Multithreading of Kostka Numbers Computation for the BonjourGrid Meta-Desktop Grid Middleware – AOC Team –

Heithem Abbes[1,2] Franck Butelle[1], Christophe Cérin[1]

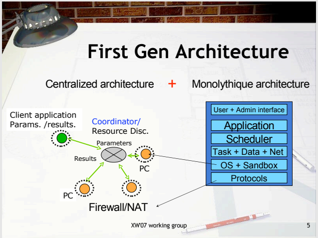
[1]Université de Paris 13, CNRS UMR 7030, Villetaneuse, France
[2]Research unit UTIC, ESSTT, Tunis, Tunisie

ICA3PP'2010, Busan

Table of contents

Desktop Grid Architectures

Desktop Grid



Key Points

- Federation of thousand of nodes;
- Internet as the communication layer: no trust!
- Volatility; local IP; Firewall

Desktop Grid Architectures

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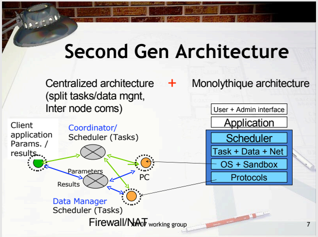

Future Generation (in 2006)

- Distributed Architecture
- Architecture with modularity: every component is “configurable”: scheduler, storage, transport protocole
- Direct communications between peers;
- Security;
- Applications coming from any sciences (e-Science applications)

In search of distributed architecture

First line: publish/subscribe system to notify and coordinate services and multiple DG without a central broker ⇒ BonjourGrid;

Second line: approach based on structured overlay network to discover (on the fly) the next node executing the next task ⇒ PastryGrid;

https://sourceforge.net/projects/pastrygrid/

(main contributions of Heithem Abbes in his PhD)

Main objectives of BonjourGrid

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- Reduce as much as possible the use of any central element;
- Create a coordinator, on the fly, without any system administrator intervention; From a vision with a single coordinator towards a vision with multiple coordinators.
- Each coordinator searches, in a concurrent way, participants (idle machines)

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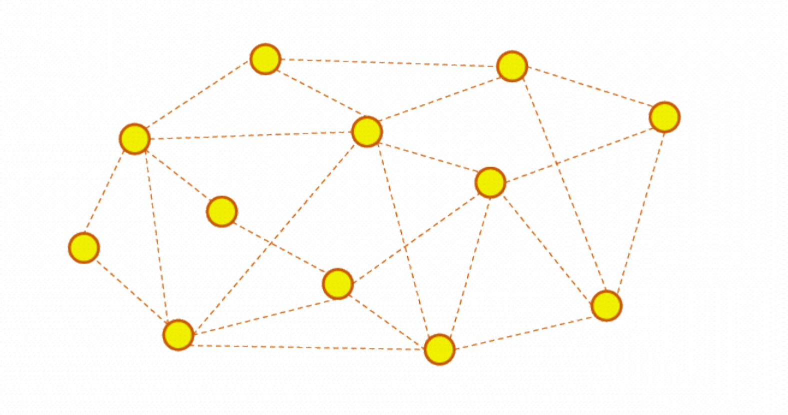
- This paper: a use case with BonjourGrid + parallelization of a computational problem;

How BonjourGrid works



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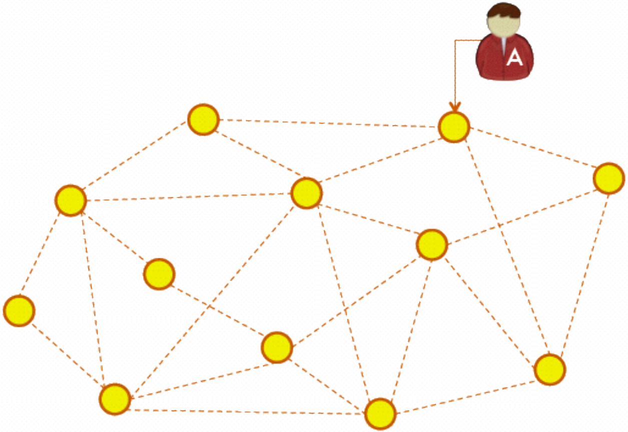

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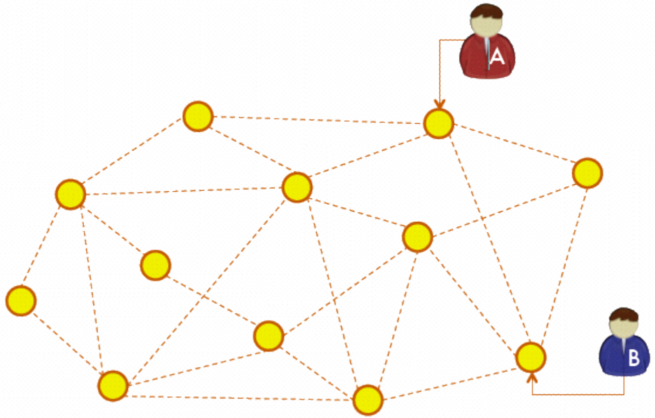

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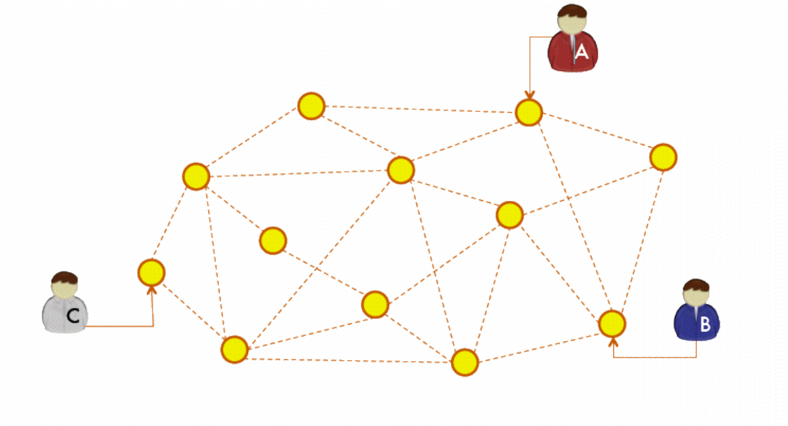

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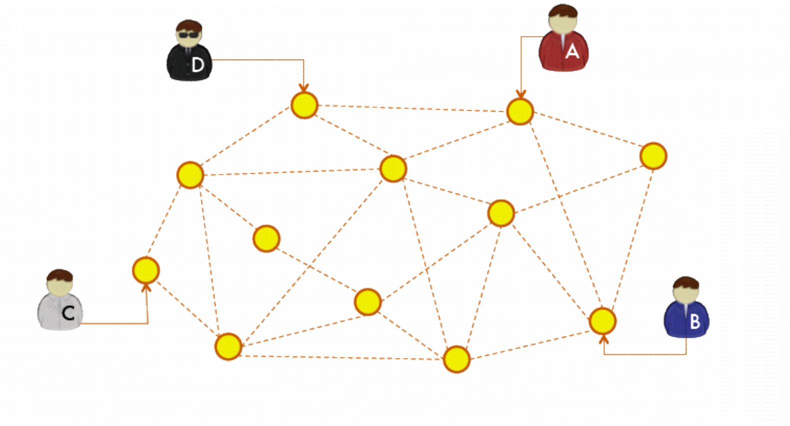

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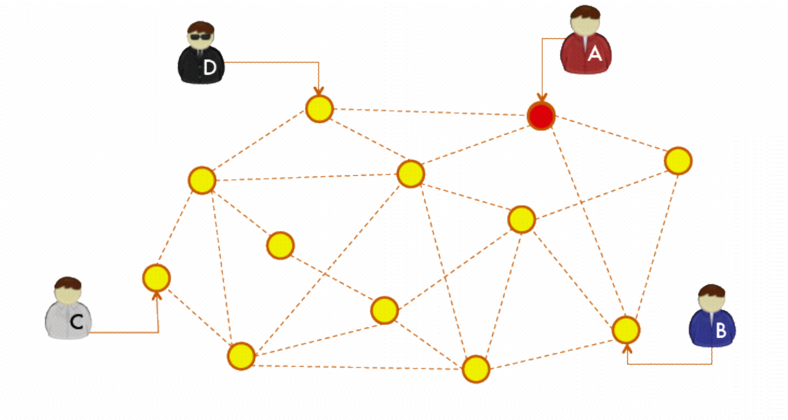

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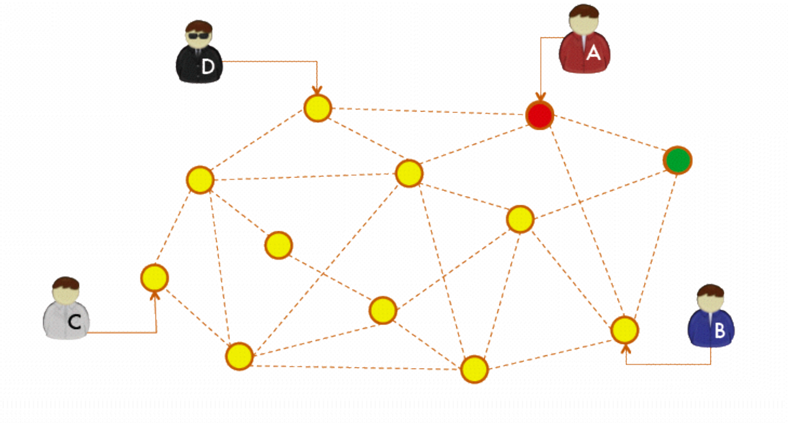

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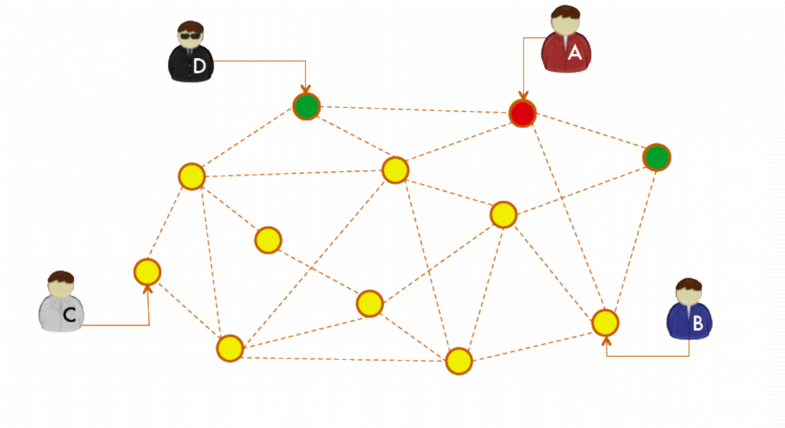

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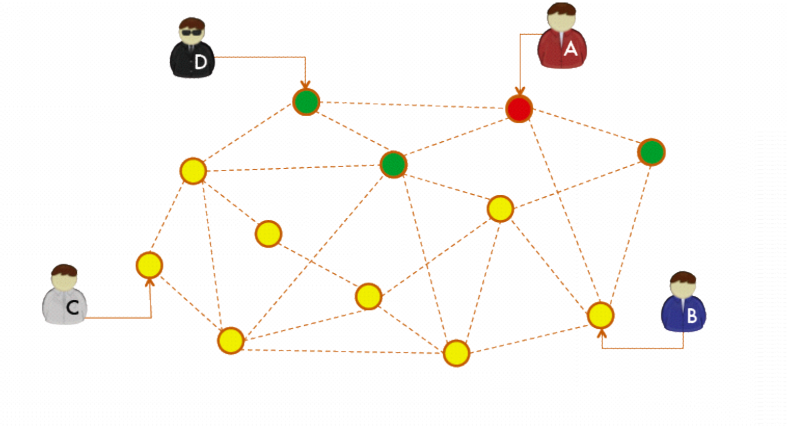

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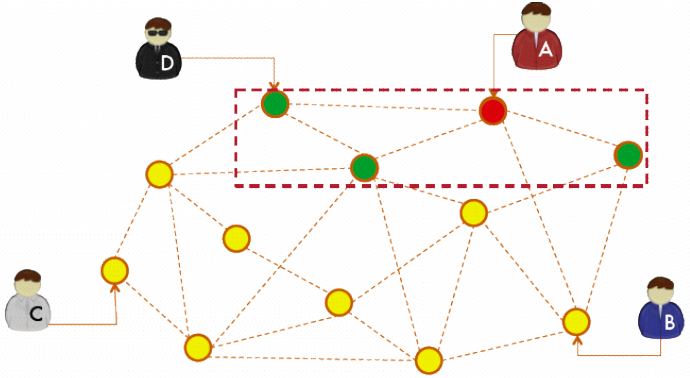

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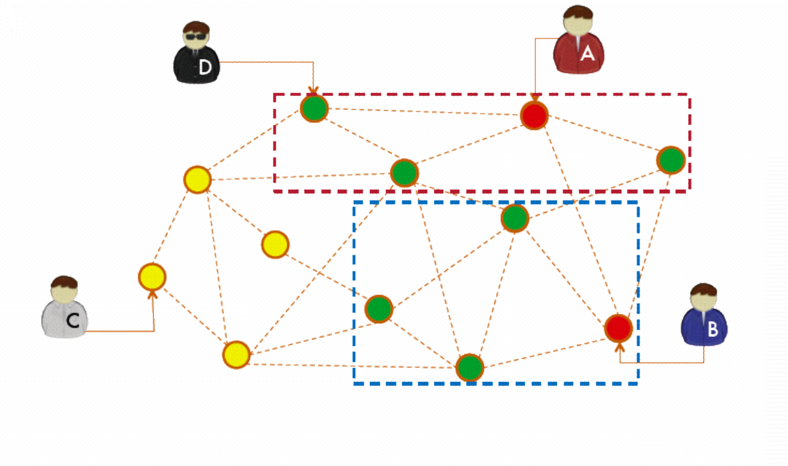

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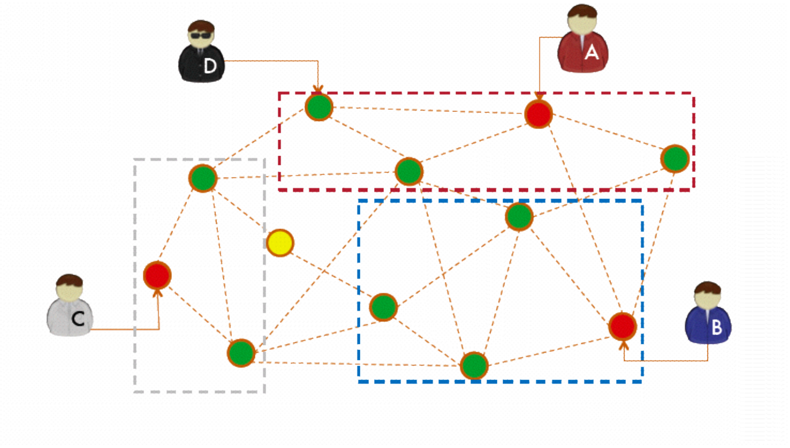

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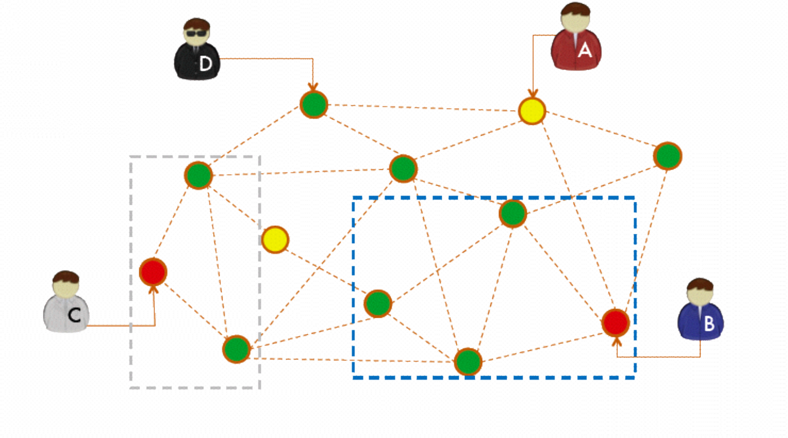

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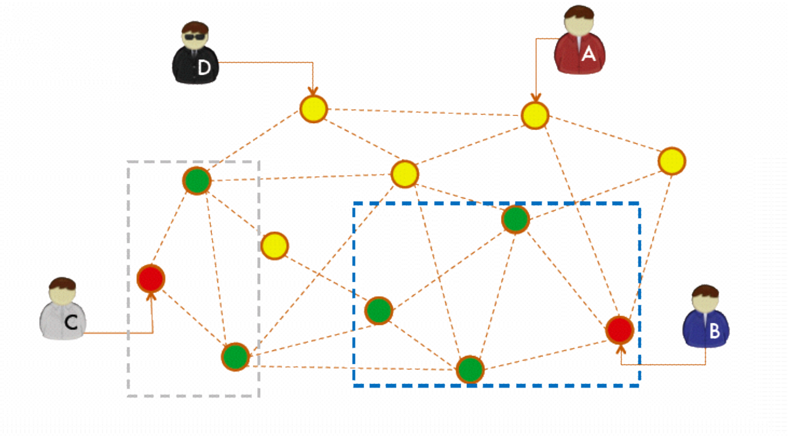

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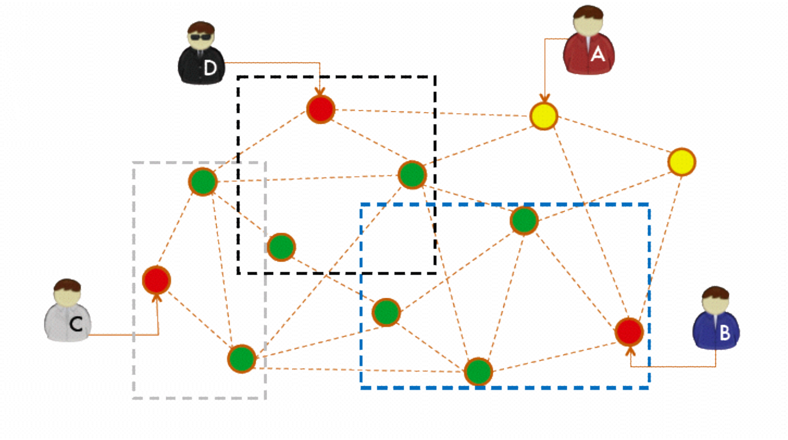

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  - Extensible Messaging and Presence Protocol (XMPP) (formerly named Jabber) is an open, XML-based protocol originally aimed at near-real-time, extensible instant messaging (IM) and presence information, but now expanded into the broader realm of message-oriented middleware

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- The current protocol has been developed/specified with 'ad-hoc' methods → we need to consolidate the trust (ongoing project to verify it, based on Colored Petri Nets)

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- Our solution: tolerate the failure of coordinators
  - For any application we create and manage dynamically copies of the coordinator;
  - We manage k copies; based on passive replication.
  - When a service disappears: we added a special status flag to distinguish between 'end of the application' / 'failure' ⇒ slaves can redirect the communication to a copy.

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  - in terms of comparing Boinc, Condor, XtremWeb over our protocol;
  - in terms of robustness in supporting FT;

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  - in terms of #coordinator versus #nodes
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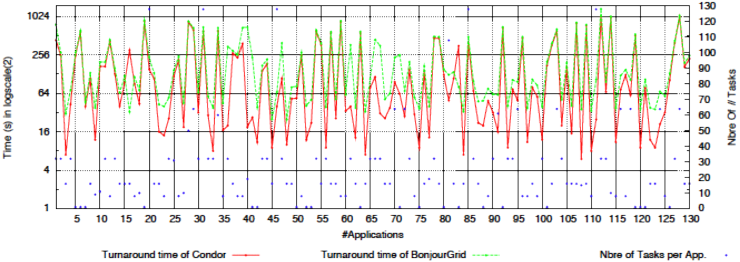
  - in terms of comparing Boinc, Condor, XtremWeb over our protocol;
  - in terms of robustness in supporting FT;
- Example Condor: 130 applications (2 to 128 // tasks), 200 nodes, application task: 1s to 500s. Result: with BonjourGrid, 35% of applications generate a delay of about 30s.

Experiments: one example



Problem Definition

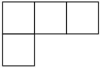
Integer Partitions and Ferrer's Diagramms

Definition : Integer Partition

write n as a sum of decreasing integers.

Example : $4 = 3 + 1 = 2 + 2 = 2 + 1 + 1 = 1 + 1 + 1 + 1$

Definition : Ferrer's Diagramm

of a $\lambda = (3, 1)$ partition of an integer. $|\lambda| = 4$: $F^{\lambda} =$ 

Important role :

- group representation theory
- Symmetric functions theory
- Frobenius (1849-1917) : irreductible representations of symmetric groups are indexed by integer partitions...

Ferrer diagrams and tableaux

- Each partition λ specifies a Ferrer diagram F^λ consisting of $|\lambda|$ boxes arranged in left-adjusted rows of lengths λ_i.
- A semistandard Young tableaux T of shape λ and weight $\beta(T)$ is a numbering of the boxes F^λ with $\beta_i(T)$ entries i for $i = 1, 2, \ldots, n$ that are weakly increasing across rows and strictly increasing down columns.

Example: $n = 6$, $\lambda = (4, 2, 2, 1)$, $\beta(T) = (1, 3, 1, 1, 2, 1)$

$F^\lambda =$

$T =$

1	2	2	5
2	4		
3	6		
5			

Calculation of Kostka coefficients

- Theorem: $K_{\lambda\beta}$ is the number of semistandard Young Tableau of shape λ and weight β
- Example: $n = 3$, $\lambda = (3, 2, 0)$, $\beta = (2, 1, 2)$.

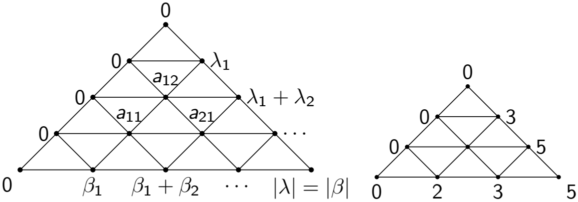
1	1	2
3	3	

1	1	3
2	3	

  Hence $K_{\lambda\beta} = 2$.
- Note: we compute the coefficients according to a dilatation N: stretched Kostka coefficient $K_{N\lambda,N\beta}$ and then we have to interpolate on the results to find the Kostka polynome in N;
- Another way to compute Kostka coefficients is using Hives model.

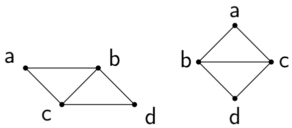
Integer Hives

- n-hive with vertex labels $a_{ij} \in \mathbb{Z}$ for $0 \leq i, j, i+j \leq n$
- Vertex labels increase from left to right.
- Example : $n = 3$, $\lambda = (3, 2, 0)$, $\beta = (2, 1, 2)$.



Hives Conditions

- Distinct types of rhombi, with vertex labels :



Hives Conditions

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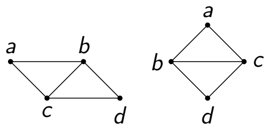
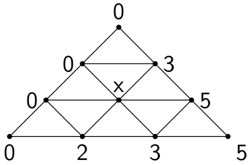


- Hive conditions in terms of vertex labels:

$$b + c \geq a + d$$

Simple example using K-hives

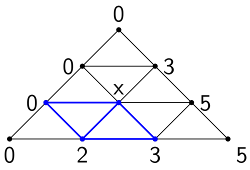
$n = 3$, $\lambda = (3, 2, 0)$, $\beta = (2, 1, 2)$ $(x \in \mathbb{Z})$.



Simple example using K-hives

$n = 3$, $\lambda = (3, 2, 0)$, $\beta = (2, 1, 2)$ $(x \in \mathbb{Z})$.

- $x + 2 \geq 3 \Leftrightarrow x \geq 1$



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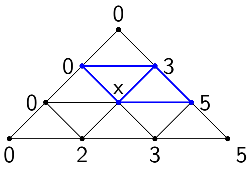

- $x \geq 1$
- $x + 3 \geq 5 \Leftrightarrow x \geq 2$

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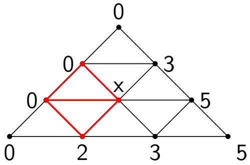

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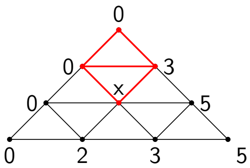

- $x \geq 2$
- $3 \geq x$

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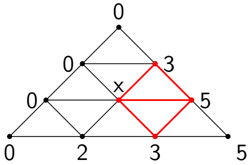

- $x \geq 2$
- $3 \geq x$
- $x + 5 \geq 6$

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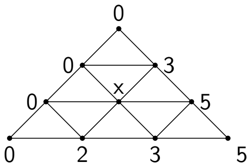


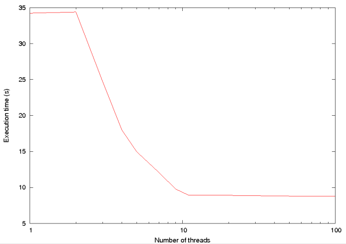
- Finally $3 \geq x \geq 2$: 2 solutions so $K_{\lambda\beta} = 2$.
- But when there is more than one free variable, enumeration must be done.

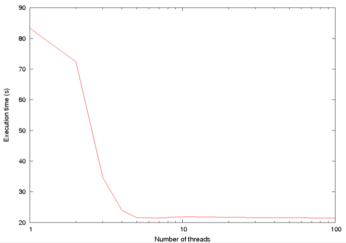
Experiments

Tools & Results

- Pthreads library: portability;
- OS: Linux;
- CPU: Bi-AMD Opteron dual core at 2.8GHz;
- Results: performance depends on the size of first interval ($n \geq 1 \Rightarrow n$ threads at the beginning) ; The number of feasible values tried by each thread depends on the interval it received from the first step; Input dependant;

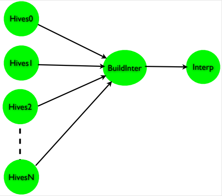
Graphical representation





The view of the user

GUI and the engineering part




```xml
<Deployment>
    <Application ApplicationDescription="monapp" Client="heithem">
        <Module ModuleDescription="hives" ModuleDirIn="/bin/">
            <Binary BinaryCpuType="amd64" BinaryExecutable="hives"
                    BinaryOsName="Linux" BinarySubFolder="linux"/>
        </Module>
        <Module ModuleDescription="buildinter" ModuleDirIn="/bin/">
            <Binary BinaryCpuType="amd64" BinaryExecutable="buildinter"
                    BinaryOsName="Linux" BinarySubFolder="linux"/>
        </Module>
        <Module ModuleDescription="interp" ModuleDirIn="/bin/">
            <Binary BinaryCpuType="amd64" BinaryExecutable="interp"
                    BinaryOsName="Linux" BinarySubFolder="linux"/>
        </Module>
    </Application>
```

Facilities

- SDAD: system for deployment; No need for learning XML syntax;
- Programming language: Python, Bonjour for Python;
- Embedded code: x86 executable, javac, scripts (Perl, Python, Bash...) ; Depending on the DG used.
- What you need to install: package containing one DG middleware (Condor, Boinc, XtremWeb) + client + server;

The view of the user

GUI and the engineering part

```
<Table>
    <Task Application="monapp" ApplicationModule="hives"
     Description="hives1" DirIn="/hives/" FileIn="dir.zip" Final="0">
        <Input InputName="x1"/>
        <Output OutputName="y1"/>
        <cmdLine>11,10,8,5 20,17,3 26,25,8,8,7 out1 1</cmdLine>
        <QoS>
           <Power NbMax="0" ErrorMargin="0.2">3000.0</Power>
        </QoS>
    </Task>

    <Task Application="monapp" ApplicationModule="hives"
      Description="hives2" DirIn="/hives/" FileIn="dir.zip" Final="0">
        <Input InputName="x2"/>
        <Output OutputName="y2"/>
        <cmdLine>11,10,8,5 20,17,3 26,25,8,8,7 out2 2 </cmdLine>
        <QoS>
           <Power NbMax="0" ErrorMargin="0.2">3000.0</Power>
        </QoS>
    </Task>

    <Task Application="monapp" ApplicationModule="buildinter"
       Description="build" DirIn="/hives/" FileIn="dir.zip" Final="0">
        <Input InputName="y1"/>
        <Input InputName="y2"/>
        <Output OutputName="y3"/>
        <cmdLine>2 out interresult  </cmdLine>
        <QoS>
           <Power NbMax="0" ErrorMargin="0.2">3000.0</Power>
        </QoS>
    </Task>

    <Task Application="monapp" ApplicationModule="interp"
      Description="interp" DirIn="/hives/" FileIn="dir.zip" Final="1">
        <Input InputName="y3"/>
        <Output OutputName="y4"/>
        <cmdLine>interresult 2 finalresult </cmdLine>
        <QoS>
          <Power NbMax="0" ErrorMargin="0.2">3000.0</Power>
        </QoS>
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- In this example: command line parameters for tasks ; QoS parameters: helping the schedular for selecting machines ⇒ information generated automatically.

Conclusion

From similar to diversity in large scale experiments

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- Future work for BonjourGrid: reservation rules; wide area Bonjour or XMPP (Jabber protocol for presence) or Web services ; Formal verification of the protocol.

Multithreading of Kostka Numbers Computation for the BonjourGrid Meta-Desktop Grid Middleware – AOC Team –

Heithem Abbes[1,2] Franck Butelle[1], Christophe Cérin[1]

[1]Université de Paris 13, CNRS UMR 7030, Villetaneuse, France
[2]Research unit UTIC, ESSTT, Tunis, Tunisie

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