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P*: A Model of Pilot-Abstractions

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Towards a Common Model for Pilot-Jobs

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NECS12 Workshop

Pilot Abstractions for Compute, Data, and Network

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Landscape of DCI and Applications: Empirical Assertions

- DCI is complex: Heterogeneous software, access-layers, policy..
- The space of possible Distributed Applications (DA) is large (and rich), but the number of effective and extensible DA small
- There are missing abstractions and poor implementations
  - Many local solutions, lack of end-to-solutions, especially tools
  - Missing conceptual frameworks and systems approach to tools
- Accept, if not embrace “distributedness”
  - Manage it, but also exploit it
  - The ability to reason: distributed performance, decomposition or aggregation!

Context

- Scientific computing applications demand (computer) resources to execute

Application

- Can be a simple script calling multiple instances of a program
- Can be a complex workflow management system that dynamically executes tasks based on a workflow description
- Resource requirements may vary over time
  - Internal dynamics of an application
  - Different solvers
  - Adaptive algorithms

Compute Resources

- Heterogeneous
  - Local clusters
  - High Throughput Computing Grids
  - High Performance Computing Clusters
  - Desktop Grids
  - IaaS (clouds)
- Capacity is fluctuating
  - Growing, shrinking
  - Changing in load and capabilities

Storage / Data Resources

- Local storage systems / data sources
- Different protocols / access mechanisms
- Distributed experiment data
- Data may be replicated
- Persistent / volatile
- Dynamic

Decoupling

Applications that are capable of using tools, abstractions and services that decouple payload management and resource assignment have been more successful at efficiently utilizing distributed resources.

Pilot Jobs

- A Pilot-Job is an abstraction that uses a placeholder job as a container for a set of compute tasks
- An instance of that placeholder job is commonly referred to as Pilot-Job or pilot

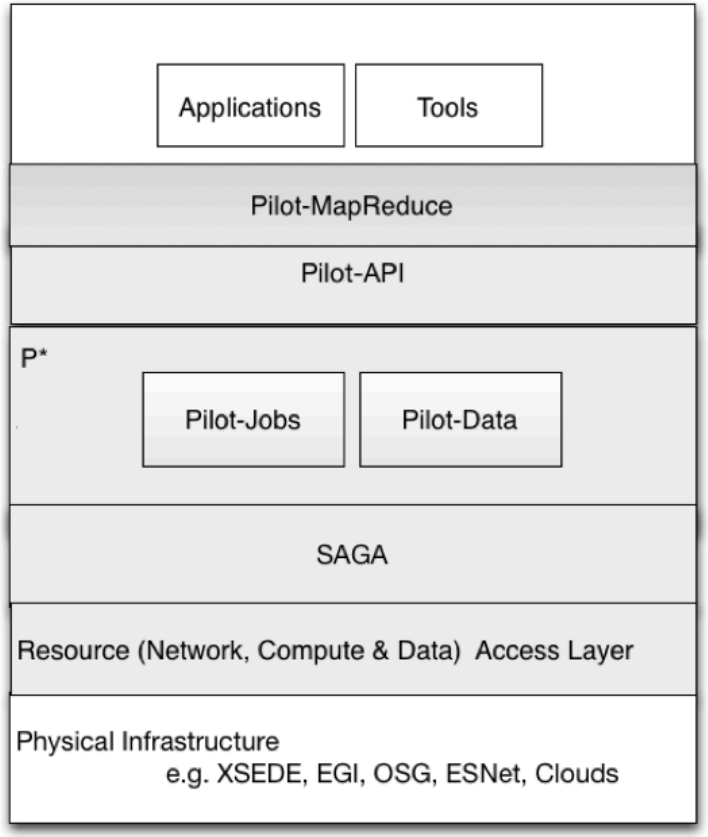
Pick your flavor …

- DIANE
- DIRAC
- CONDOR Glide-In
- Swift Coasters
- ToPoS
- Falkon
- PanDA
- Nimrod/G
- BigJob
- …

P*: a model

- A model for Pilot Abstraction
- Minimal but Complete
- Establish terminology
- Provide a framework for comparison

Positioning of P*



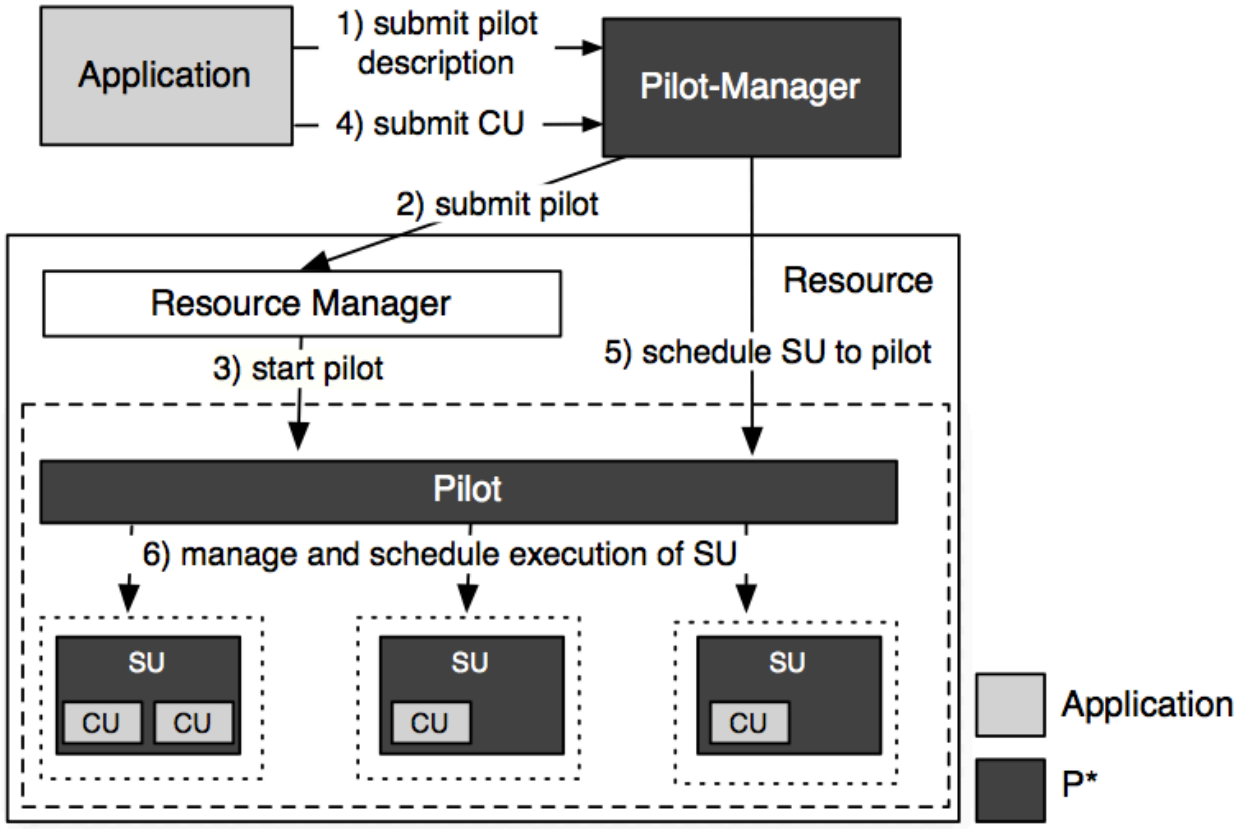
Pilot-Abstraction for Dynamic Distributed Data

- Similar heterogeneity for data infrastructure
- Application level capabilities on logical level and not on file level
- Fundamentally task placement is independent of data placement
- Dynamic decision for data
- Other considerations (varying data sources, data rates, etc)

Elements of the P* model

- Pilot-Compute (PC)
- Pilot-Data (PD)
- Compute Unit (CU)
- Data Unit (DU)
- Scheduling Unit (SU)
- Pilot-Manager (PM)

P* Model of Pilot Abstractions



Pilot-API

- Python implementation of P* model
- Exhibits the decoupling of Workload and Resources

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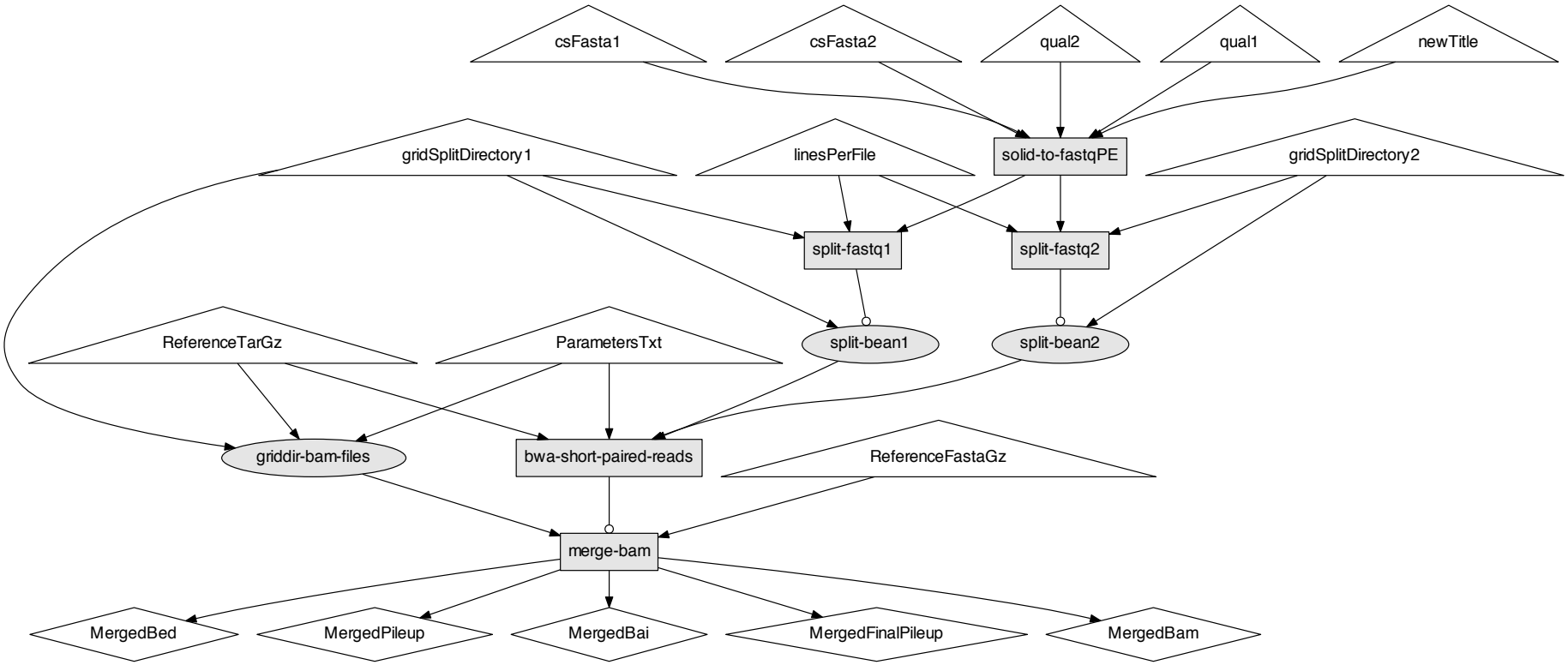
NGS Workflow



Element: Pilot Compute(PC)

- The placeholder entity that gets submitted to a resource
- Often has the role of an agent:
  - collects information
  - manages the resources allocated
  - exchanges data
- Executes application code

PilotCompute Creation

```
# Instantiate a PilotComputeService running on localhost
pilot_compute_service =
                          PilotComputeService('localhost')

# Define a PilotComputeDescription
pilot_compute_desc = {
      'service_url': 'cream://gb-ce-amc.amc.nl/
                      cream-pbs-medium'
}

# Create a PilotCompute through the PilotComputeService
pilot_compute_service.create_pilot(pilot_compute_desc)
```

Element: Pilot Data(PD)

- The placeholder entity that represents a storage resource (reservation)
- Can have the role of an agent:
  - collects information
  - manages the resources allocated
- Physically stores the data

PilotData Creation

```
# Instantiate a PilotDataService
pilot_data_service = PilotDataService()

# Define a PilotDataDescription
pilot_data_description = {
      'service_url': 'srm://tbn18.nikhef.nl/
                      home/mark/pilotdata/'
}

# Create a PilotData
pilot_data_service.create_pilot(pilot_data_description)
```

Element: Compute Unit (CU)

- Is defined by the application
- Encapsulates a self-contained piece of work that is submitted to the PJ framework
- E.g.:
  - task, job, rpc, web service call, etc.

ComputeUnit

```
# Define ComputeUnitDescription for solid-to-fastqPE
compute_unit_description = {
   'executable':  'solid-to-fastqPE',
   'arguments':   [<...APPLICATION_ARGUMENTS...>],
   'input_data':  [solid_du],
   'output_data': [fwd_fastq_du, rev_fastq_du],
}

# Submitting solid-to-fastqPE ComputeUnit
cd_service.submit_compute_unit
                          (compute_unit_description)
```

Element: Data Unit (DU)

- Is defined by the application
- Encapsulates a self-contained piece of logical data that is submitted to the PJ framework
- E.g.:
  - file, chunk, database, etc.

Input DataUnit

```
# Define DataUnitDescription for  short read files
solid_dud = {'file_urls': [
      'file:///Test42/Test42_F3.csfasta.bz2'),
      'file:///Test42/Test42_F3_QV.qual.bz2'),
      'file:///Test42/Test42_R3.csfasta.bz2'),
      'file:///Test42/Test42_R3_QV.qual.bz2')]
}

# Submit the DataUnit, this will initiate a transfer.
solid_du = cd_service.submit_data_unit(solid_dud)
```

Output DataUnit

```
# DataUnit for forward fastq output file
data_unit_description = {
        'file_urls': ['Test42_fwd_read.fastq.gz']
}

fwd_fastq_du = DataUnit(data_unit_description)
```

Element: Scheduling Unit (SU)

- Represents a DataUnit / ComputeUnit internal to the runtime system
- Allows for aggregation and division of application level payload

Mapping

P* Element	BigJob	DIANE	Condor-G/ Glide-in
Pilot-Manager	BigJob Manager	RunMaster	condor_master condor_collector condor_negotiator condor_schedd
Pilot	BigJob Agent	Worker Agent	condor_master condor_startd
Compute Unit (CU)	Task	Task	Job
Scheduling Unit (SU)	Sub-Job	Task	Job

Three services

- PilotComputeService
  - Manages a pool of compute resources
- PilotDataService
  - Manages a pool of storage resources
- ComputeDataService
  - Manages the application's workload

PilotComputeService

- **PilotComputeService** is responsible for creating and managing the PilotComputes
- It is the application's interface to the Pilot-Manager in the P* Model
- Created from **PilotComputeDescription**
- Creates a **PilotCompute**

PilotDataService

- **PilotDataService** is responsible for creating and managing the PilotDatas
- It is the application's interface to the Pilot-Manager in the P* Model
- Created from **PilotDataDescription**
- Creates a **PilotData**

ComputeDataService

- The **ComputeUnitDescription** is a task description based on SAGA Job Description
- It offers the application to describe a **ComputeUnit** in an abstract way that is dealt with by the Pilot-Manager

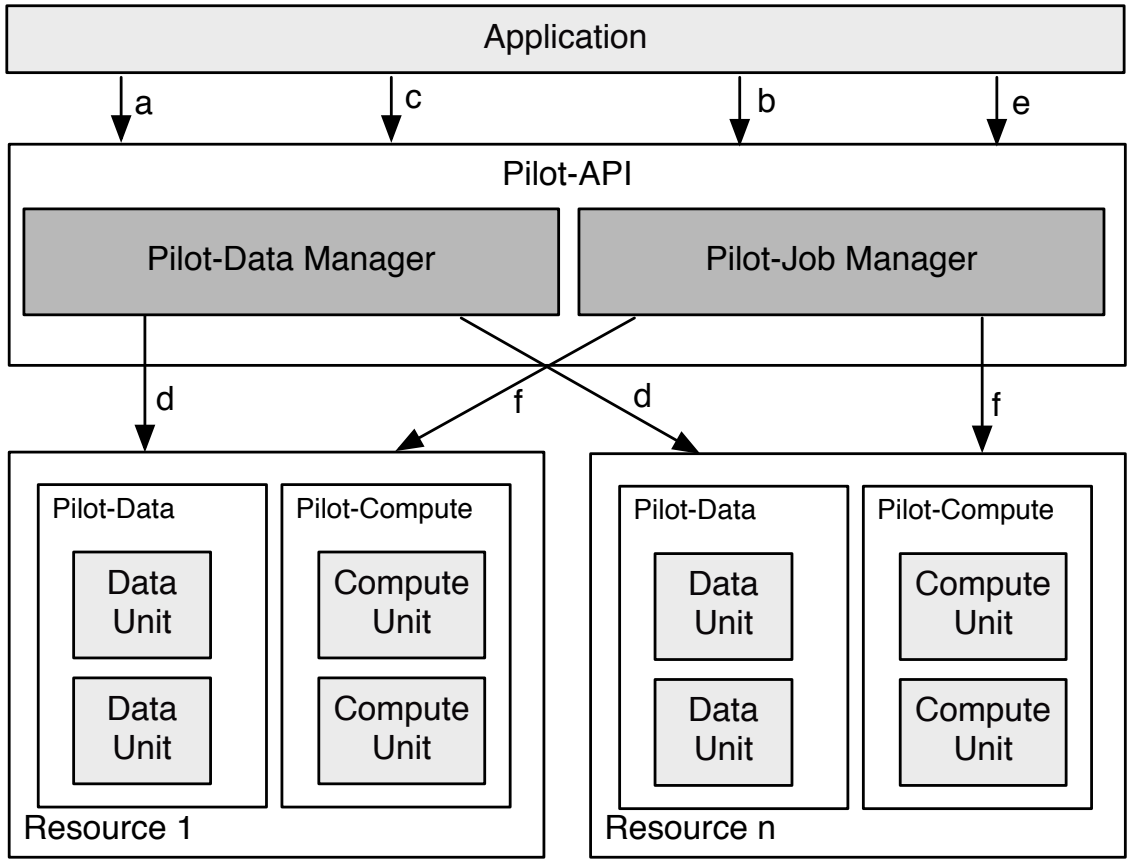
ComputeDataService

```
# Instantiate a ComputeDataService
cd_service = ComputeDataService()

# Connect PilotComputeService to ComputeDataService
cd_service.add_pilot_compute_service
                                    (pilot_compute_service)

# Connect PilotDataService to ComputeDataService
cd_service.add_pilot_data_service(pilot_data_service)

# Submitting solid-to-fastqPE ComputeUnit
cd_service.submit_compute_unit
                                (compute_unit_description)
```

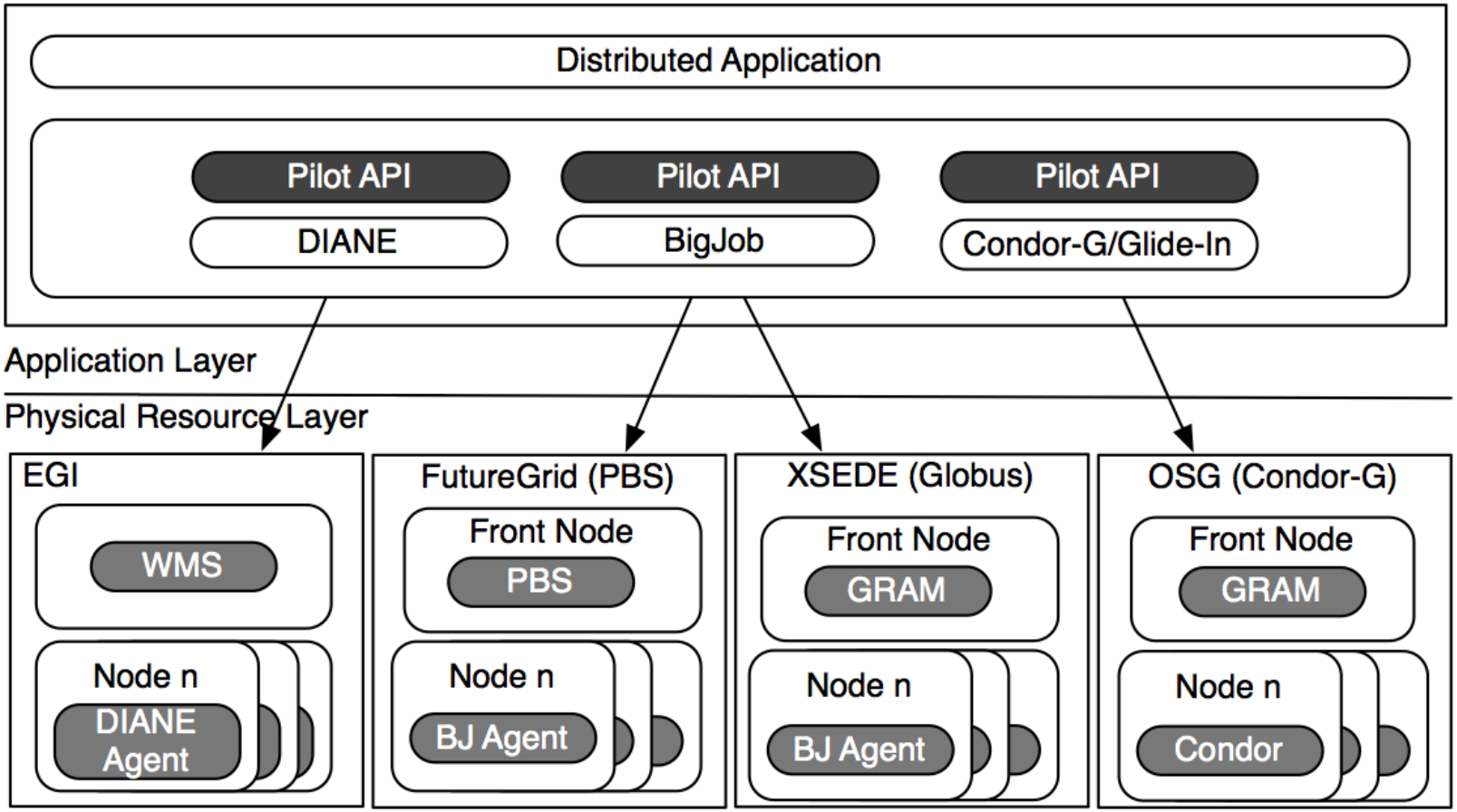
Characteristics and other properties

Properties	**BigJob**	**DIANE**	**Condor-G/ Glide-in**
Coordination	M/W	M/W	M/W
Communication	Advert Service	CORBA	TCP
Scheduling	FIFO, custom	FIFO, custom	Matchmaking, priority-based scheduler
Agent Submission	API	GANGA Submission Script	Condor CLI
End User Environment	API	API and M/W Framework	CLI Tools
Fault Tolerance	Error propagation	Error propagation, retries	Error propagation, retries
Resource Abstraction	SAGA	GANGA/ SAGA	Globus
Security	Multiple (GSI, User/-Pass.)	Multiple (GSI)	Multiple (GSI, Kerberos)

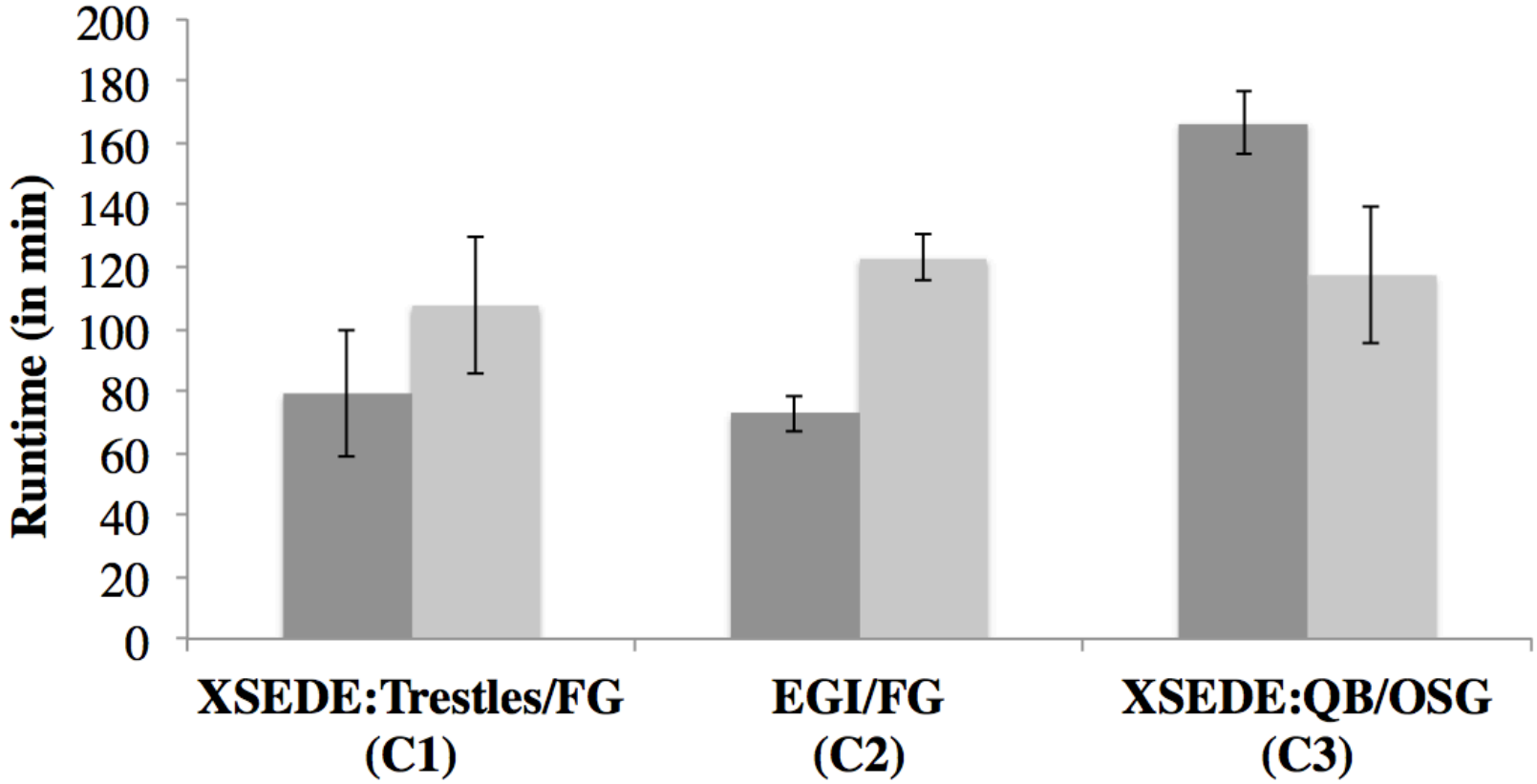
> 1000 words


Application
a
c
b
e
Pilot-API
Pilot-Data Manager
Pilot-Job Manager
d
f
d
f
Pilot-Data
Data Unit
Data Unit
Pilot-Compute
Compute Unit
Compute Unit
Resource 1
Pilot-Data
Data Unit
Data Unit
Pilot-Compute
Compute Unit
Compute Unit
Resource n

Pilot-API and PJ frameworks



PJ Framework Interoperability



Conclusions

- Established P* as an abstraction for supporting dynamic execution
- Common framework for comparisons
- Well defined Pilot-API for application developers

Discussion

- Applicability to workflow paradigm
- Extension with networking
- Clouds are an important and useful development but not a panacea

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