JavaGAT Tutorial

Getting started with the Grid Application Toolkit

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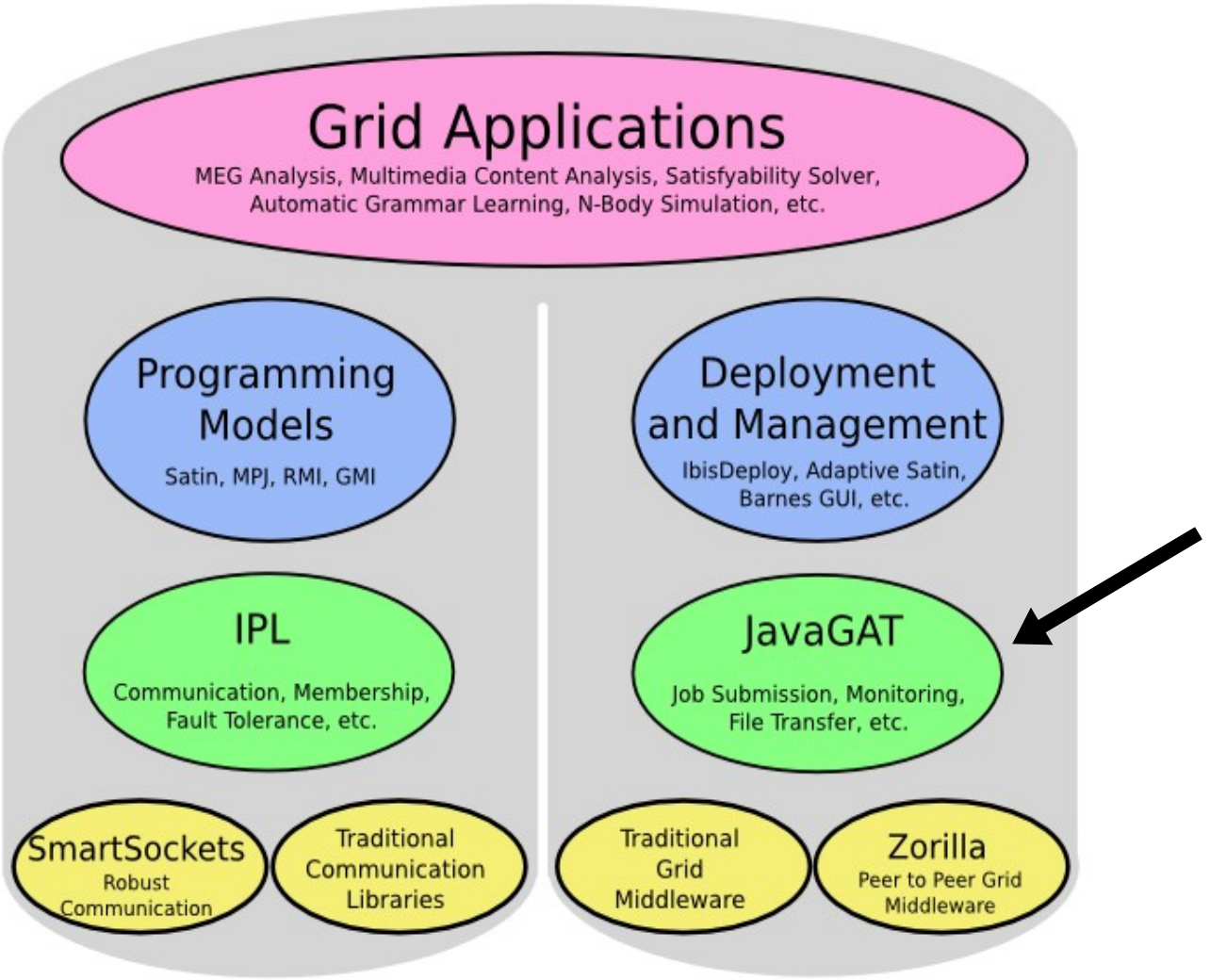
Overview

- What is GAT and why do we need it?

- JavaGAT structure and overview
- Security
- Grid I/O
- Resource Management
- Application Information Management
- Monitoring

- Hands-on session

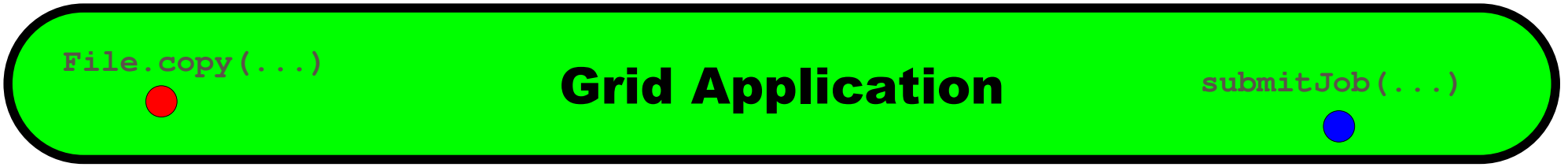
Overview


Grid Applications
MEG Analysis, Multimedia Content Analysis, Satisfyability Solver,
Automatic Grammar Learning, N-Body Simulation, etc.
Programming Models
Satin, MPJ, RMI, GMI
Deployment and Management
IbisDeploy, Adaptive Satin, Barnes GUI, etc.
IPL
Communication, Membership, Fault Tolerance, etc.
JavaGAT
Job Submission, Monitoring, File Transfer, etc.
SmartSockets
Robust Communication
Traditional Communication Libraries
Traditional Grid Middleware
Zorilla
Peer to Peer Grid Middleware

Writing Grid Applications

Grid Application

Writing Grid Applications



Writing Grid Applications

Writing Grid Applications

cp
ftp

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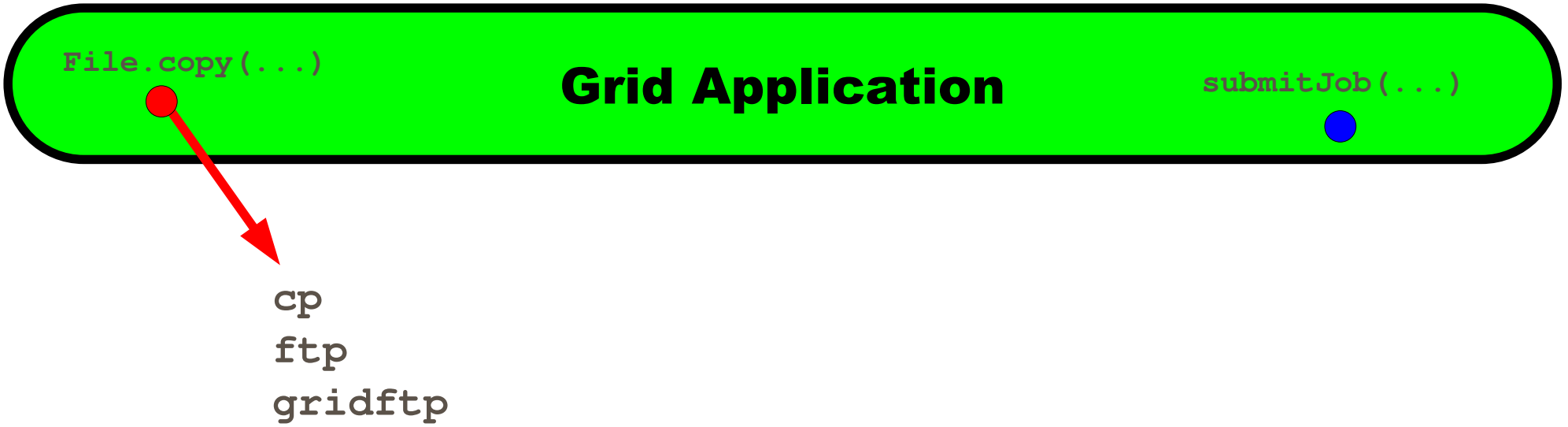

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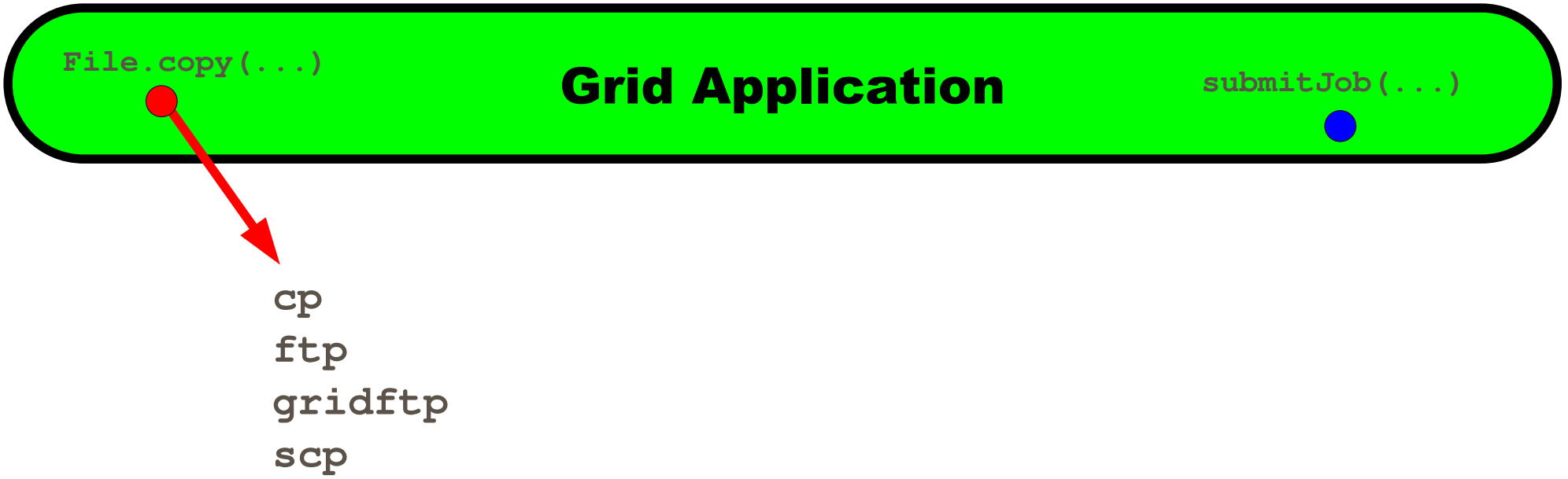

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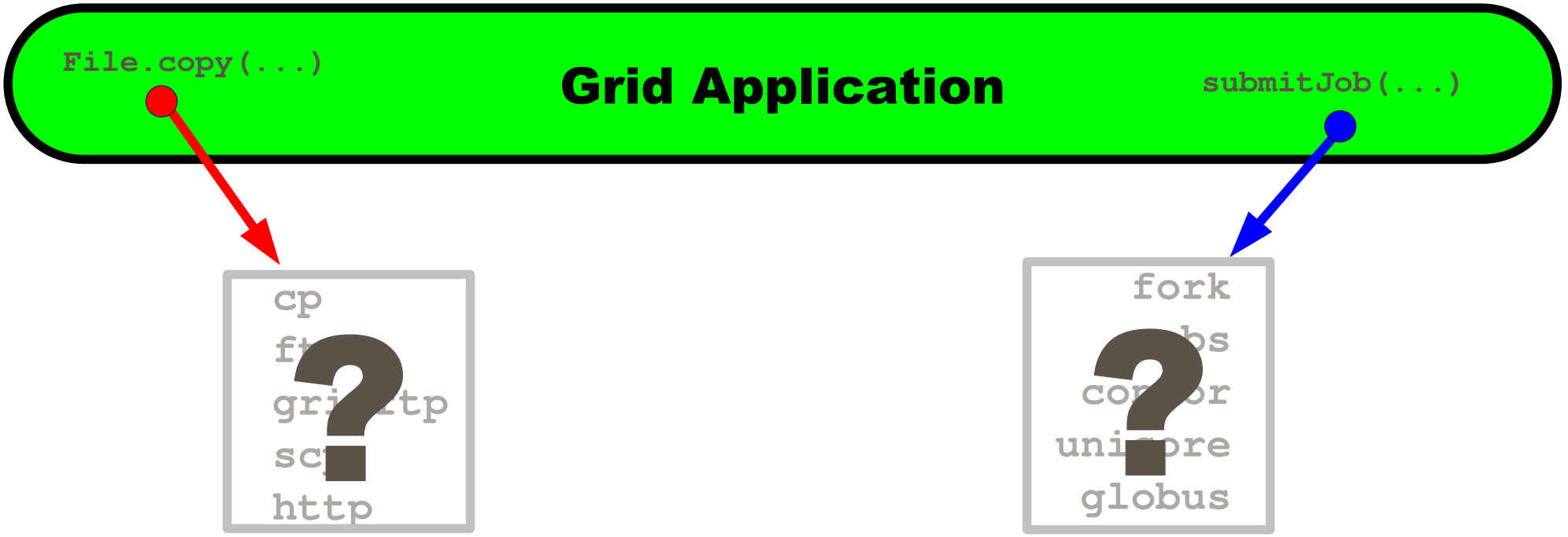

- Which should you use?

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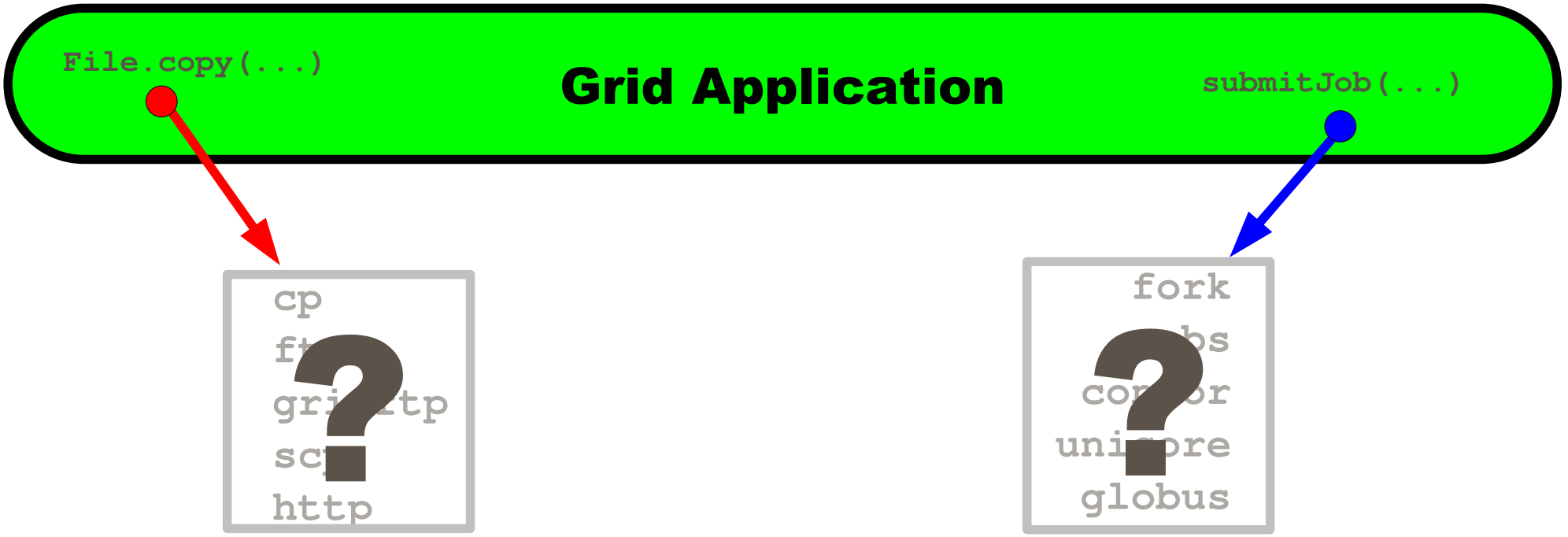

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- Some might not be available on all sites

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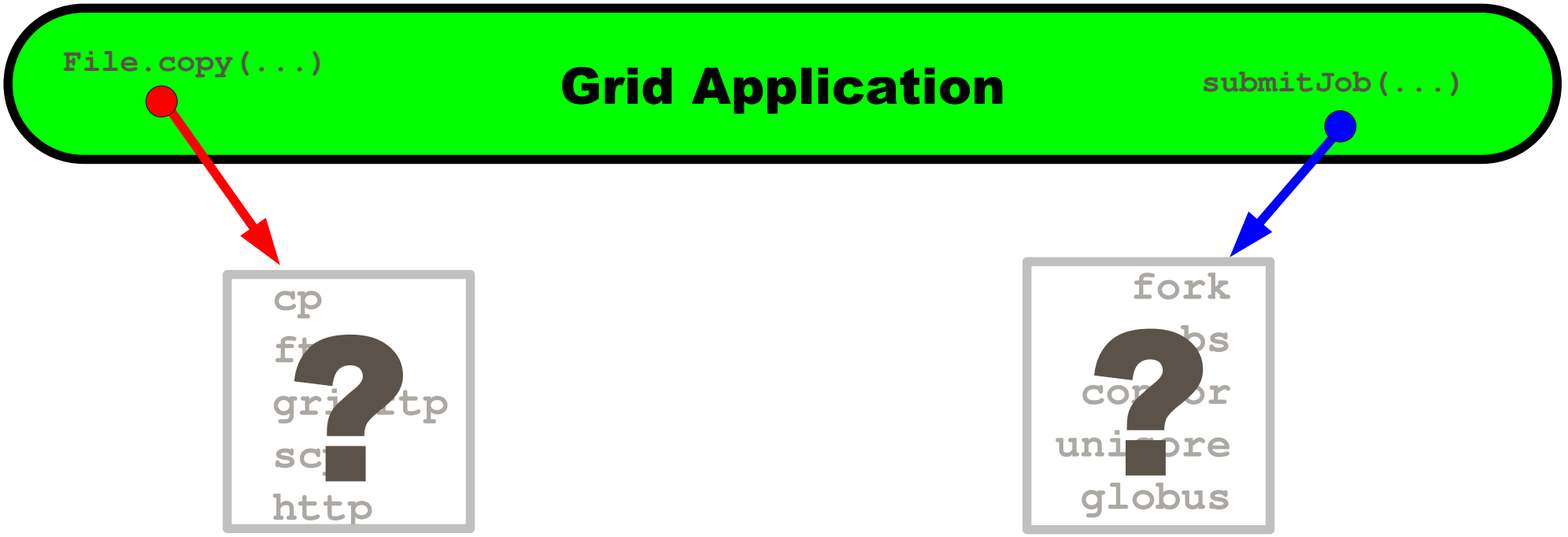

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- Some may not work for all users (certificates)

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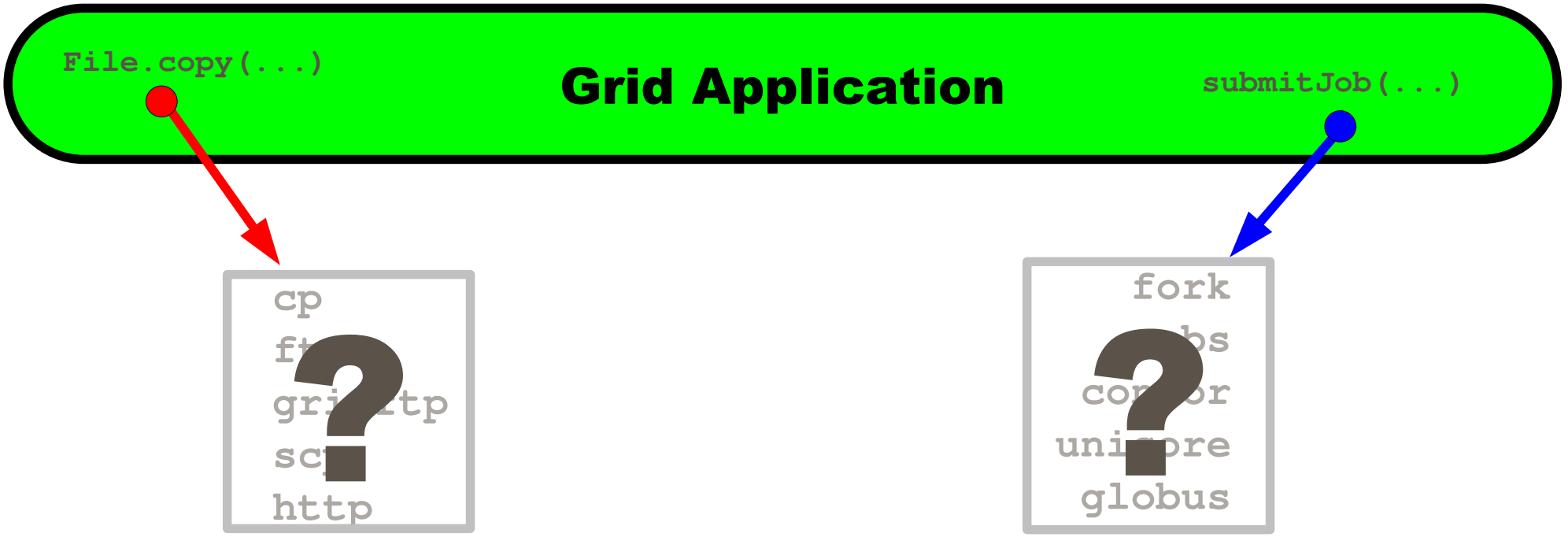

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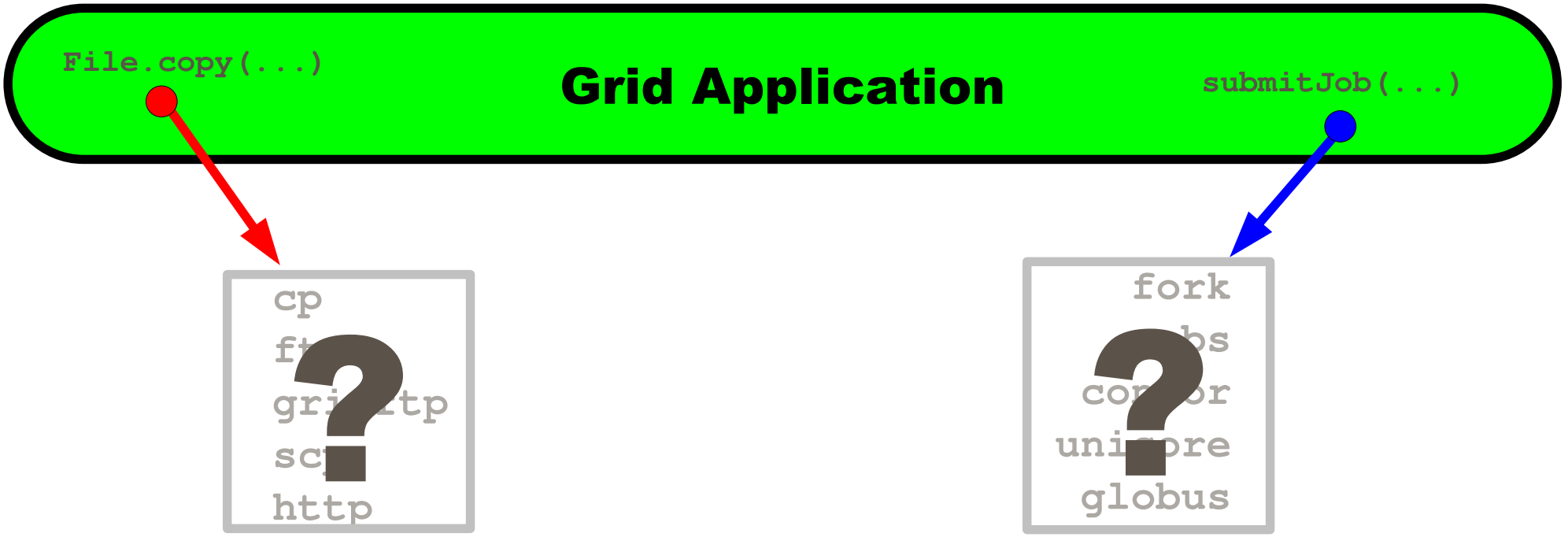

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- Exponential number of combinations!

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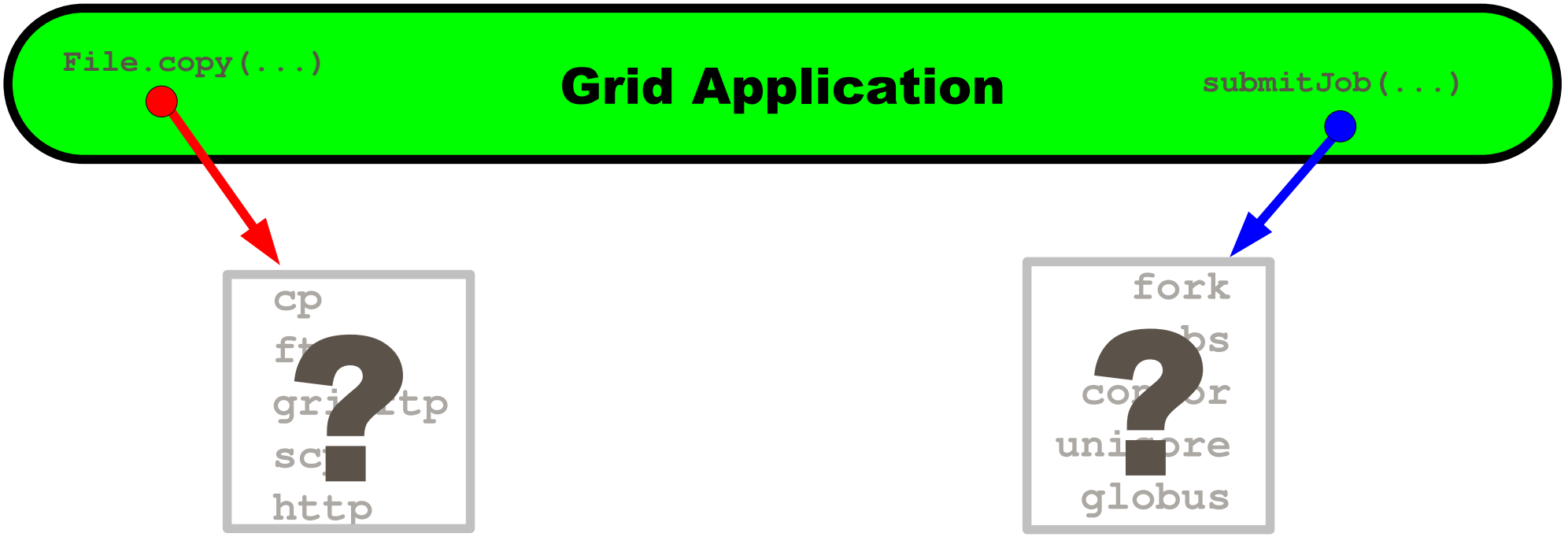


- Which should you use?
- Some might not be available on all sites
- One may not work for all users / at all sites
- Version differences (Globus changes every 2 months)
- Exponential number of combinations!

Not portable!

Globus File copy (C++)

```
int RemoteFile::GetFile (char const* source,   char const* target) {
globus_url_t                        source_url;
globus_io_handle_t                  dest_io_handle;
globus_ftp_client_operationattr_t   source_ftp_attr;
globus_result_t                     result;
globus_gass_transfer_requestattr_t  source_gass_attr;
globus_gass_copy_attr_t             source_gass_copy_attr;
globus_gass_copy_handle_t           gass_copy_handle;
globus_gass_copy_handleattr_t       gass_copy_handleattr;
globus_ftp_client_handleattr_t      ftp_handleattr;
globus_io_attr_t                    io_attr;
int                                 output_file = -1;

if ( globus_url_parse (source_URL, &source_url) != GLOBUS_SUCCESS ) {
  printf ("can not parse source_URL \"%s\"\n", source_URL);
  return (-1);
}

if ( source_url.scheme_type != GLOBUS_URL_SCHEME_GSIFTP &&
     source_url.scheme_type != GLOBUS_URL_SCHEME_FTP    &&
     source_url.scheme_type != GLOBUS_URL_SCHEME_HTTP   &&
     source_url.scheme_type != GLOBUS_URL_SCHEME_HTTPS  ) {
  printf ("can not copy from %s - wrong prot\n", source_URL);
  return (-1);
}
globus_gass_copy_handleattr_init  (&gass_copy_handleattr);
globus_gass_copy_attr_init        (&source_gass_copy_attr);

globus_ftp_client_handleattr_init (&ftp_handleattr);
globus_io_fileattr_init           (&io_attr);

globus_gass_copy_attr_set_io      (&source_gass_copy_attr, &io_attr);
                                   &io_attr);
globus_gass_copy_handleattr_set_ftp_attr
                                  (&gass_copy_handleattr,
                                   &ftp_handleattr);
globus_gass_copy_handle_init      (&gass_copy_handle,
                                   &gass_copy_handleattr);
```

```
if (source_url.scheme_type == GLOBUS_URL_SCHEME_GSIFTP ||
    source_url.scheme_type == GLOBUS_URL_SCHEME_FTP    ) {
  globus_ftp_client_operationattr_init (&source_ftp_attr);
  globus_gass_copy_attr_set_ftp (&source_gass_copy_attr,
                                 &source_ftp_attr);
}
else {
  globus_gass_transfer_requestattr_init (&source_gass_attr,
                                  source_url.scheme);
  globus_gass_copy_attr_set_gass(&source_gass_copy_attr,
              &source_gass_attr);
}

output_file = globus_libc_open ((char*) target,
              O_WRONLY | O_TRUNC | O_CREAT,
              S_IRUSR  | S_IWUSR | S_IRGRP |
              S_IWGRP);
if ( output_file == -1 ) {
  printf ("could not open the file \"%s\"\n", target);
  return (-1);
}
/* convert stdout to be a globus_io_handle */
if ( globus_io_file_posix_convert (output_file, 0,
                                   &dest_io_handle)
     != GLOBUS_SUCCESS) {
  printf ("Error converting the file handle\n");
  return (-1);
}

result = globus_gass_copy_register_url_to_handle (
         &gass_copy_handle, (char*)source_URL,
         &source_gass_copy_attr, &dest_io_handle,
         my_callback, NULL);
if ( result != GLOBUS_SUCCESS ) {
  printf ("error: %s\n", globus_object_printable_to_string
          (globus_error_get (result)));
  return (-1);
}
globus_url_destroy  (&source_url);
return (0);
}
```

CoG/RFT File copy (C++)


```
package org.globus.ogsa.gui;

import java.io.BufferedReader;
import java.io.File;
import java.io.FileReader;
import java.net.URL;
import java.util.Date;
import java.util.Vector;
import javax.xml.rpc.Stub;
import org.apache.axis.message.MessageElement;
import org.apache.axis.utils.XMLUtils;
import org.globus.*
import org.gridforum.ogsi.*
import org.gridforum.ogsi.holders.TerminationTimeTypeHolder;
import org.w3c.dom.Document;
import org.w3c.dom.Element;

public class RFTClient {
 public static void copy (String source_url, String target_url) {
  try {
   File requestFile      = new File (source_url);
   BufferedReader reader = null;
   try {
     reader = new BufferedReader (new FileReader (requestFile));
   } catch (java.io.FileNotFoundException fnfe) { }
   Vector requestData = new Vector ();
   requestData.add (target_url);
   TransferType[] transfers1      = new TransferType[transferCount];
   RFTOptionsType multirftOptions = new RFTOptionsType ();

   multirftOptions.setBinary           (Boolean.valueOf  (
         (String)requestData.elementAt (0)).booleanValue ());
   multirftOptions.setBlockSize        (Integer.valueOf  (
         (String)requestData.elementAt (1)).intValue     ());
   multirftOptions.setTcpBufferSize    (Integer.valueOf  (
         (String)requestData.elementAt (2)).intValue     ());
   multirftOptions.setNotpt            (Boolean.valueOf  (
         (String)requestData.elementAt (3)).booleanValue ());
   multirftOptions.setParallelStreams  (Integer.valueOf  (
         (String)requestData.elementAt (4)).intValue     ());
   multirftOptions.setDcau(Boolean.valueOf(
          (String)requestData.elementAt (5)).booleanValue ());

 int i = 7;
 for (int j = 0; j < transfers1.length; j++)
 {
   transfers1[j] = new TransferType ();

   transfers1[j].setTransferId     (j);
   transfers1[j].setSourceUrl      ((String)requestData.elementAt (i++));
   transfers1[j].setDestinationUrl ((String)requestData.elementAt (i++));
   transfers1[j].setRftOptions     (multirftOptions);
 }

TransferRequestType transferRequest = new TransferRequestType ();
transferRequest.setTransferArray (transfers1);

int concurrency = Integer.valueOf
                ((String)requestData.elementAt(6)).intValue();

if (concurrency > transfers1.length)
{
  System.out.println ("Concurrency should be less than the number"
                      "of transfers in the request");
  System.exit (0);
}
transferRequest.setConcurrency (concurrency);

TransferRequestElement requestElement = new TransferRequestElement ();
requestElement.setTransferRequest (transferRequest);

ExtensibilityType extension = new ExtensibilityType ();
extension = AnyHelper.getExtensibility (requestElement);

OGSIServiceGridLocator factoryService = new OGSIServiceGridLocator ();
Factory factory = factoryService.getFactoryPort (new URL (source_url));
GridServiceFactory gridFactory = new GridServiceFactory (factory);

LocatorType locator = gridFactory.createService (extension);
System.out.println ("Created an instance of Multi-RFT");

MultiFileRFTDefinitionServiceGridLocator loc
                  = new MultiFileRFTDefinitionServiceGridLocator();
RFTPortType rftPort = loc.getMultiFileRFTDefinitionPort (locator);
  ((Stub)rftPort)._setProperty (Constants.AUTHORIZATION,
                                NoAuthorization.getInstance());
  ((Stub)rftPort)._setProperty (GSIConstants.GSI_MODE,
                                GSIConstants.GSI_MODE_FULL_DELEG);
  ((Stub)rftPort)._setProperty (Constants.GSI_SEC_CONV,
                                Constants.SIGNATURE);
  ((Stub)rftPort)._setProperty (Constants.GRIM_POLICY_HANDLER,
                                new IgnoreProxyPolicyHandler ());

  int requestid = rftPort.start ();
  System.out.println ("Request id: " + requestid);

 }
 catch (Exception e)
 {
  System.err.println (MessageUtils.toString (e));
 }
}
```

Why GAT?

- The situation today:
  - Grids: everywhere
  - Grid applications: nowhere
- Why is this?
  - Application programmers accept the Grid as a computing paradigm only very slowly.
- Problems:
  - Interfaces are NOT simple
  - Portability / interoperability
    - Different and evolving interfaces to the ’Grid’
    - Environment changes in many ways
    - WSDL and web services do not solve all these problems

What is GAT?

- GAT: Grid Application Toolkit
  - API and Toolkit for developing and running portable grid applications independently of the underlying grid infrastructure and available services
- GAT is used by applications to access grid services
- Simple API
- GAT Adaptors (“plugins”)
  - Connect GAT to grid services
  - Allow for multiple providers (Globus, Unicore, ProActive, …)
- GAT does not aim to replace existing “grid infrastructure.”
- Open source, BSD-like licence

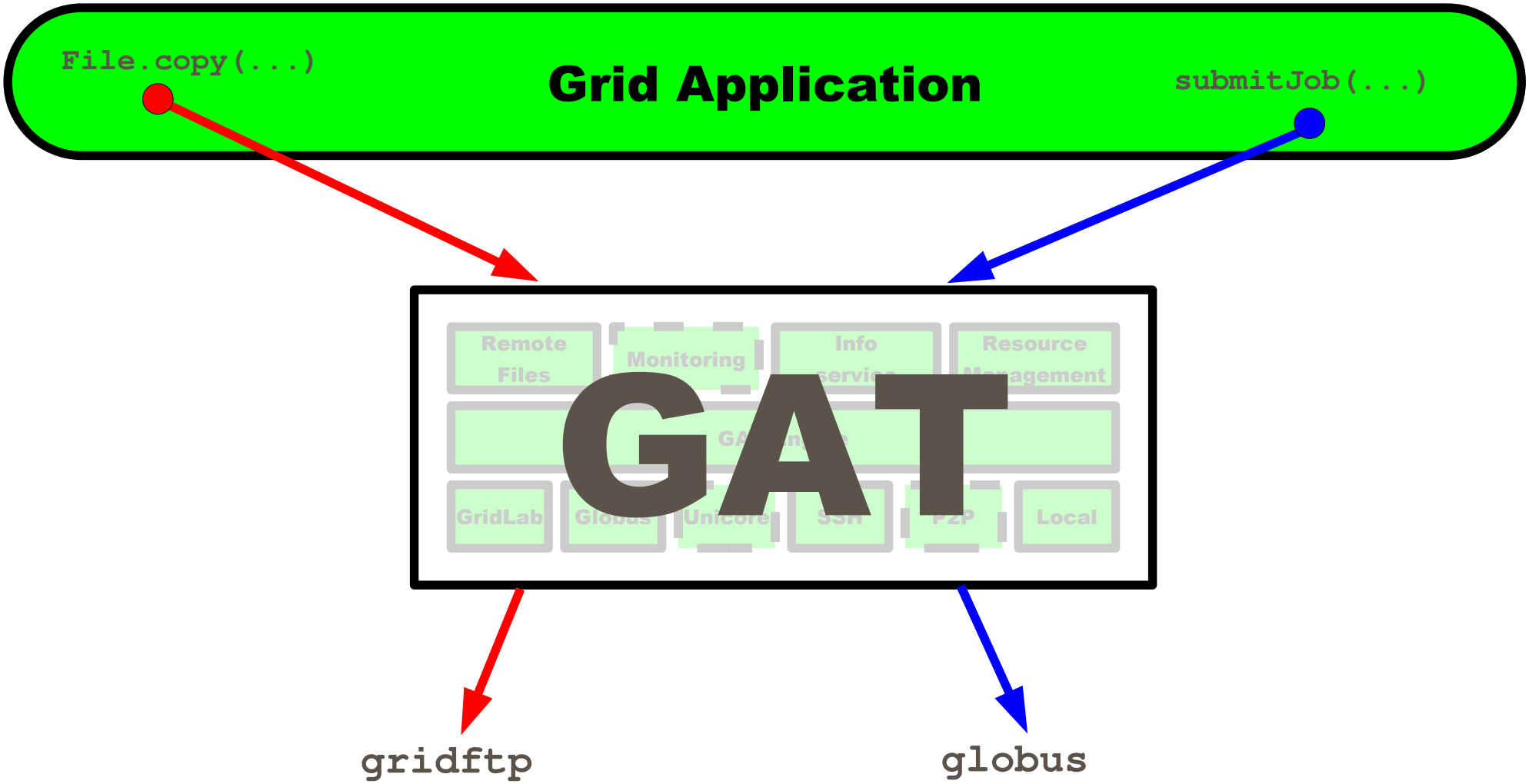
GAT Philosophy

- Applications make GAT-API calls for grid operations
  - Applications link against GAT
- Applications run irrespective of available infrastructure
  - GAT Engine loads all available adaptors at runtime
  - Upon a call to the GAT-API the GAT Engine determines which adaptor(s) provide the “grid operation”
  - Upon “grid operation” failure another adaptor may be called
- There exist a set of default adaptors which provide default local capabilities
  - Grid applications can thus be compiled, linked, and tested without any available grid services
  - The same application executable can run in a “full grid environment.” No recompilation / linking

GAT API features

- Security (deal with passwords, credentials, etc)
- Grid I/O
  - File operations, remote file access, file replication
  - Inter-process communication
- Resource Management
  - Resource brokering
  - Forking grid applications, job management
- Application Information Management
  - Global repository for application specific information
  - Query this information repository
- Monitoring
  - Grid monitoring
  - Application monitoring and steering

Grid Applications with GAT



File Copy with GAT (C++)


```
#include <GAT++.hpp>

void RemoteFile::GetFile (
    GAT::Context context, std::string source_url,
    std::string target_url) throws GAT::Exception {
    GAT::File file (context, source_url);
    file.Copy      (target_url);
}
```

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- What is GAT and why do we need it?

- JavaGAT overview and structure
- Security
- Grid I/O
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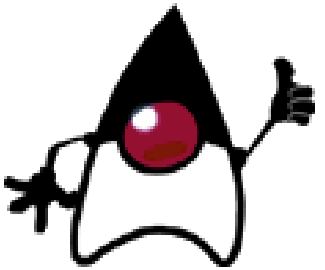
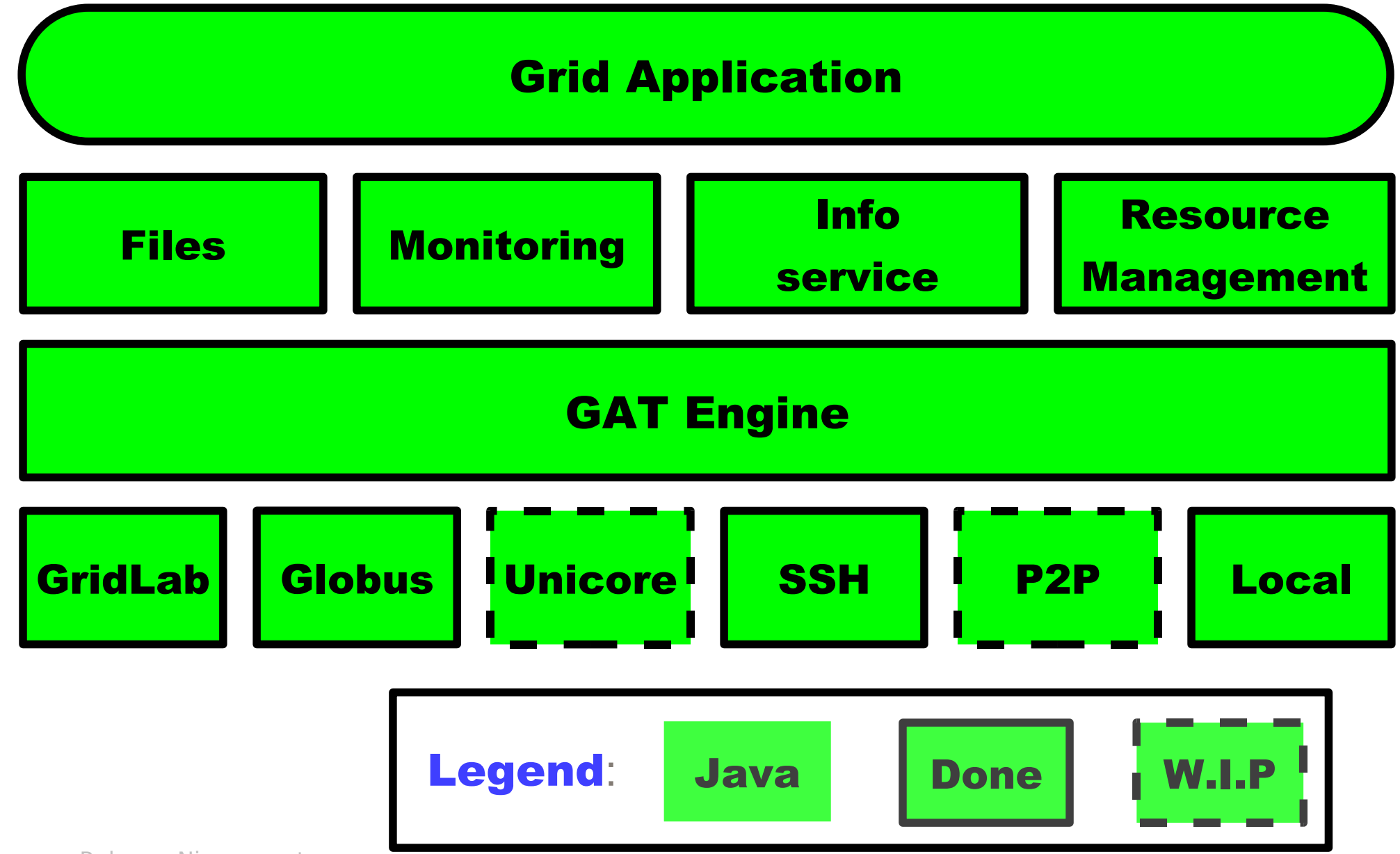
- Hands-on session

Why Java?



- Java is widely used, object oriented.
- Secure (language, sandbox)
- Java is “write once, run everywhere”.
  - Compile application on your desktop machine.
  - This creates machine independent bytecode.
  - Copy application files and the GAT to any grid site (portal typically does this for you).
  - Just run it. No recompilation / configuration.
- Performance of current JITs is good.
  - Compiled (just-in-time)
  - Runtime, profile-driven optimizations
  - Applications are typically 10% slower than C.
- Ideal for grid computing?

Java GAT Structure



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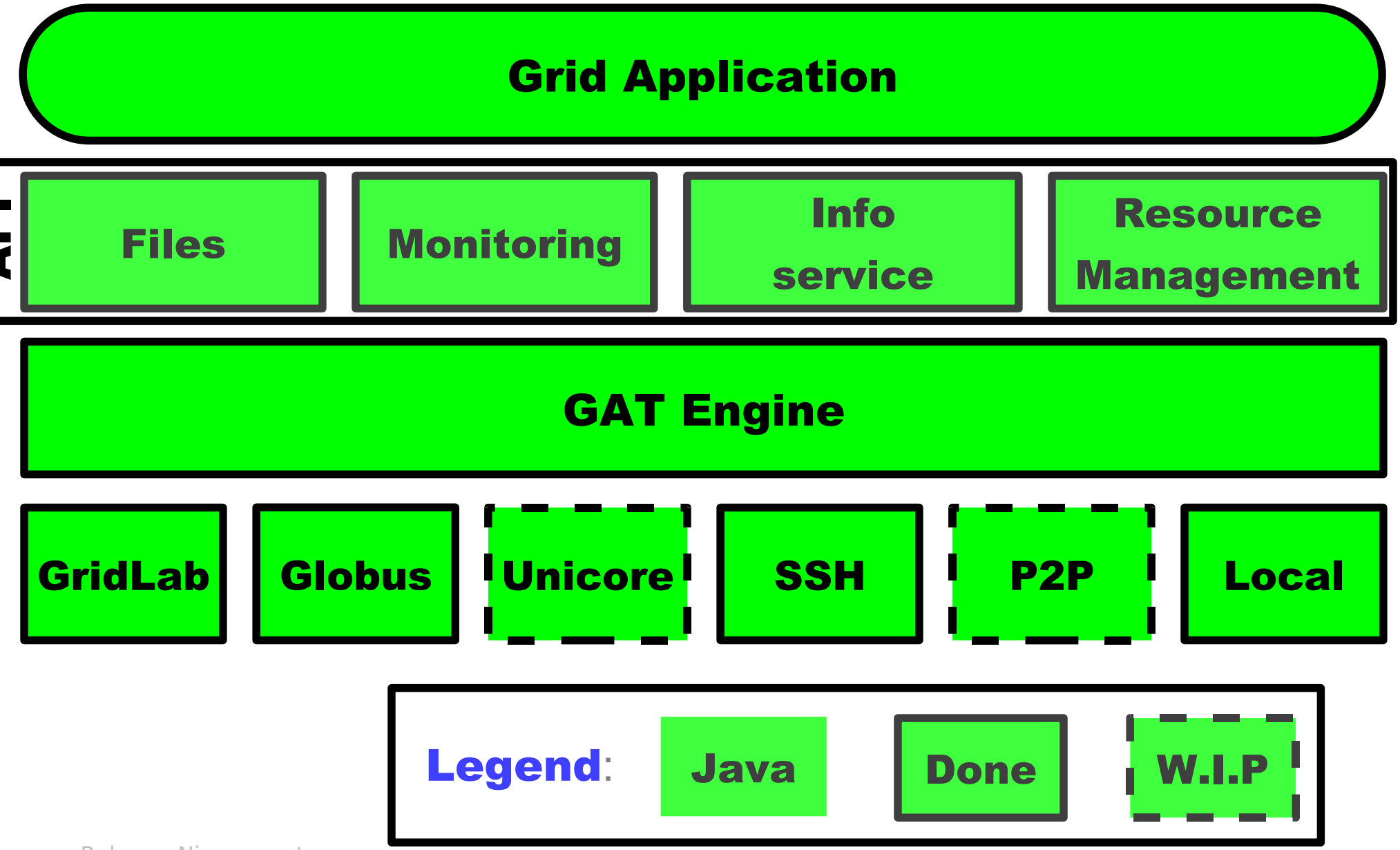

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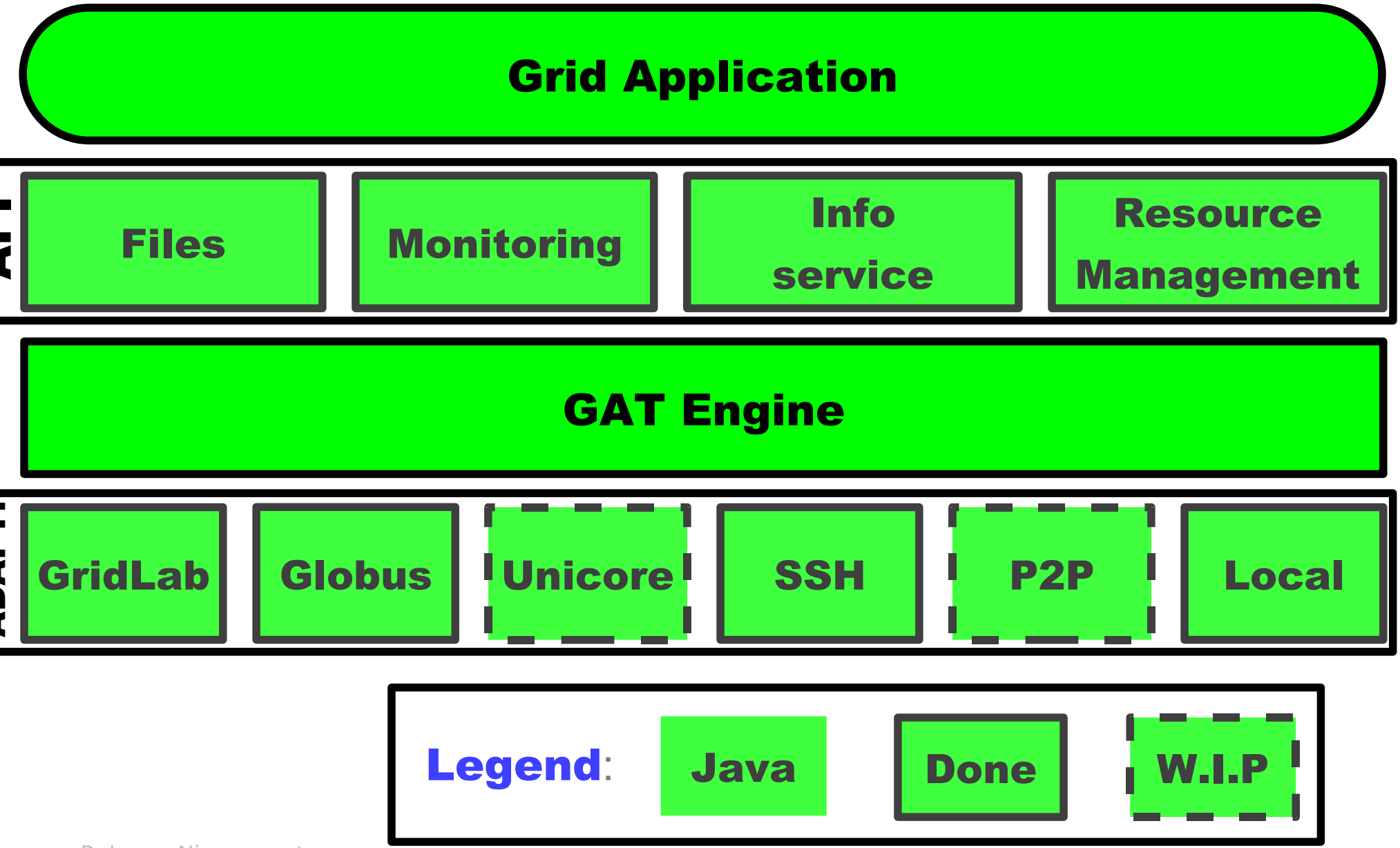

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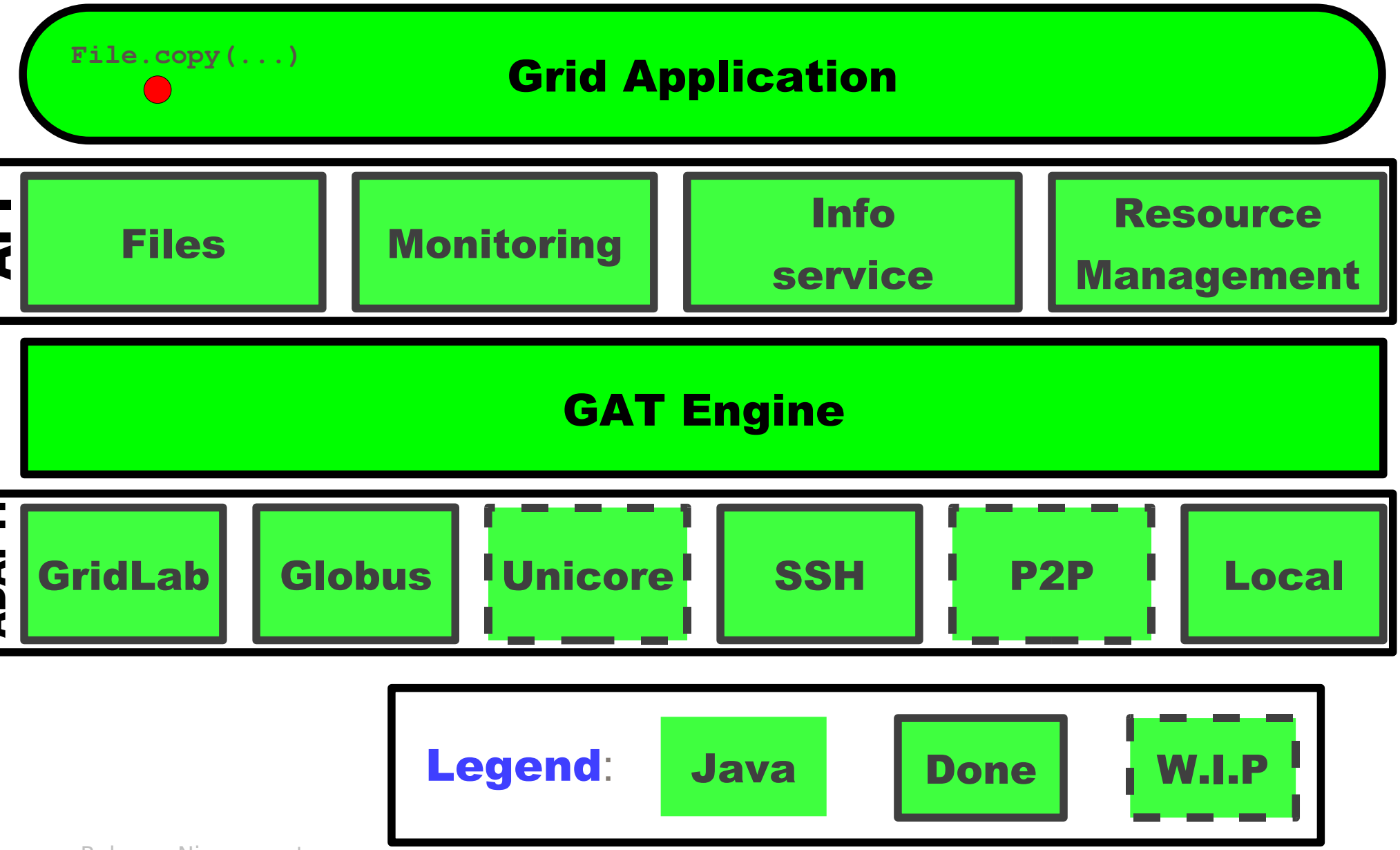

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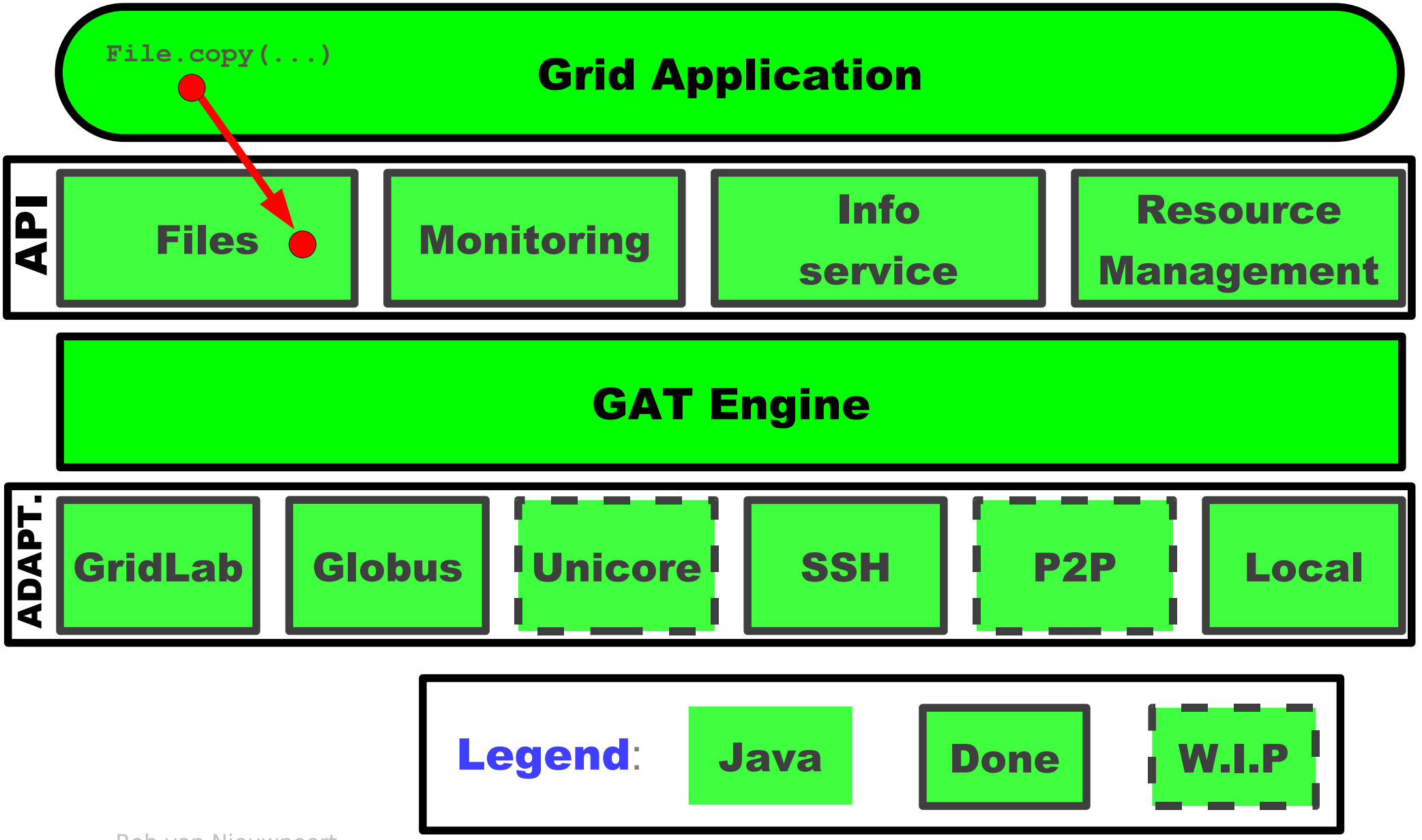

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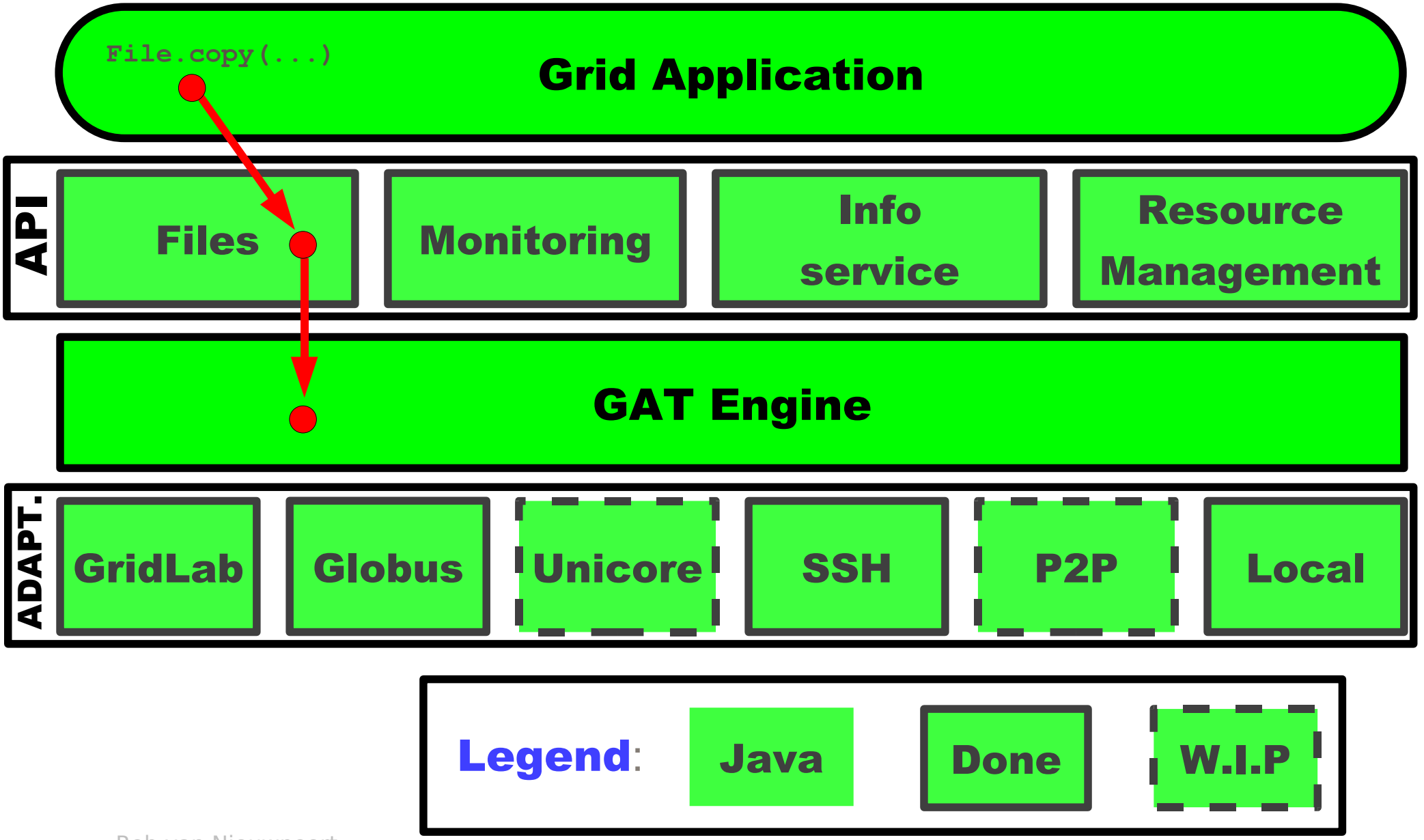

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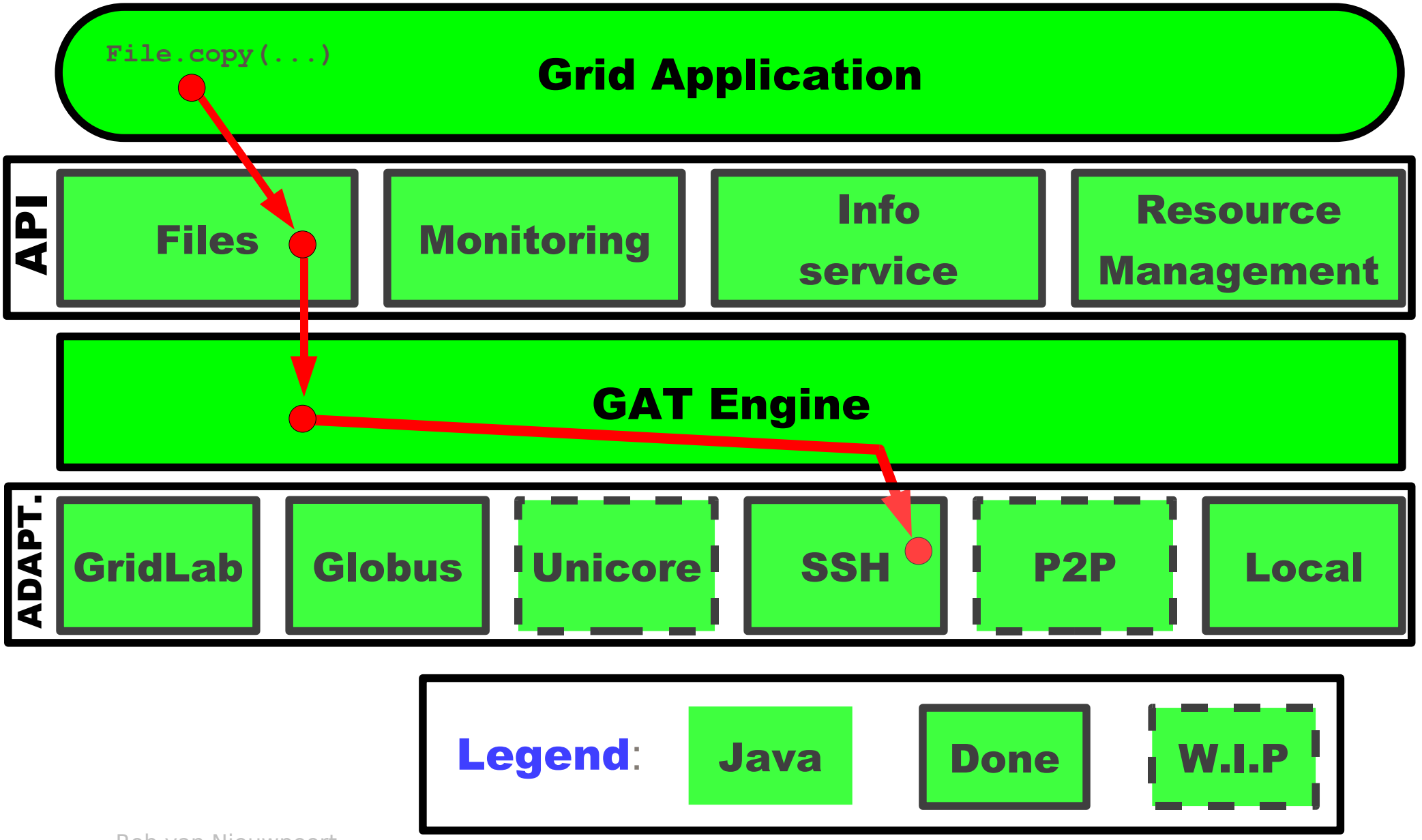

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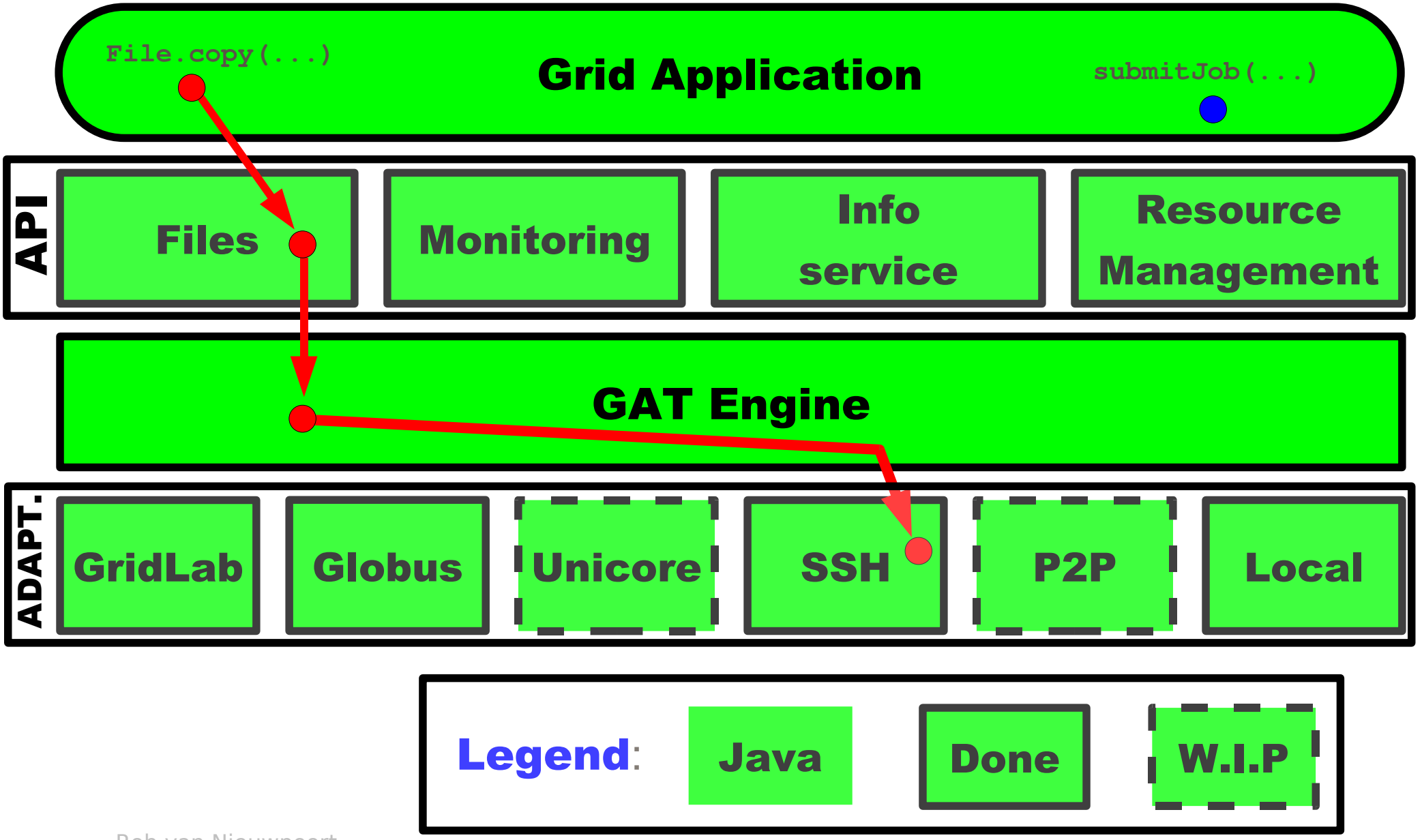

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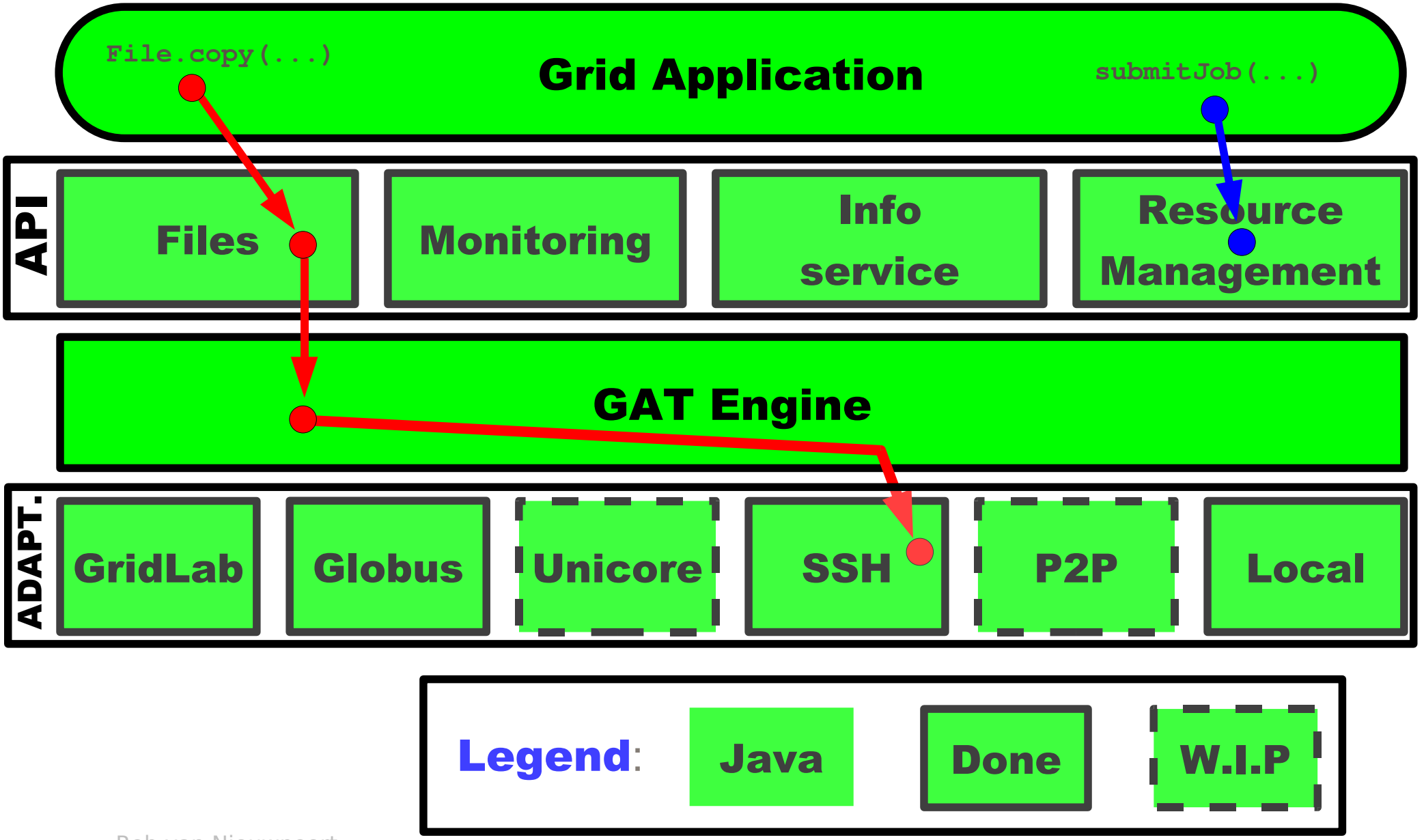

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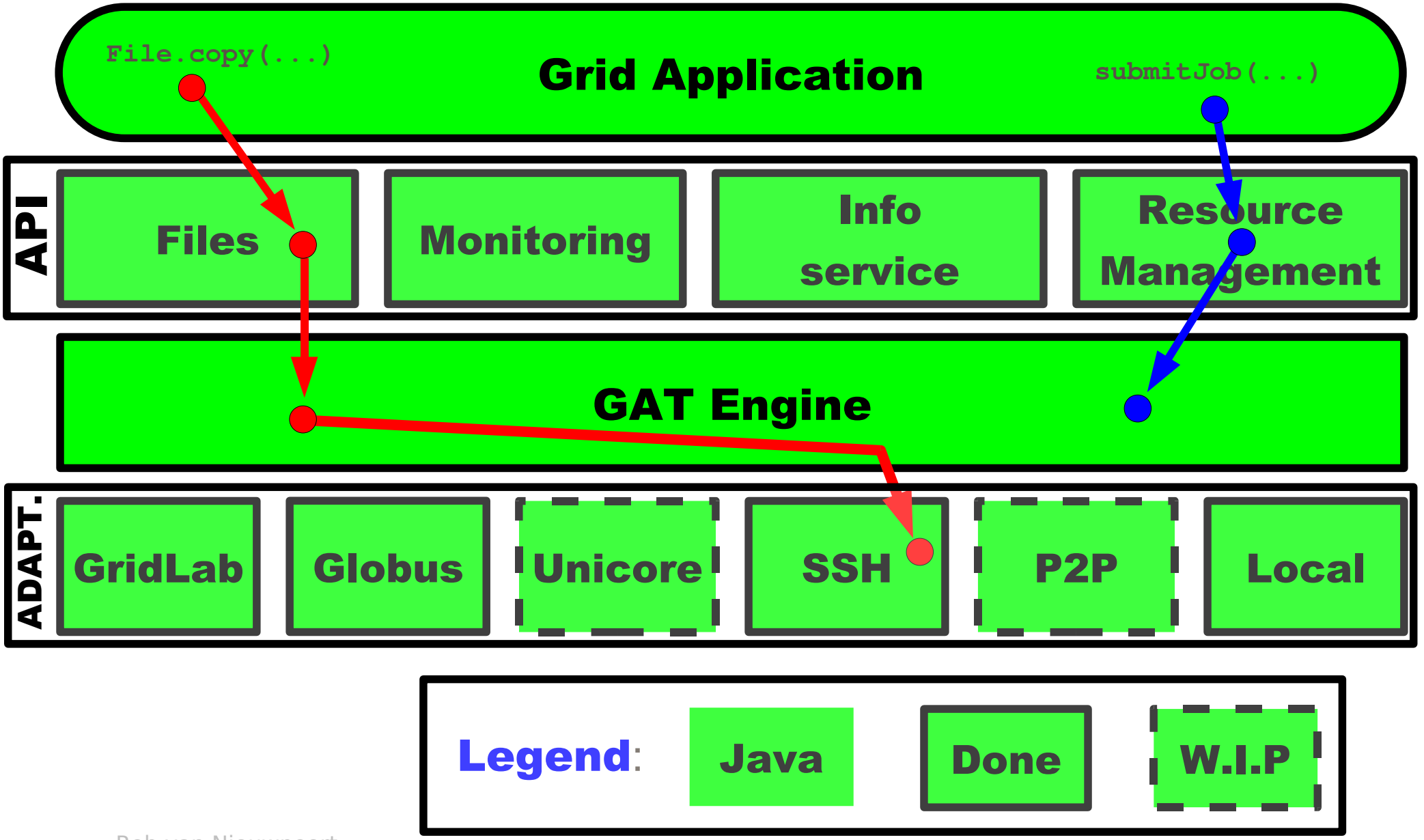

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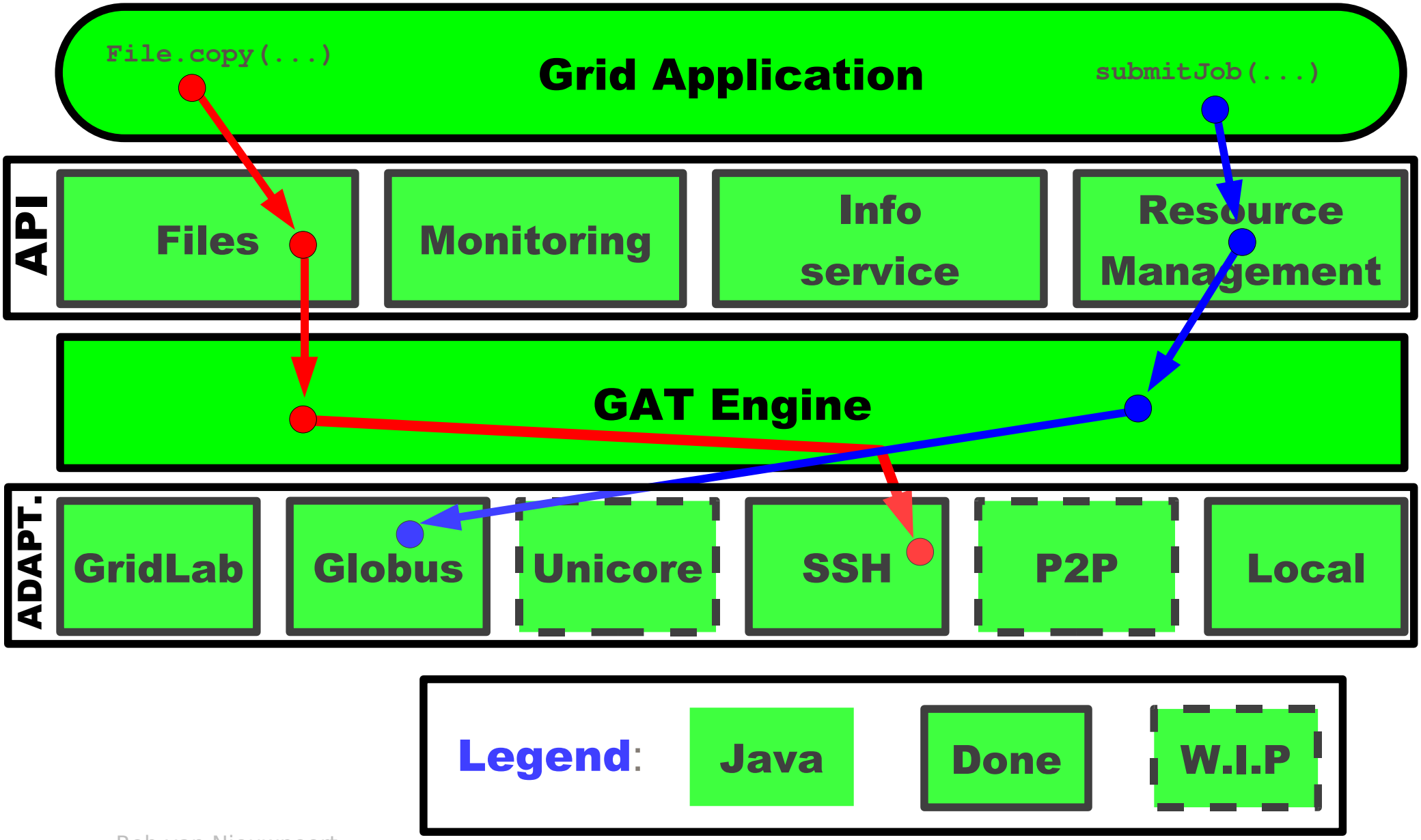

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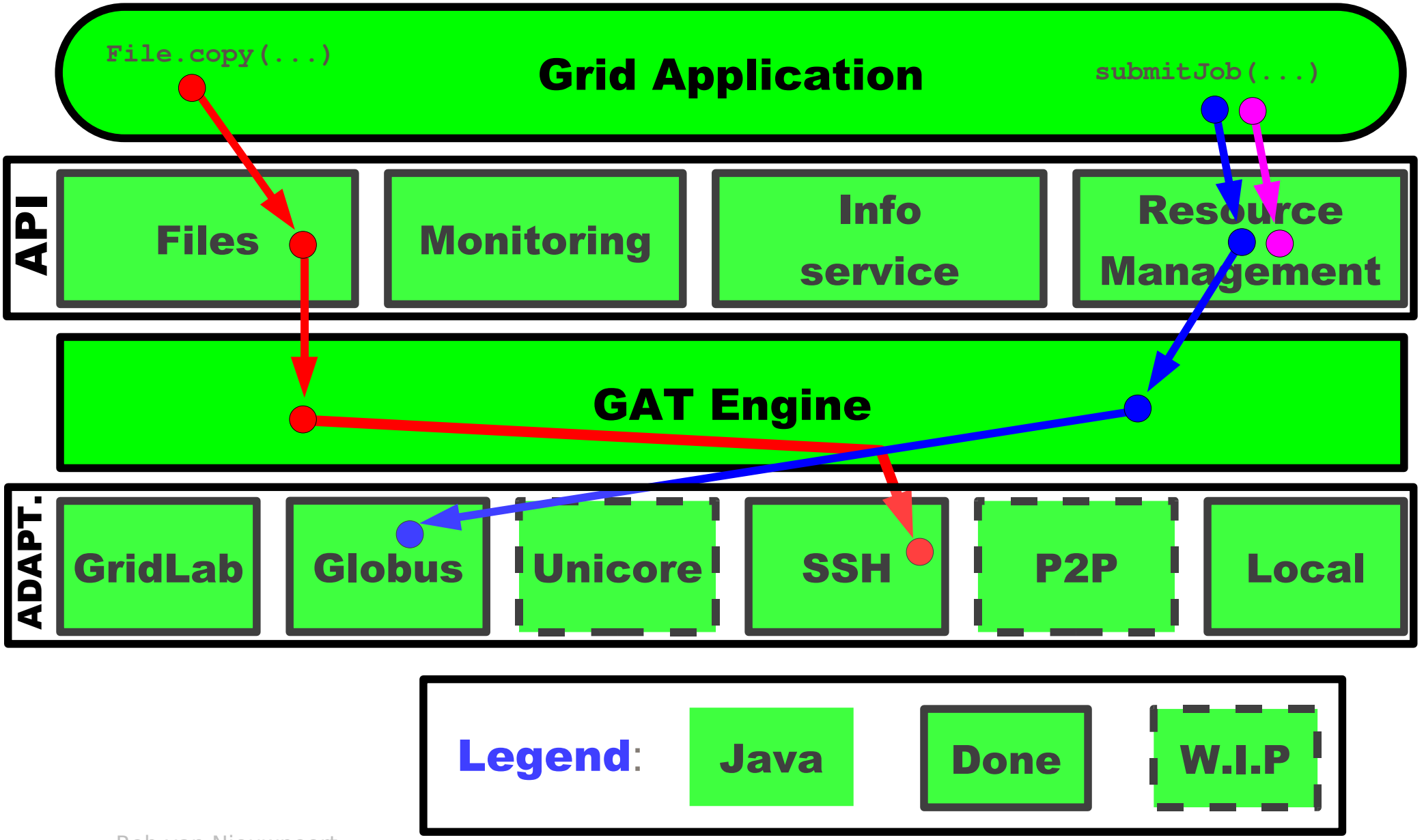

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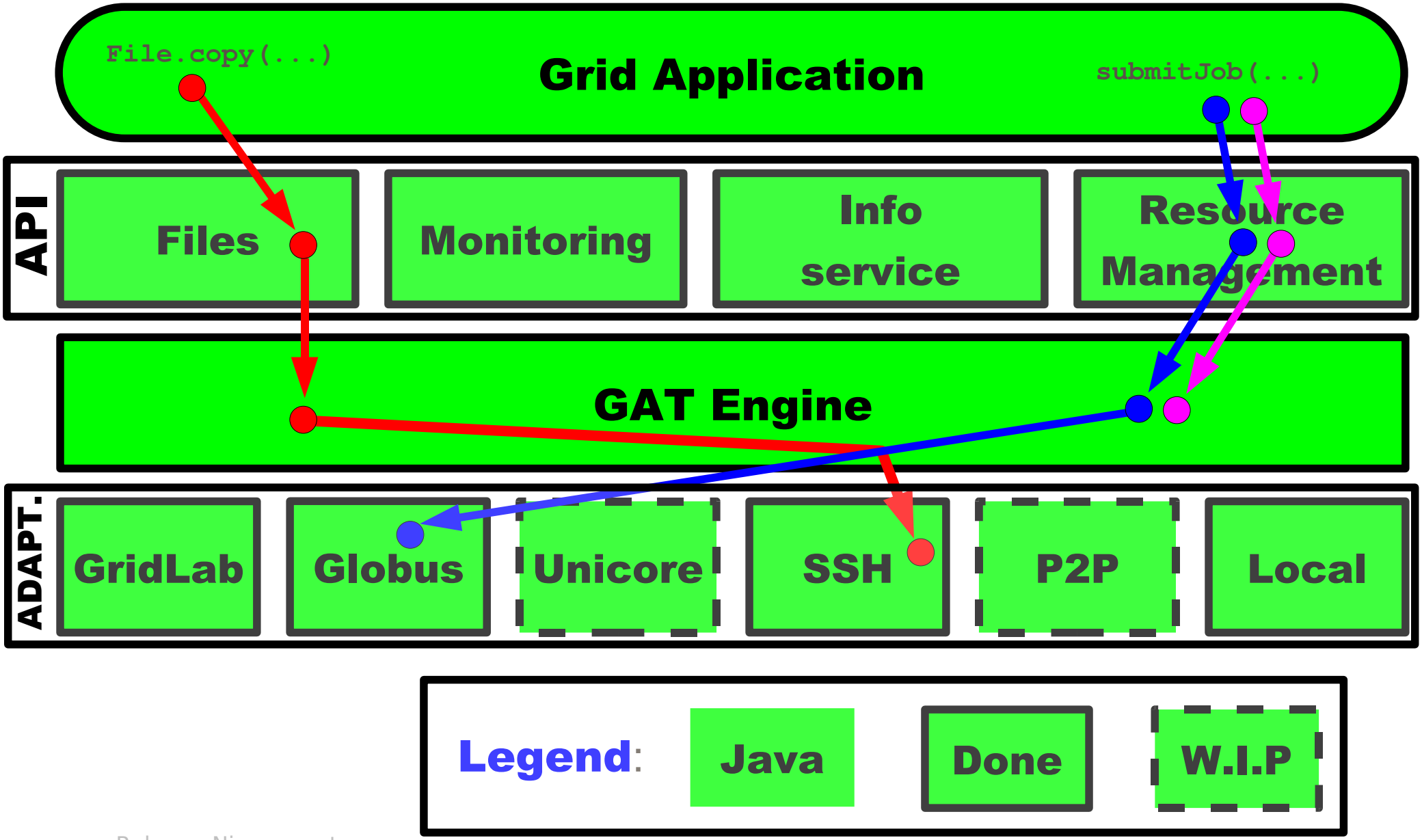

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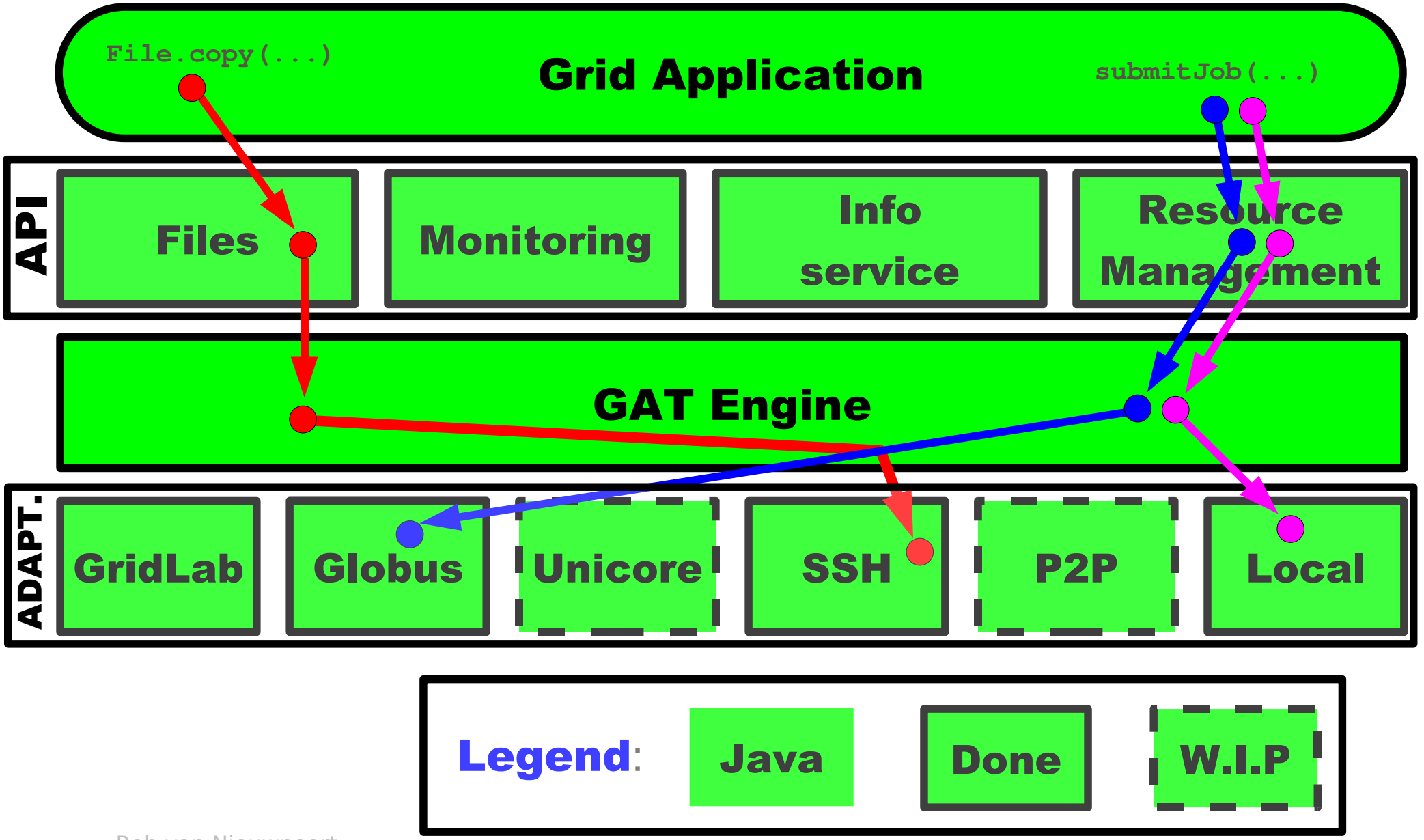

Implementation

- Adaptors are Java JAR files, dynamically loaded into the application.
- Late binding (specification allows this):
  - The GAT engine selects the best adaptor for each **method**.
  - Example: Create file object.
  - File.copy from site A to site B and C.
  - A -> B copy with GridFTP.
  - A -> C copy with GridLab Data movement.
  - Provides flexibility and fault tolerance.
- Other implementations (C, C++, ...) use static binding

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Some Basic GAT Objects

- Preferences
  - Key value pairs
  - Adaptor-specific instructions
  - Global or local, local overrides global
  - Example: `( "File.adaptor.name", "globus" )`
- GATContext
  - Contains security information
  - Contains global preferences
  - There can be more than one context
  - Needed to create GAT objects
- GAT
  - Factory for all GAT objects
- GAT Exceptions
  - Nested, helps debugging (Needed because of late binding)

Some Basic GAT Objects

- URI
  - Slightly different semantics compared to java.net.URI
  - Use the right number of /'s in the URI's
  - Full URI is easy....
    - `protocol://machine/<path>file`
  - ....but some fields may be blank
    - `file:///output` (local file in current directory)
    - `file:////output` (local file in root (/) directory)
    - `file:////tmp/output` (local file in /tmp directory)
    - `ftp://10.0.0.1/output` (remote file in default ftp dir)
- Use the right scheme (protocol) in the URI:
  - JavaGAT can choose (late binding):
    - `any://`
  - Force a specific adaptor (early binding):
    - `ftp://, gsiftp://, http://, file://, ....`

Example


```
GATContext context = new GATContext();
Preferences prefs = new Preferences();
prefs.put("File.adaptor.name", "globus");
context.addPreferences(prefs);

src = new URI("hello");
file = GAT.createFile(context, src);

OR use local preferences to override globals:

file = GAT.createFile(context, morePrefs, src);
```

GAT Security

- SecurityContext
  - A container for security Information.
- Abstract, use subclasses
  - PasswordSecurityContext
  - CertificateSecurityContext
  - MyProxyServerCredentialSecurityContext
- Notes restrict the access to the context
  - Avoid broadcasting of passwords / credentials
  - Restrict access to a set of hosts or adaptors
  - One or more notes -> restricted to those adaptors/hosts
  - No notes -> any adaptor can use context for any host
- Typically not needed if default credentials / private keys are used

GAT Security example


```
GATContext context = new GATContext();
SecurityContext pwd =
    new PasswordSecurityContext(username, password);

// restrict access
pwd.addNote("hosts", "hostname1:port1,hostname2:port2");
pwd.addNote("adaptors", "ftp,ssh");

SecurityContext cert =
    new CertificateSecurityContext(keyfile, username, passphrase);

// add them to the GAT context
context.addSecurityContext(pwd);
context.addSecurityContext(cert);
```

Overview

- What is GAT and why do we need it?

- JavaGAT structure and overview
- Security
- Grid I/O
- Resource Management
- Application Information Management
- Monitoring

- Hands-on session

Grid I/O Use Cases

- Copy, move, read, write files on the grid
- Random access to remote files
- Replicate files between different grid sites
- Inter-process communication

Available Adaptors for Grid I/O

- File, streams and random file access:
  - Local files
  - GridLab data service
  - FTP, HTTP, HTTPS
  - GridFTP (Globus)
  - SSH, SFTP
- Logical file (replication):
  - Generic adaptor on top of GAT File
  - Logical file adaptor for GridLab replica service
- Pipe
  - Sockets

Grid I/O Classes

- File
- FileInputStream / FileOutputStream
- RandomAccessFile

} Extend java.io classes

Grid-enable your code, just by replacing one “new” statement

- LogicalFile
  - Replicated file support

- Basic Inter-process communication
  - Endpoint
  - Pipe
  - PipeListener

GAT File

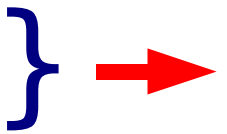
- Represents both files and directories (like java.io)
  - canRead, canWrite
  - delete
  - mkdir
  - list
  - copy
  - move
  - ...

GAT File example

```
package tutorial;

import org.gridlab.gat.*;
import org.gridlab.gat.io.File;

public class RemoteCopy {
    public static void main(String[] args) throws Exception {
        GATContext context = new GATContext();

        URI src = new URI(args[0]);
        URI dest = new URI(args[1]);
        File file = GAT.createFile(context, src);              // create file object

        file.copy(dest);                                       // and copy it
        GAT.end();
    }
}
```

GAT File Streaming Example

```
package tutorial;
class RemoteCat {
    public static void main(String[] args) throws Exception {
        GATContext context = new GATContext();
        URI loc = new URI(args[0]);

        FileInputStream in = GAT.createFileInputStream(context, loc);
        InputStreamReader reader = new InputStreamReader(in);
        BufferedReader buf = new BufferedReader(reader);

        while(true) {
            String result = buf.readLine();
            if(result == null) break;
            System.out.println(result);
        }
        in.close();
        GAT.end();
    }
}
```



GAT Remote Random Access Files

- Random access to remote files
  - read
  - write
  - seek
  - length
  - ...

GAT Logical File (replica management)

- LogicalFile class
  - An abstract representation of a set of identical physical files
  - addFile / addURI
  - removeFile / removeURI
  - replicate(URI destination)
- Replicate a logical file to a new location.
  - Copy one of the files in the set to the new location
  - Choose the “best” one
    - Closest in terms of bandwidth
    - Cheapest
    - ...
    - Depends on adaptor
- Typically used for staging in files for jobs
  - Resource broker (or GAT) chooses one of the files in the set

The future of GAT

- GAT will be supported for at least the four years
- GAT is being standardized within GGF
  - This will take time
  - Standard is called SAGA (Simple API for Grid Applications)
- Java reference implementation of SAGA is being developed by us
  - A layer on top of the JavaGAT
- API differences
  - Conceptually, SAGA is very close to GAT
  - SAGA adds task model to GAT for asynchronous grid operations
  - SAGA is Posix-like, not Java-like
  - SAGA is less configurable by design (e.g., no preferences)

JavaGAT users

- Download is anonymous, so we don't know
- Max Planck Institute for Astrophysics in Garching
- D-Grid
- Astrogrid
- Louisiane State University
- University of Texas
- AMOLF, Institute for Atomic and Molecular Physics
- The Dutch Virtual Labs for E-science project (Vl-e)
- The workflow system Triana (University of Cardiff)
- Georgia State University
- Vrije Universiteit Amsterdam (Ibis, teaching)
- The Multimedian project
- Zuse Institute Berlin, Germany
- VU Medical Center Amsterdam

Conclusion

- The GAT provides a simple and stable API to various Grid environments
- But powerful!
- Independent of grid middleware
- Portable
- Downloads:
  - www.cs.vu.nl/ibis
  - Distributions
  - Anonymous SVN access at gforge.cs.vu.nl
  - Java Platforms: any (Java 1.5 or higher)
  - Support via gforge site mail, forum, bug tracking