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dataClay

The integration of persistent data, parallel programming, and true sharing

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EXCELENCIA
SEVERO
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Agenda

- The pillars
- The dark side
- The secret potential
- Time to wake up!

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- The motivation
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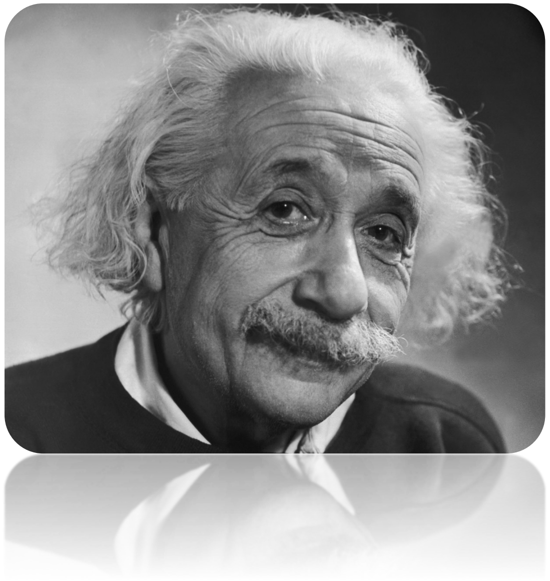
From a different perspective...

- **“We cannot solve our problems with the same thinking we used when we created them”**

  Albert Einstein



- **Some of today’s thinking**
  - Data stored in
    - Files
    - Databases
  - Data is a 2nd-class citizen
    - Accessed with its own primitives
    - Data and code are different

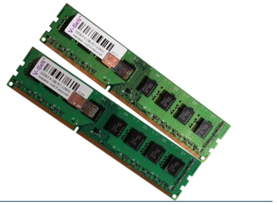
Before everything started
The pillars of dataClay

- **What ignited our research, our "big bang"**
  - Different data models: persistent vs. non persistent
  - New storage devices: byte addressable
  - Coupling data and code
  - Sharing is what really matters

- **And then dataClay came to life …**

  (more details on how all fits together
  in the next minutes)

Two data models!
Why waste time doing it twice?

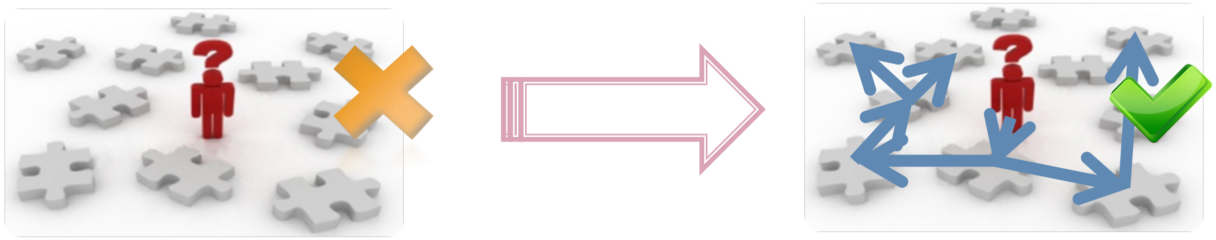


- **Today**
  - We have one data model for volatile data
  - Traditional data structures and/or objects
  - We have a different data model for the persistent data
  - Relational database, NoSQL database, files

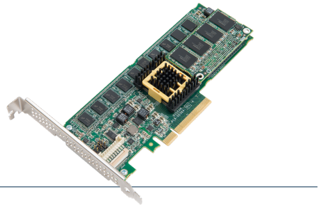
- **Future**
  - Store data in the same way as when volatile
  - Store objects and their relations

Data selection
No more database queries

- **In memory**
  - Data is “never” queried like in a DB
  - Data linked according to needs of program
  - Next data item found by following a link, not a query
- **Persistent data should behave in a similar way**
  - Following links is faster than a queries over whole dataset
  - Programs should not make any differences whether data is
    - In memory or
    - In persistent storage



New storage devices
Better to be prepared on time



- **New storage hardware is coming**
  - Storage class memory
  - Non-volatile RAM
- **Main characteristics**
  - Performance between memory and SSDs
  - Byte addressable
- **File systems or table based DB are not the right abstraction**
  - Both were designed to use block devices
  - Can be used, but would be a pity
    - What a potential loss!!

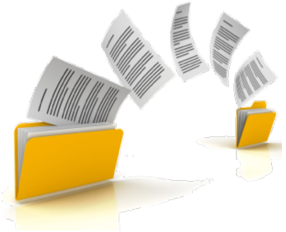
Coupling data and computation

They can live isolated, but ...

- **Computation and data are two different abstractions**
  - They are separated
- **This brings the problem of**
  - Should I move the data to compute it?
    - Does not work for big data sets
  - Should I move computation to the data?
    - Deployment difficult
- **If data and code were the same thing ...**
  - Using data would be much easier
  - (and safer ➔ see more in a few minutes)

Data sharing today
And why it is not enough

- **Download files**
  - Flexible
  - Only for static data
  - Avoid unneeded copies and transfers
  - Data provider loses control over the downloaded data



- **"Data services" an API to access the data**
  - Data provider keeps control
  - Both dynamic and static data
  - No unneeded copies or transfers
  - API restricted to what the provider can do

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- The technology
  The dark side
- **The secret potential**
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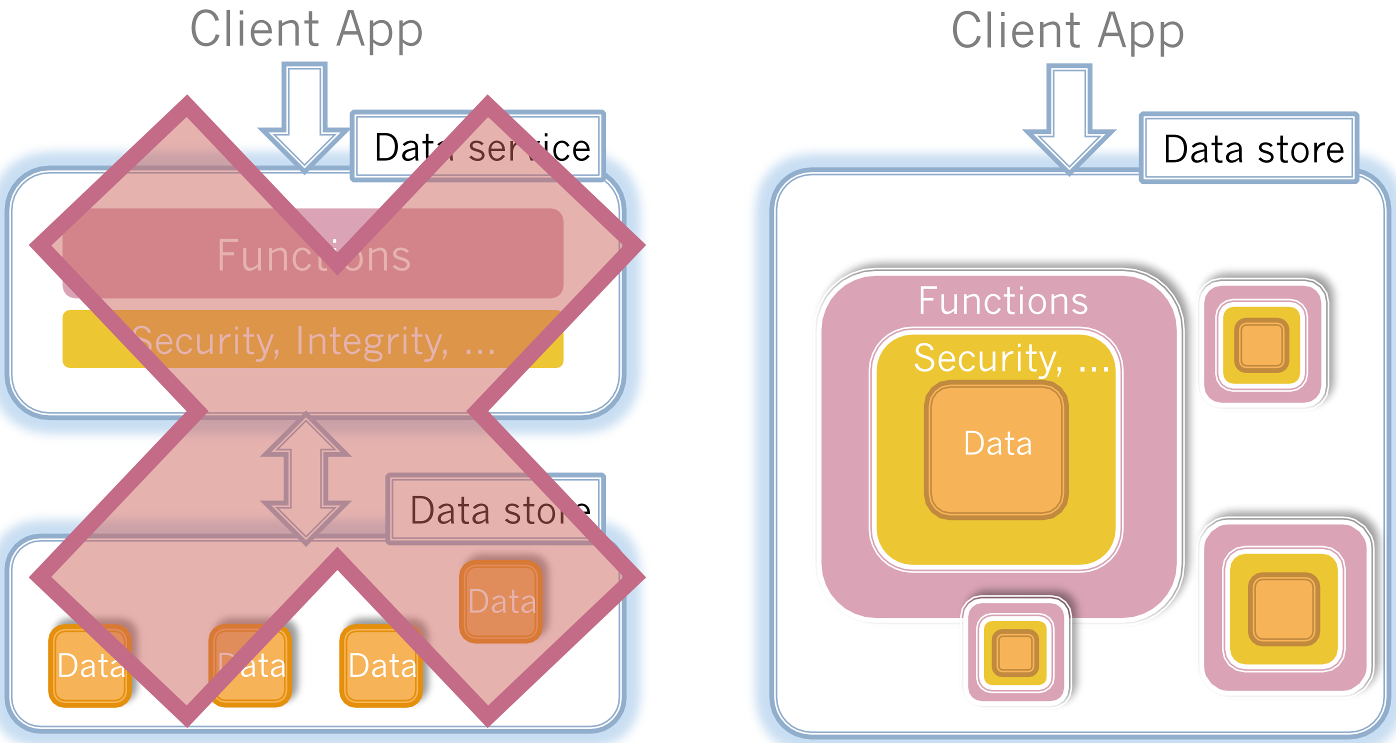
Our vision
What dataClay does

- **dataClay is a platform that enables**
  - Apps to make **objects** and their **relationships persistent**
  - 3rd parties to add mode data or "**change**" the **data model**
  - 3rd parties to **upload computations** to be shared
  - Each user to see different "views" of the data
  - Data owner to maintain control over its data
  - Efficient access to data

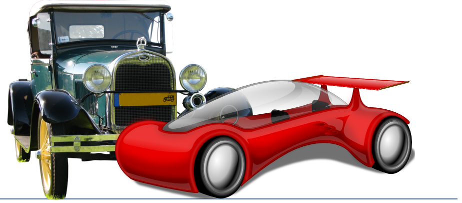
- **Key technologies**
  - Self-contained objects
  - Data enrichment by 3rd parties

Key technology
Self-contained objects

- **Push the idea of data services to the limit**
  - Based on the OO paradigm



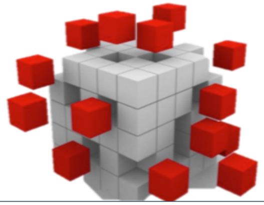
Self-contained objects
But, what is really new?



- **Self-contained and data services**
  - Same concept different implementation?

- **Then…**
  - … we need something else …
  - … something to make it really flexible!

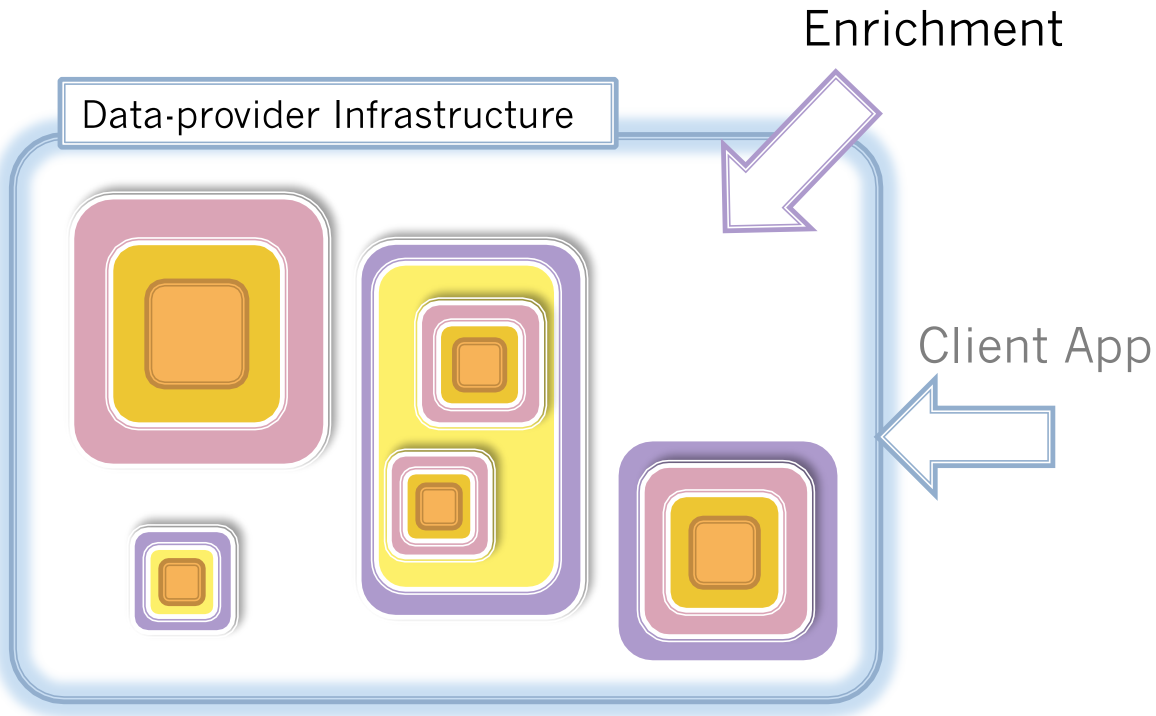
3rd-party enrichment
What is it exactly?



- **By enrichment we understand:**
  - Adding new information (fields or data) to existing datasets
  - Adding new code to existing datasets
    - New methods
    - New implementations
- **This enrichment should**
  - Be possible during the life of data
  - Not be limited to the data owner
  - Enable different views of the data to different users/clients
    - Not everybody should see the same enrichments
    - Several enrichments should be available concurrently
  - Enable the avoidance of queries

3rd-party enrichment
And now animated

- Data can be enriched both with **data and code**
- **Code will be executed in the provider infrastructure**



Using a single infrastructure?
Killing the bottleneck

- **Using a “single” infrastructure may become a bottleneck**
- **Security and privacy policies should be part of the data**
  - Thus, data could be offloaded to other infrastructures
    - Without breaking the data policies
  - Data owner enables 3rd party enrichment and …

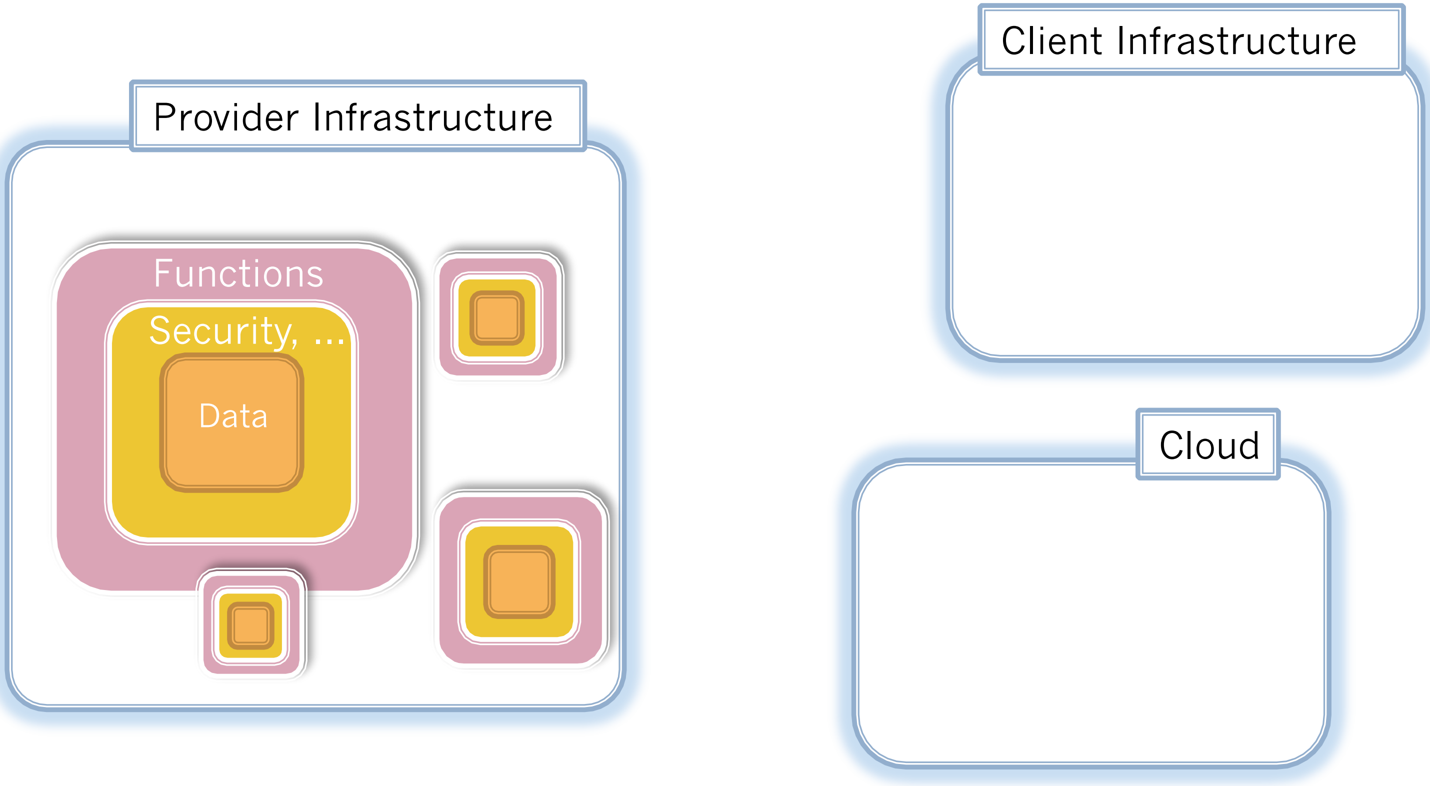
    … does not lose control

- **How it is implemented?**
  - Policies are defined using a declarative language
  - Policies enforced as part of object methods

Distributing objects

Distributing objects

- **Efficient usage of resources**
  - Data and code can be offloaded
    - to resources not accessible by the data provider



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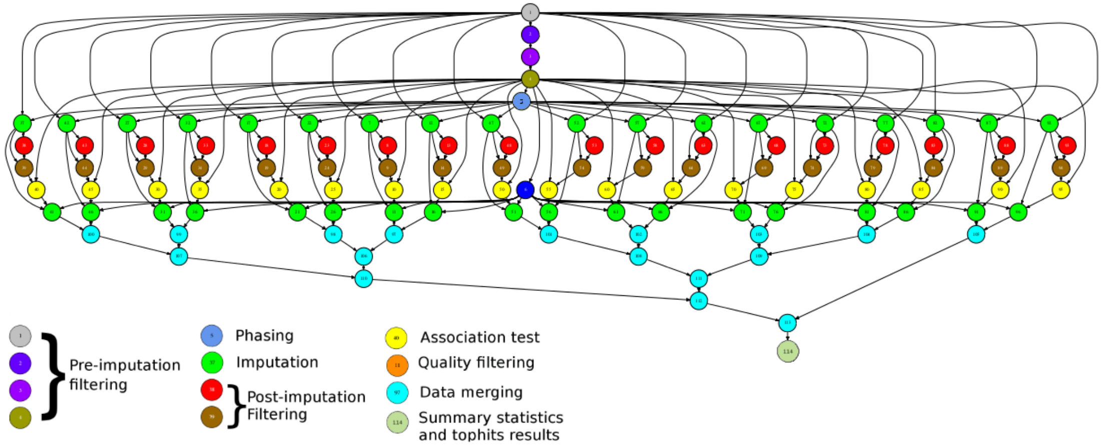
Task-based programming

- Task is the unit of work
- Data dependences between tasks
  - Imply partial order
  - Exhibit potential parallelism
  - Imply local synchronization
    - Not global!
- Implicit workflow



COMPSs

- **Sequential programming**
  - General purpose programming language + annotations
    - Currently Java and Python
- **Task based**
  - Builds a task graph at runtime
    - Express potential concurrency
    - Includes dependencies
  - Simple linear address space
- **Unaware of computing platform**
  - Enabled by the runtime for clusters, clouds and grids

Python (PyCOMPSs) syntax
How to write PyCOMPS code

- **Invoke tasks**
  - As functions/methods

Main Program

```
foo = Foo()
myFunction(foo)
foo.myMethod()
…
foo =
   compss_wait_on(foo)
foo.bar()
```

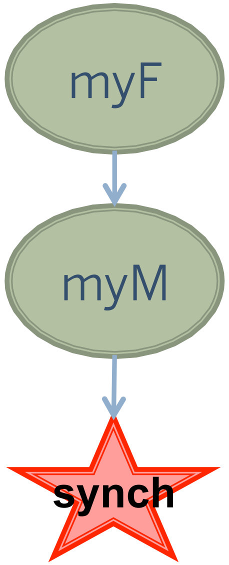
- **API** for data synchronization

- **Task definition** in function declaration
  - decorators

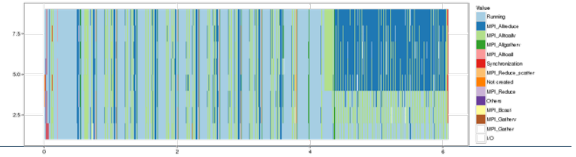
Function definition

```
@task( par = INOUT)
def myFunction(par):
   …
```

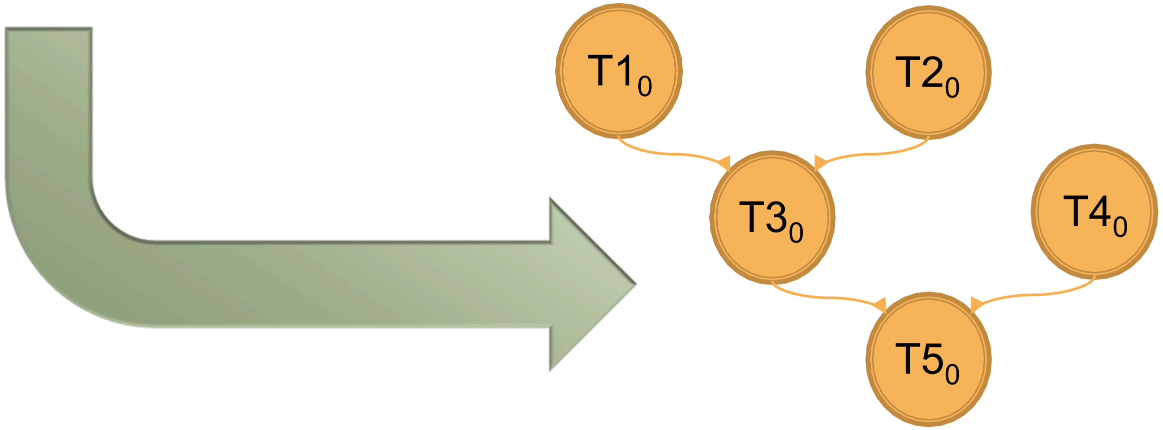
```
class Foo(object):
   @task()
   def
myMethod(self):
      …
```



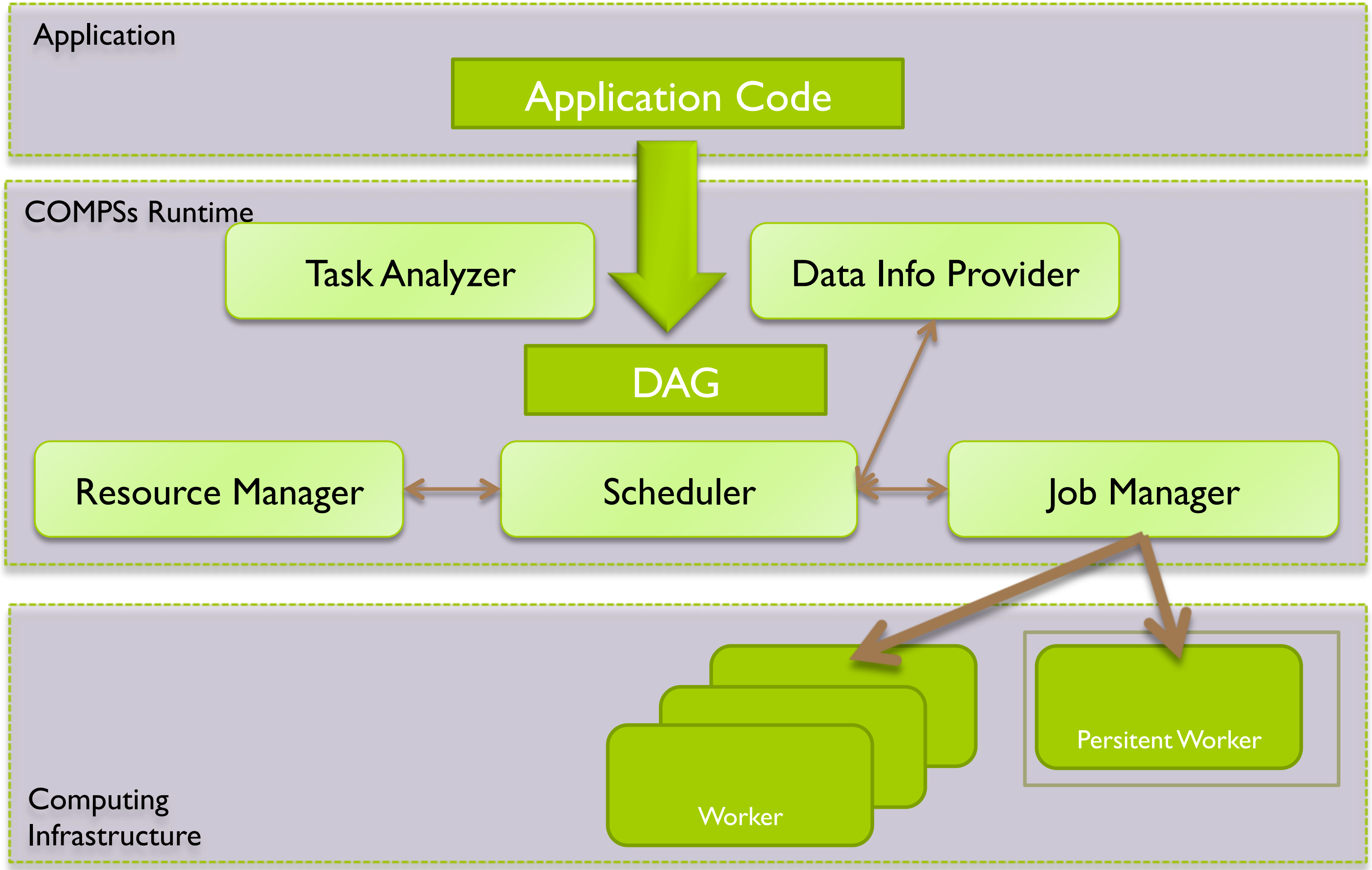
Parallel execution



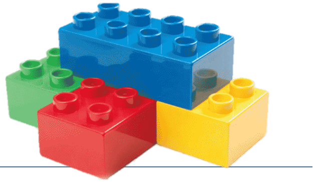
```
...

T1  (data1, out data2);
T2  (data4, out data5);
T3  (data2, data5, out data6);
T4  (data7, out data8);
T5  (data6, data8, out data9);

...
```

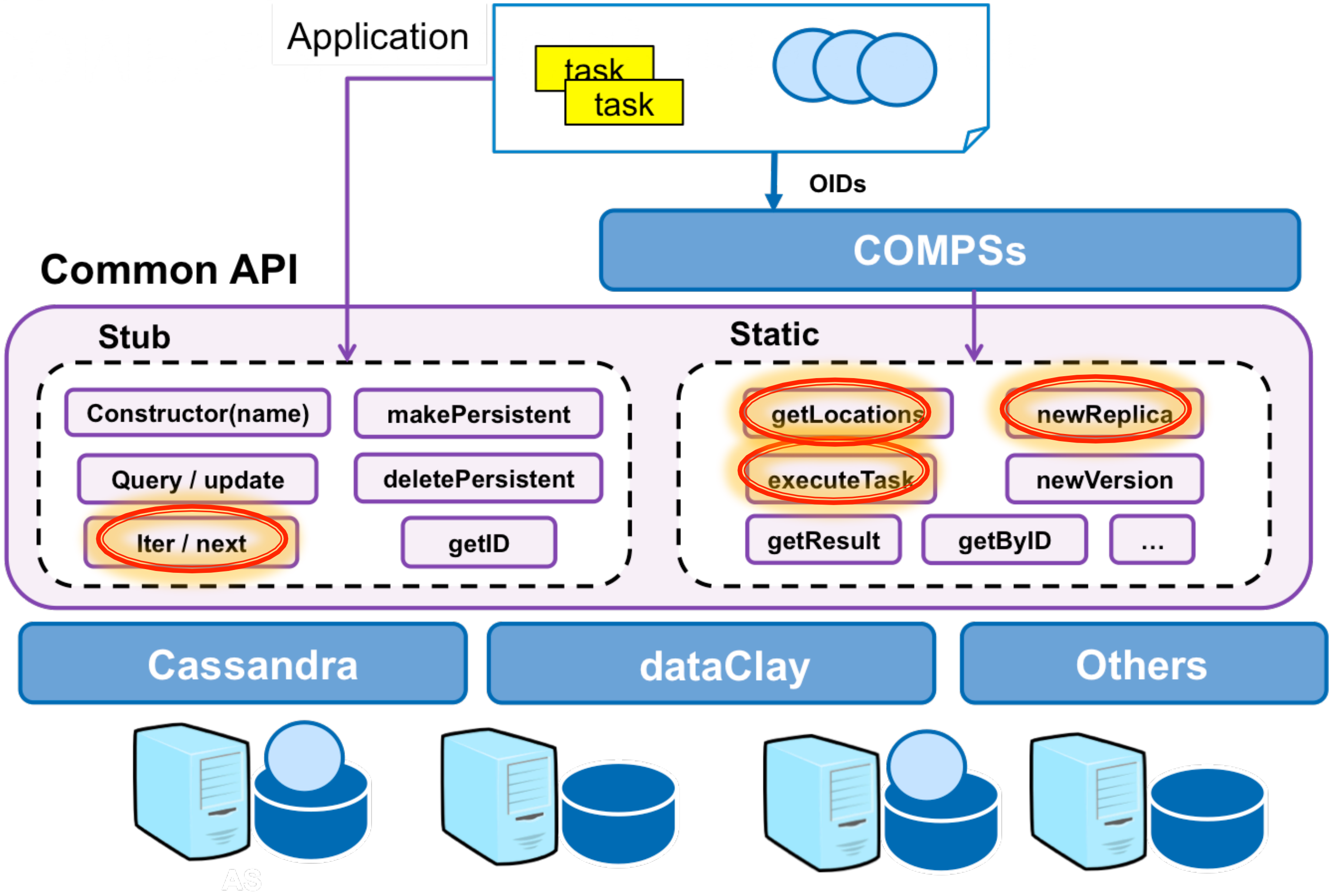


COMPSs framework



COMPSs & dataClay integration
Global view

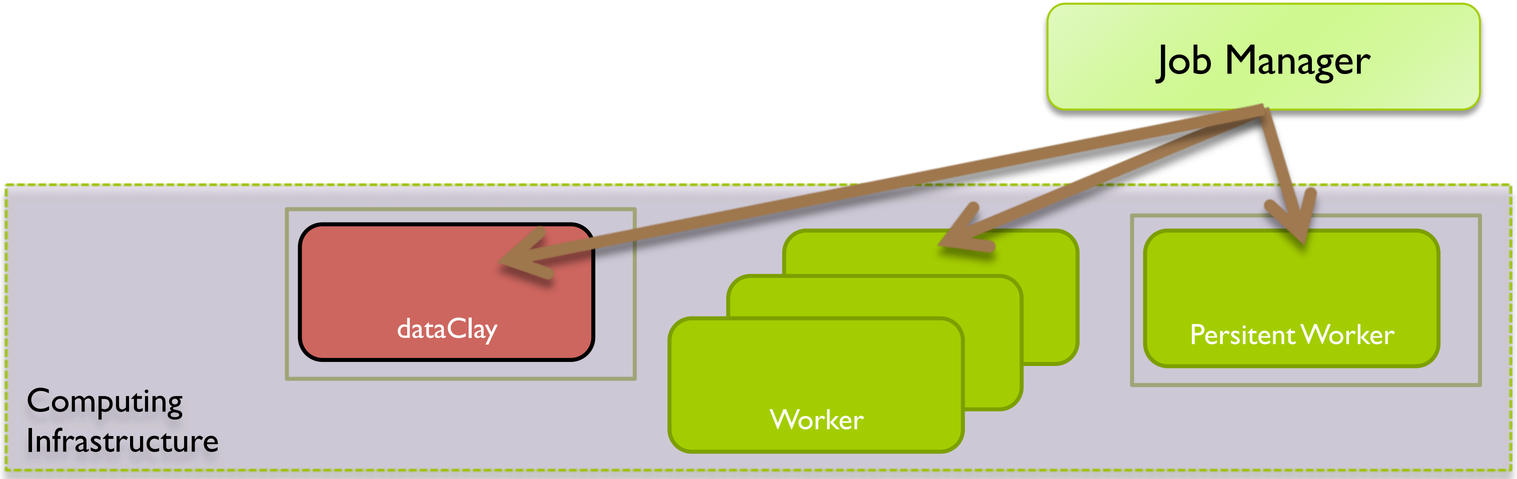




ExecuteTask
dataClay as a COMPSs worker

- **Executes a method (possibly static) in a given backend**
  - Replaces COMPSs worker threads

- **As opposed to direct method execution**
  - You can decide the execution backend `executeTask`
  - Asynchronous
    - Result can be checked by using `getResult`



A trivial example to follow

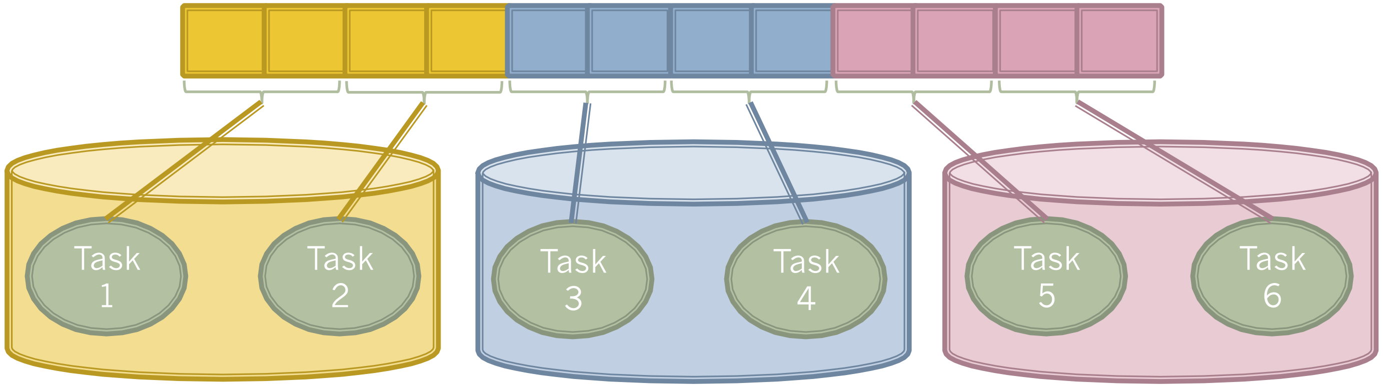
- **Input: collection of persons**
  - Person

```
    ...
    Integer age
    ...
     Boolean isOlder (limit, outCollection) {
                 if (age>limit) add self into outCollection
    }
```

- **Output: collection of persons older than a given age (*limit*)**

"Per object" **parallelism**

- **COMPSs "instantiates" one worker per object**
  - Iterates over a collection using a standard iterator
    - Instantiates the method in the node where the object is
      - Targeted at object methods
      - `getLocations`
    - Blocking may be needed
      - Object-method granularity may be too small
      - It implies grouping objects in the same backend



“Per object” **parallelism**

- **Declare method `isOlder` as a parallel task**
- **Code**

```
For element in the collection
 // For each element
 // This method is executed in parallel
 // in the node where the data is
  element.isOlder(age)
```

- **Parallelizing for each element may be too small**
  - Blocking

“Per object” **parallelism**

- **Create a new method `isOlderBlocking(age,ini,num)`**

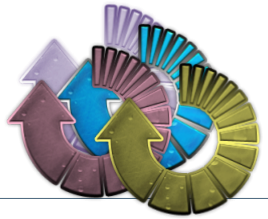
```
For element between ini and ini+num
  element.isOlder(age)
```

- **Code**

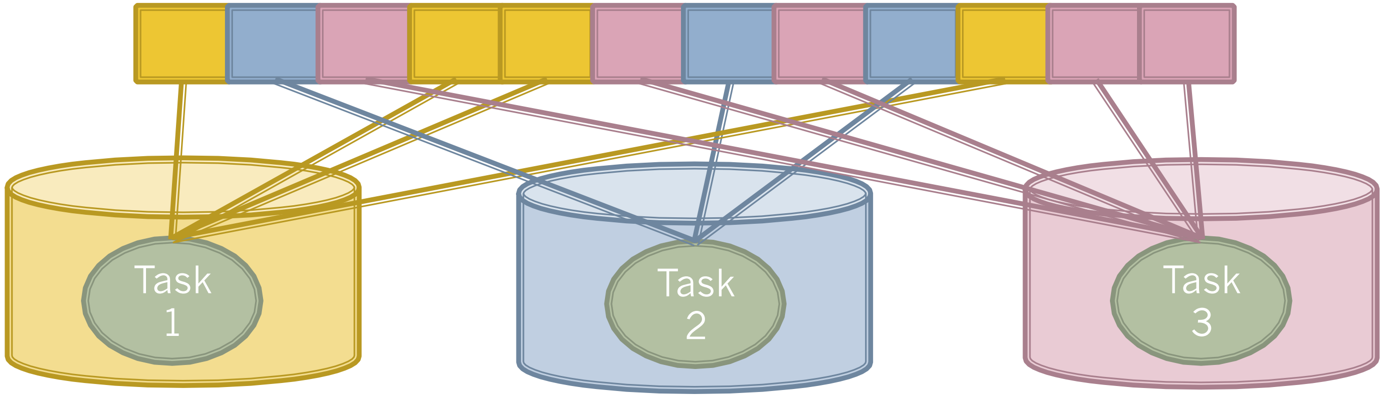
```
For i in (#elements in collection/block)
 // For each element
 // This method is executed in parallel
  element.isOlderBloking(age,i*block, block)
```

- **Now we have the right granularity**
  - The scientist needs to define blocking size
  - And placement if locality is important!!!

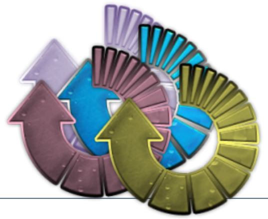
“*Per backend*” **parallelism**



- **COMPSs ‘‘instantiates’’ one worker per backend**
  - Obtains all locations using on the collection
    - `getLocations`
  - Each task executes a collection method
    - Iterates over a “*local*” iterator
      - Will only return objects in the current back end
      - Work stealing may be implemented if needed



“*Per backend*” **parallelism**



- **Create a new collection method `isOlderCollection(age)`**

```
For element in collection using local iterator
 // No parallelism here
 element.isOlder(age)
```

- **Define this method as “parallel”**
- **Code**

```
// Parallelism: executed in all backends with
// elements
isOlderCollection (age)
```

- **Now we have the right granularity**
  - The scientists has not done different code
    - Only encapsulated and used a “local” iterator

"Other" iterators

- **These are just examples, other iterators could be defined**
  - To implement locality as in a close backend
  - To implement work stealing
  - To take into account heterogeneity
- **The iterators are implemented as general in the collection**
  - Scientist only need to understand what they do
    - And use them

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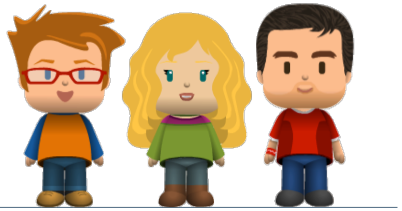
Conclusions
Ideas to take back home

- **Integrating persistent data into the programming model**
  - Unifies the model for both persistent and volatile data
  - Simplifies the decision of where to compute
    - Code is part of the data
  - Enables the use of data parallelism
    - Iterators can be adapted transparently to the programmer
  - Enables data distribution
    - Behavior policies are embedded

I travel, they do the work
Thanks to …



- **Current team**
  - **Anna Queralt**
  - Jonathan Martí
  - Daniel Gasull
  - Juanjo Costa
  - Alex Barceló

- **Master students**
  - David Gracia
  - Christos Ioannidis

- **Former team members**
  - Ernest Artiaga