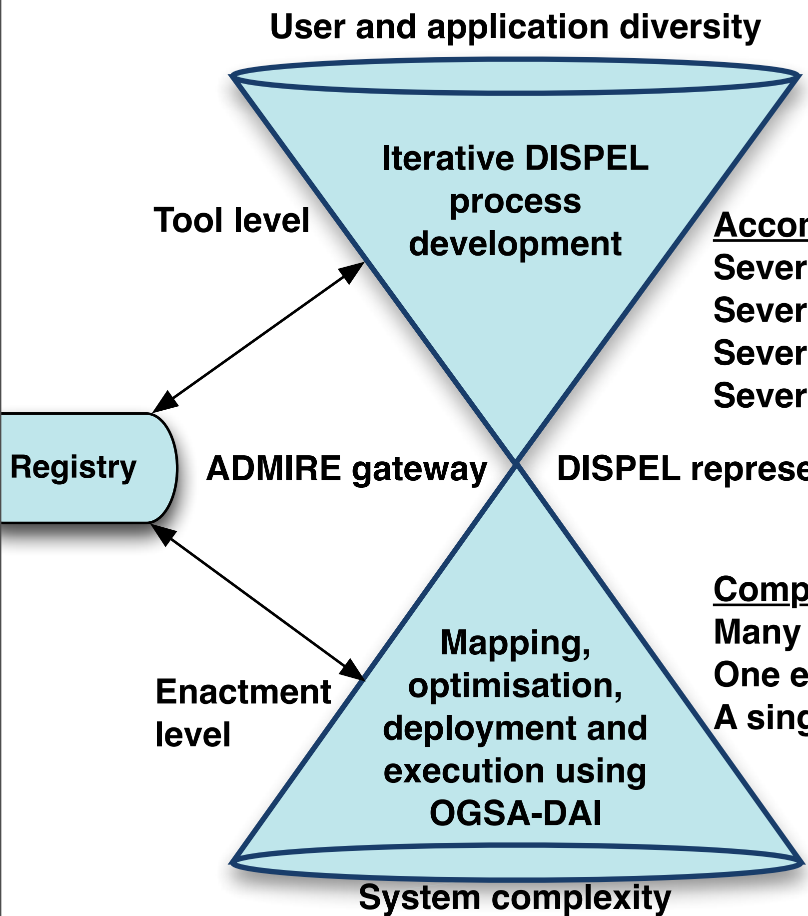


Changed our place in the universe

DISPEL

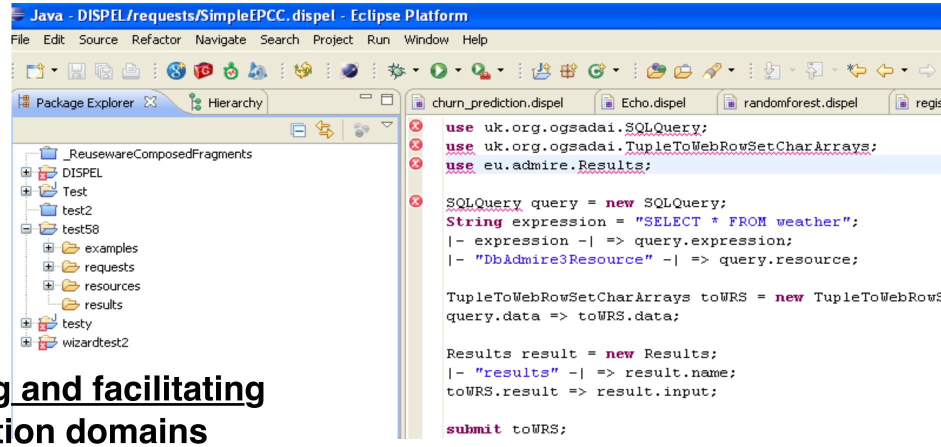
Data-Intensive Process Engineering Language

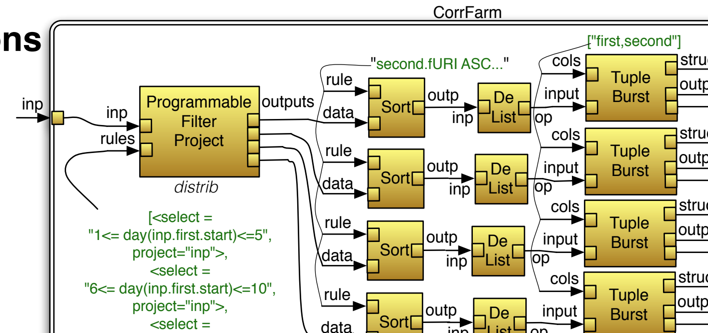
- A language for constructing data-flow graphs
  - Nodes are processing elements
  - Arcs are data-flow paths
- A language for generating data-flow patterns
  - Functions hide detail of graphs
  - Functions generate graphs
- A language for discussing data-flow engineering
  - Designed to be read and written by humans
  - As well as by programs
  - Supports validation and optimisation



Accommodating and facilitating
Several application domains
Several tool sets
Several process representations
Several working practices

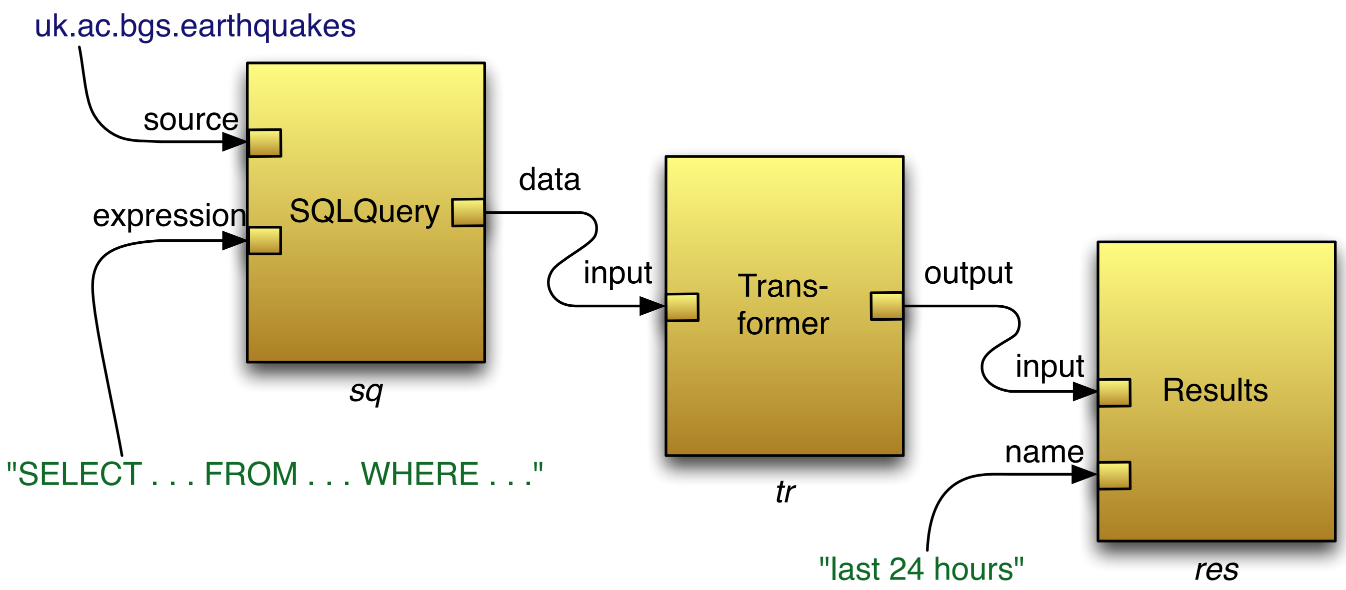
Composing and providing
Many autonomous resources
One enactment mechanism
A single platform





EDIM1

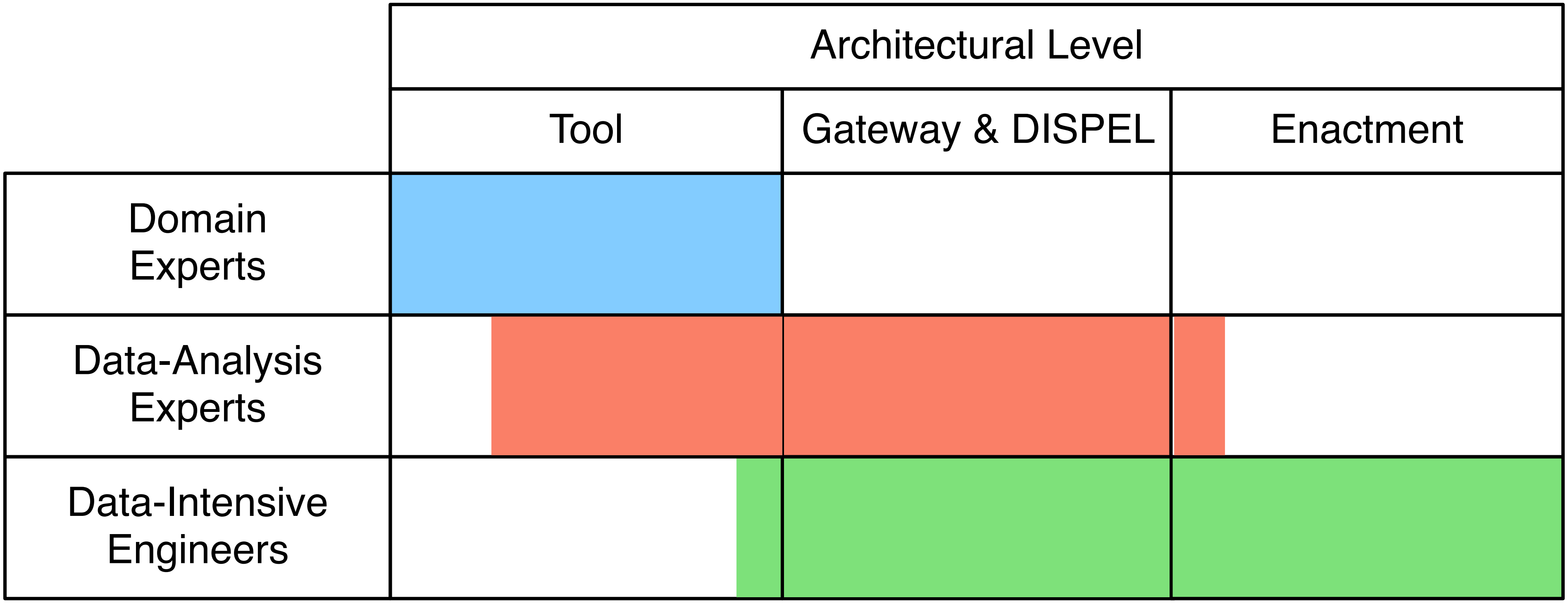
A simple DISPEL graph



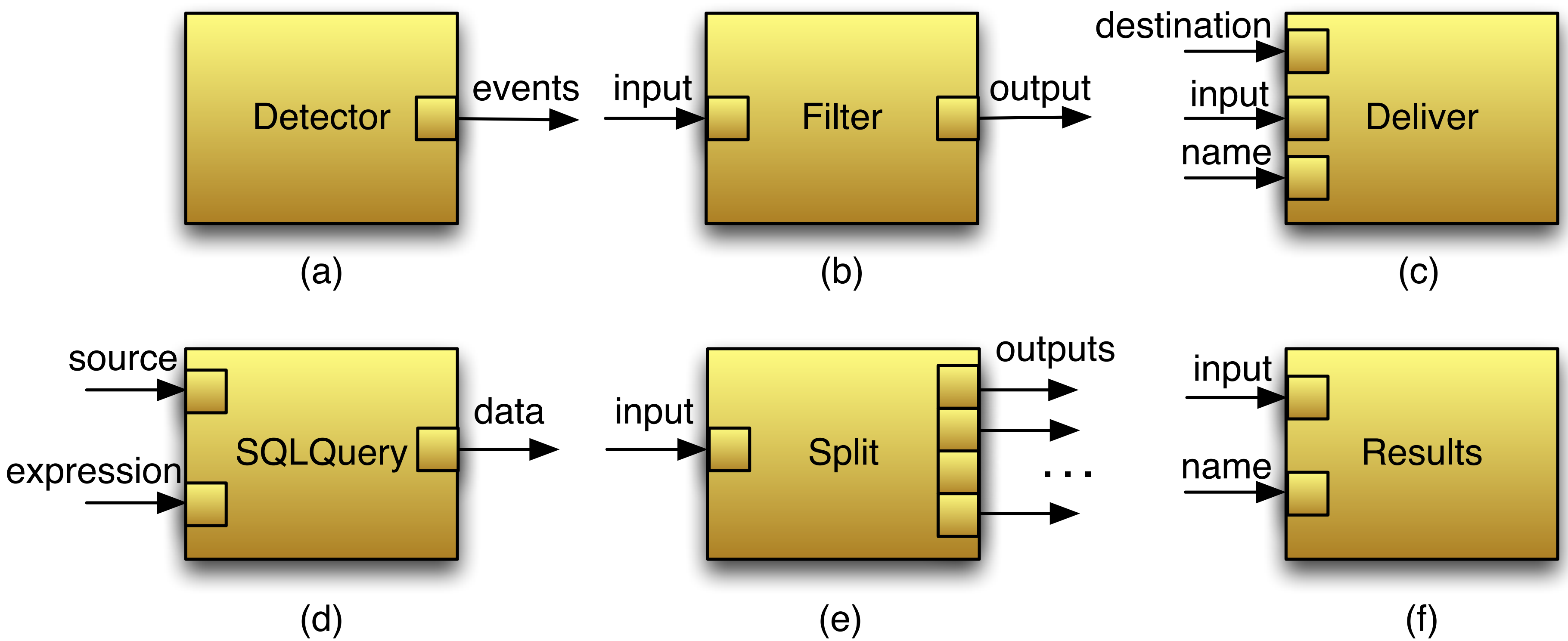
The DISPEL to Generate it

```
package book.examples.seismology {                    //set working context
  use dispel.db.SQLQuery;                             //import PE SQLQuery
  use book.examples.seismo.Transform;                 //import PE Transform
  use dispel.lang.Results;                            //import PE Results

  SQLQuery sq = new SQLQuery;                         // new instance of SQLQuery
  Transform tr = new Transform;                       // new instance of Transform
  Results res = new Results;                          // new instance of Results

  sq.data => tr.input;                                // set up data flow from sq to tr
  tr.output => res.input;                             // set up data flow from tr to res
  |- "uk.ac.bgs.earthquakes" -| => sq.source;         // URI of source of data
  |- "SELECT ... FROM ... WHERE ..." -| => sq.expression;    //query gets traces
  |- "last 24 hours" -| => res.name;                  //name of results for user

  submit res;                                         // submit for enactment
}
```

Who ‘speaks’ DISPEL



Processing Elements



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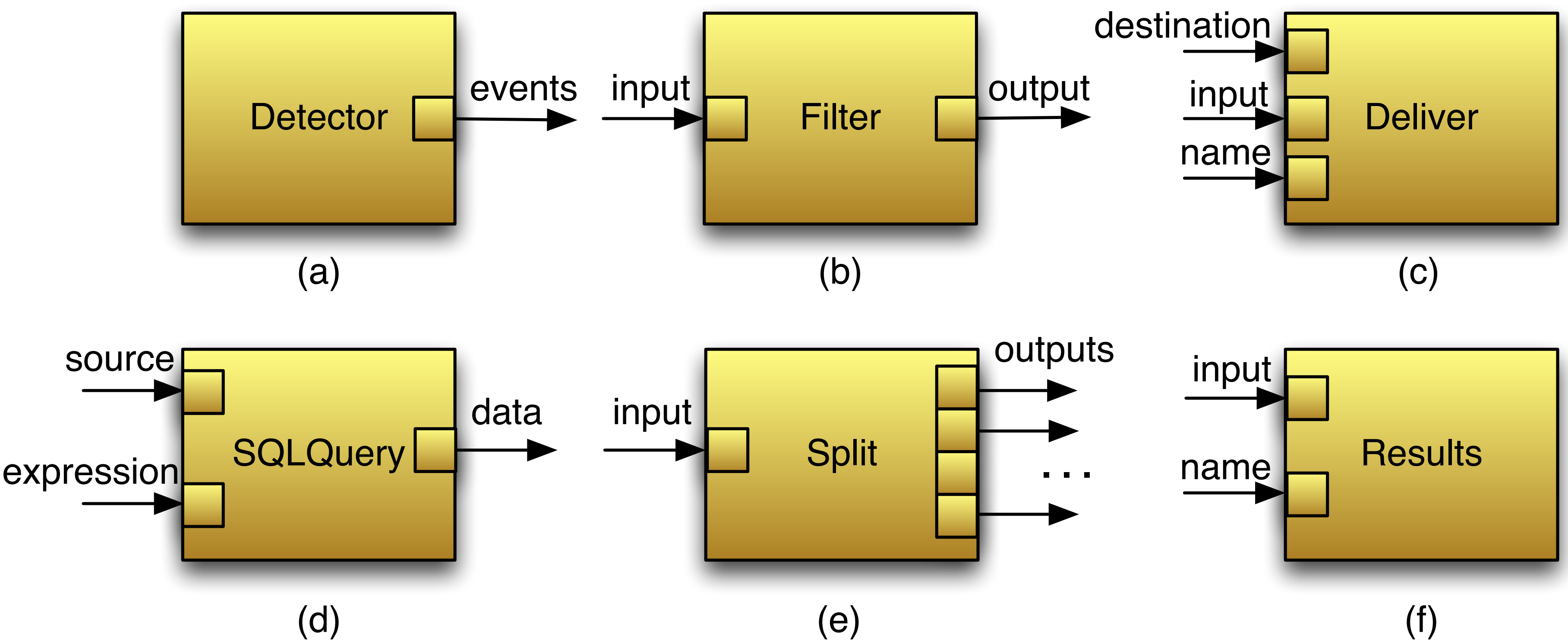

Expect well-organised libraries of well-described PEs

Description:

- names, inputs, outputs
- formats & meaning of each input and output
- auto-iteration behaviour, termination & errors
- optimisation properties
- use, relationships and logical properties

Functions

- Algorithms to generate graphs
  - parametric variation
  - patterns
  - parameters
  - subgraphs
- Abstraction and Optimisation
  - smart methods for common patterns
  - hiding pattern implementation for stability
  - late evaluation permits contextual optimisation

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Description:
- names, type signature

Enactment Model

1. DISPEL language processing
   1.1. Validation & Import from Registry
   1.2. Format & Meaning mis-match handling
   1.3. Interpretation to generate graph
2. Graph optimisation & mapping
   2.1. Re-ordering & Parallelisation
   2.2. Identification of target locations
   2.3. Selection of PE implementations / instances
   2.4. Partitioning into co-located subgraphs
3. Deployment
4. Execution, Monitoring & Clean up

DAGMan

Condor
High Throughput Computing

VisTrails

meandre

swift

Kepler

MOTEUR

pegasus

Taverna

Trident
Microsoft Research

TRIANA

ASKALON

KNIME

Ian J. Taylor, Ewa Deelman, Dennis B. Gannon, and Matthew Shields.
Workflows for e-Science: Scientific Workflows for Grids. Springer London, 2007.

DISPEL is Different 1

- Spanning Distributed Independent Hosts
  - Fragments of one workflow can run in different regimes
  - Different security models
  - Different file systems
  - Different DBMS
  - Different Operating Systems
  - Different DISPEL implementations
- Agnostic about Size & Scale
  - Processing Elements of any size
  - Data values in streams of any size
  - Streams of any length
  - Graphs of any size

DISPEL is Different 2

- Patterns & Pattern Composition
  - Functions define & generate patterns
  - Higher-order functions compose patterns
  - Functions can be refined to optimise
- Component-Description Driven
  - Rich description of components
  - Capturing logical properties
  - Collecting component-builders' hints
- Restricted language for workflow longevity
  - Only hints and *no* WF-definition time concrete mappings
  - Late mapping permits optimisation and enactment, *for the system is at execution time* - much different from definition time!

Summary and Conclusions

Summary

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- DISPEL is an experimental data-intensive language
  - draws on workflows & database query internals
  - auto-iteration over values flowing through connections
  - agnostic about value sizes - implementation challenge
  - controlled access to system information
  - optimisation based on description & operation
  - distributed termination protocol

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    - seven different application domains
- Differences
    - functional pattern handling
    - multi-scale streams
    - restricted information to permit platform evolution
- Status
    - two implementations: to OGSA-DAI & to Java
    - much still to do to fully explore the ideas

?

www.verce.eu

research.nesc.ac.uk/node/828

www.ogsadai.org.uk

omii-uk

www.omii.ac.uk

epcc

Picture composition by Luke Humphry based on prior art by Frans Hals