



Trends in Computing Power used by Various BOINC Communities

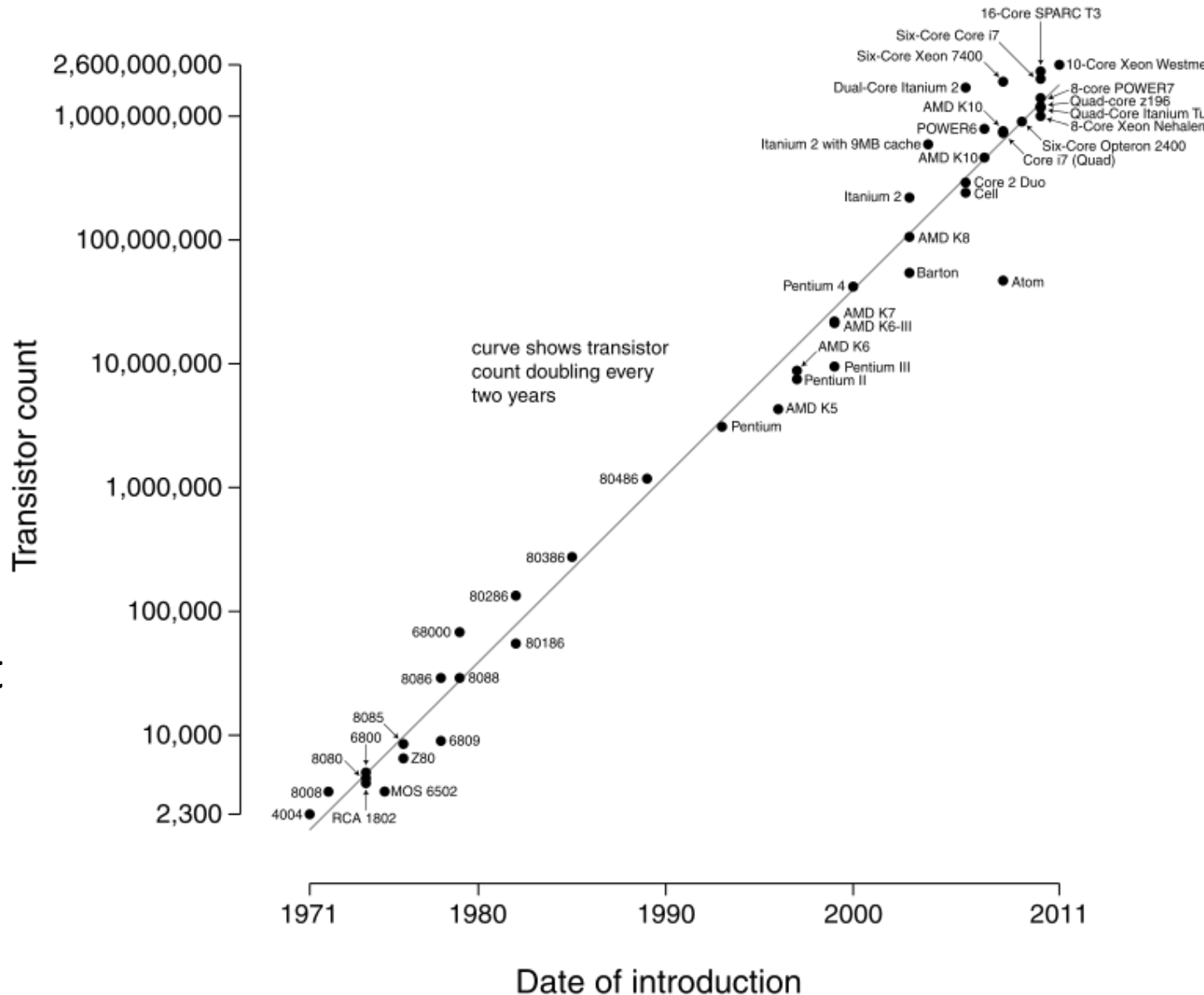
Yuri Gordienko

G.V.Kurdyumov Institute for Metal Physics, National
Academy of Sciences (Kyiv, Ukraine)

10th BOINC Workshop – 30 September 2014 – Budapest

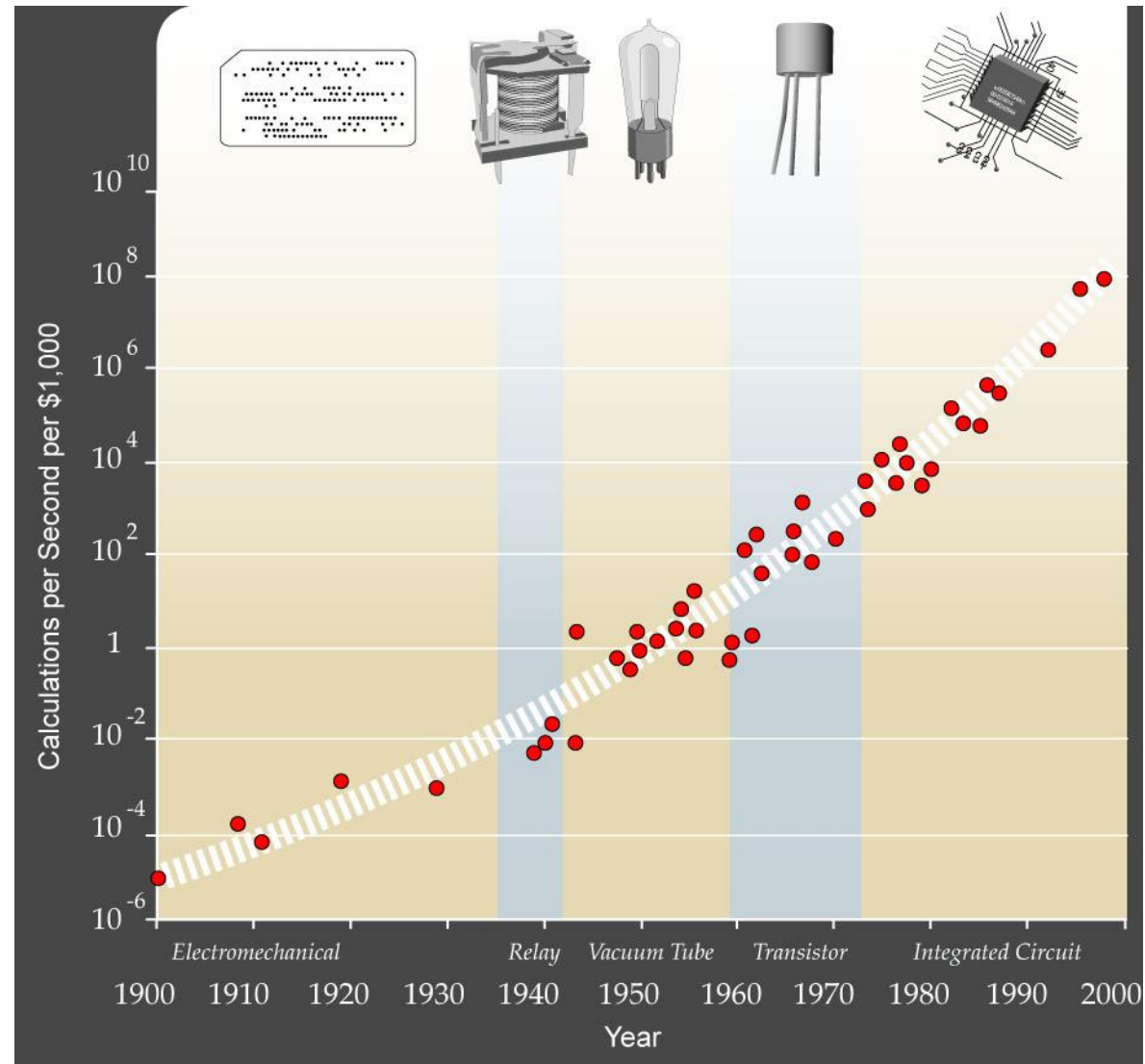
State of the Art – CPU

Moore' Law:
CPU transistors
versus dates of
introduction.
The line
corresponds to
exponential
growth with
transistor count
doubling every
two years



State of the Art – High-tech

Kurzweil's extension
of Moore's law:
calculations per second versus time -
from integrated
circuits to
earlier transistors,
vacuum
tubes, relays and
electromechanical
computers



(C) Kurzweil

Let's Measure Progress of Computing Power in BOINC Projects

Motivation:

- Can we measure the actual (not theoretical like in Moore's law) increase of global computing power using ...
... BOINC projects are some subsets of the global PC computing community?
- Can we consider them as "statistically representative samples"?

Aims:

- to explore the progress of computing power in BOINC projects
- to compare it among various BOINC projects
- to check and extend Moore's Law?

Methods:

- use available open statistics on hosts in BOINC-projects
- use closed statistics on actually working machines (**not available at the moment**)

Data Used

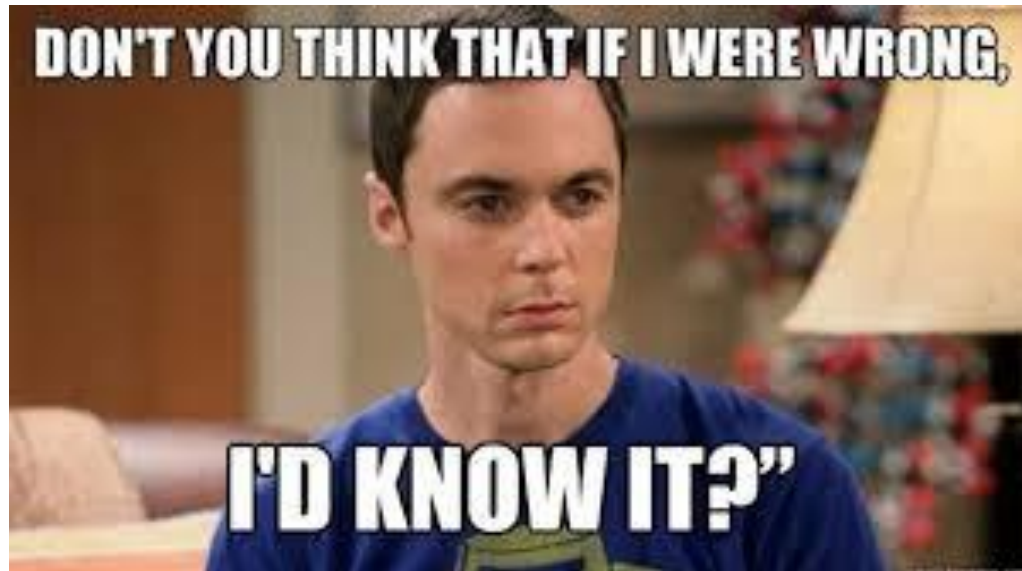
- FLOPs (FPOPs) – the FLoating Point OPerations per second
 "p_fpop"
- IOPs – the Integer OPerations per second
 "p_iops"
- CPUs – the number of CPUs in the host
 "ncpus"
- ...
- ...
- Others like:
 "p_membw"
- or
 "d_total"
- and more ...

Example 1: SLinCA@Home IMP Desktop Grid

size: small (even **nano**)

history: short (2009-2014-...)

hosts: CPU



Scaling Laws in Cluster Aggregation

- SLinCA@Home

Our team in G.V.Kurdyumov Institute for Metal Physics (IMP), National Academy of Sciences (Kyiv, Ukraine) maintains DG BOINC infrastructure **on the basis of BOINC SZTAKI Desktop Grid technology** at the premises of SLinCA@Home IMP Desktop Grid (<http://dg.imp.kiev.ua/slinca>).

SLinCA@Home

About SLinCA@Home

SLinCA (Scaling Laws in Cluster Aggregation) is a research project that uses Internet-connected computers to do research in field of materials science. You can participate by downloading and running a free program on your computer.

SLinCA is based at G.V.Kurdyumov Institute for Metal Physics (National Academy of Sciences of Ukraine - NASU).

Project Description, Wiki, FAQ, and other sections are under construction, but some info can be found in the relevant publications.

SLinCA@Home is supported by our partners: OEGISCO, IDGF, and Distributed Computing team (Ukraine).

Join SLinCA@Home

- Read our rules and policies
- This project uses BOINC. If you're already running BOINC, select Attach to Project. If not, download BOINC.
- When prompted, enter <http://dg.imp.kiev.ua/slinca/>
- If you're running a command-line or pre-5.0 version of BOINC, create an account first.
- If you have any problems, get help here.

Technical Details

- Number of registered users: **1781**.
- Number of active users: **323**.
- Number of hosts: **596**.
- Number of active teams: **70**.
- Estimated performance: **291,414** GFLOP/s.
- Peak performance: **1229,765** GFLOP/s.
- The current conditions for 1 workunit per 1 CPU core (2.4GHz) are as follows: time to run (nonlinear chronometry of progress) ~2-4 hours; RAM<60 MB; HDD<40 MB.
- Project performance
- Server Status
- Applications
- Download BOINC add-on software

Returning participants

- Your account - view stats, modify preferences
- Team - create or join a team
- Certificate - Your personal proof of the work completed

Community

- Profiles
- User search
- Message boards - share your opinion with others
- Questions and Answers - if you have a question or problem
- Statistics and leaderboards
- Language

User of the day

alida
Hallo. Mein Name ist Stefan und komme aus der N'xho von K'f'n in Deutschland. Ich rechne f'f' BOINC weil mich die Idee dahinter sehr fasziniert.

News

SERVER STATUS: We foresee potential problems with a stable power supply -> server could be unavailable in the next 5 days.
March 04, 2011, 13:28 GMT
During the following 5 days (4-8 March) we foresee some potential problems with a stable power supply. That is why, we apologize in advance, if some unpredictable problems will appear due to temporal inaccessibility of SLinCA project server, despite all these hardships, by our estimations we will finish the next half-year programme of calculations ... during the next week (and major upgrade of application will be made)! Thanks to all for your tremendous support!
SERVER STATUS: Server hardware will be upgraded today.
February 28, 2011, 07:45 GMT
For the further stable scaling-up we will upgrade our project server hardware today (28 February, 2011) with a short interruption from 10:00 GMT to 12:00 GMT. Then all inprogress workunits will be accepted, and the limited number of unsent workunits will be available.
The next milestone on the testing stage: peak performance > 1 TFLOP/s...

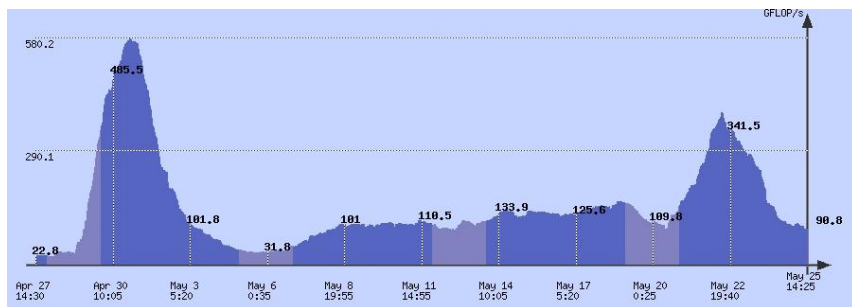
February 24, 2011, 06:58 GMT
Owing to our urgent supporters we improved our work and reached the remarkable level of >1 TFLOP/s (~400 active PCs), despite the alpha-testing status of our project (limited server hardware, nonlinear chronometry of progress, long workunits up to 4-5 hours, absence of checkpointing - at the moment, some temporal hardships with stability of application versions, etc.). In short: we accelerated our work by more than 30-40 times in comparison to our annual plan and got production results at the testing stage even. :) Thanks to all for this 'nano'-scale, but very important step! We are not truly 'public' yet (project-related wiki and other docs are under construction yet), but we will try to reach this level as soon as possible.
SERVER STATUS: Server hardware will be upgraded this week with a short interruption.
February 22, 2011, 07:25 GMT
During the last weekend we determined the limits of hardware for stable server operation. Our server was stable up to processing ~20 KWUs (with some delays and faults after this value). We would like to thank you for cooperation that allowed us to find these limits. For the further stable scaling-up we will upgrade hardware during this week with a short interruption, which will be announced before this.
SERVER STATUS: Test of server hardware stability.
February 19, 2011, 10:25 GMT
During the next weekend (19-20 Feb 2011) we will carry out 'field tests' for stability of server hardware in relation to the sharply increased number of workunits (~>1000) and participants (~>1000). In advance, we would like to thank you for your courage and apologize for potential failure of server and some results (if any).
SERVER STATUS: Bug with 'non-running feeder' was fixed.
February 16, 2011, 12:25 GMT
Yesterday, conflict between two versions of application created a mess in our database. We fixed this problem and apologize for failure of some results.
...more

Newly available as an RSS feed: [RSS](#)

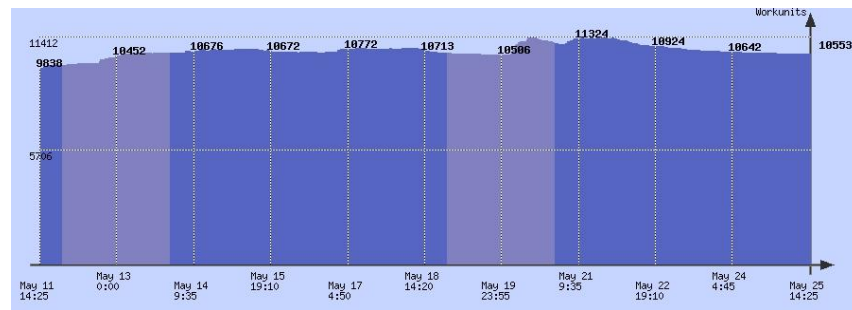
SLinCA@Home – Overview

The current status of IMP Desktop Grid infrastructure:

- ~4000 workers;
- ~ 20 000 in-progress workunits;
- ~150 GFLOPs (average performance)
- ~300-550 GFLOPs (weekly peak performance) and 1.3 TFLOPs (max).



Typical performance timeline



Number of in-progress workunits

SLinCA@Home – Volunteer Community

IMP team mostly cooperate with a national-wide Ukrainian user community on the premises of the public site “Distributed Computing Team ‘Ukraine’” (<http://distributed.org.ua>), discussed and contributed the best practices in DCI operations at their special fora.

The screenshot shows the website 'Ukraine - Distributed Computing Team' with a blue header and navigation menus on the left. The main content area features a central banner with the text 'Ukraine distributed.org.ua Distributed Computing Team' and a welcome message in Russian. Below the banner are links to a forum and a list of projects. On the right, there are two sidebars: one showing BOINC ratings for various projects and another showing a list of supporters.

Ukraine - Distributed Computing Team

Добро пожаловать !

Ukraine distributed.org.ua
Distributed Computing Team

Приветствуем вас на сайте
Украинской команды распределенных
вычислений !

[наш командный форум] [список всех известных нам проектов]

Цель нашей команды – свободными вычислительными ресурсами
наших компьютеров помочь ученым решать задачи в
разнообразных областях науки и техники.

Проекты **распределенных вычислений** (Distributed Computing) имеют **увлекательную историю** и серьезный вычислительный потенциал. Сегодня нам, владельцам персональных компьютеров, предлагают принять участие в решении самых разнообразных научно-исследовательских задач – от изучения свойств белков до поиска гравитационных волн

BOINC рейтинг
(кликабельно)

Ukraine	
BOINC combined	
Credits:	2,225,102.639
BSrac:	6,308.820
Rank:	41
Rank%:	99.956

Поддержка (обращайтесь)

Folding@Home	
NikeLong	246659609
Alex	266184514
ReMMeR	338177212

Rosetta@Home	
uNiUs	172324149
KoDak	313871706

World Community Grid	
Dmitrio	250896826

FightAIDS@Home	
RHAngel	50177406

RC5/OGR	
Tamagoch	53619819
Paul B. Atton	46941577

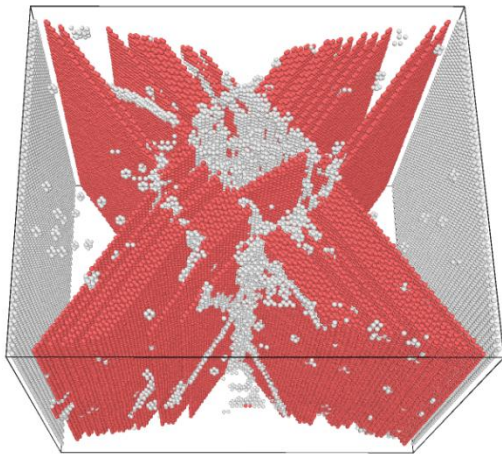
Seti@Home	
Andrey Fenchenko	285577622

Use Case 1: Stress relaxation phenomena in Al/Cu/Si crystals

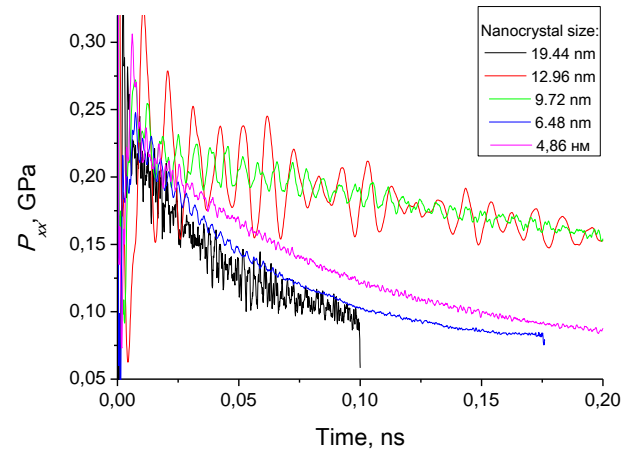
Application: LAMMPS-over-DCI (LAMMPS wrapped in DC-API by SZTAKI)

Science Community: physics, materials science – 2 user groups (6 end users): IMP + KNU (Taras Shevchenko Kyiv National University, Kyiv, Ukraine).

Scientific Aim: MD simulation of relaxation behavior of stresses in nanocrystals.



The evolution of the defect substructure in Al nanocrystal (after 15 ps, defects only are shown: gray color — point defects, red color — stacking faults) .



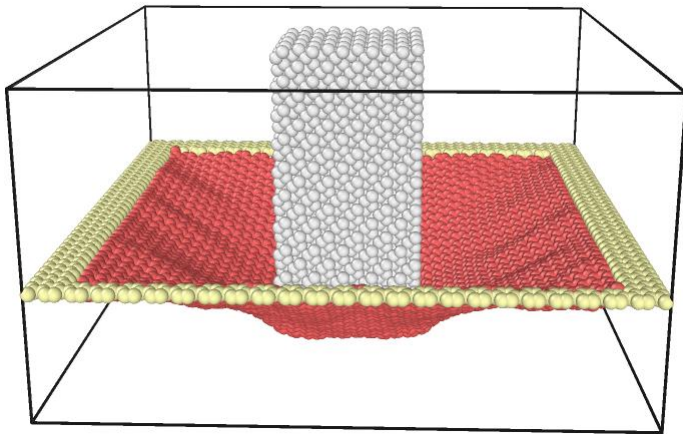
Oscillation of the internal stress P_{xx} for different nanocrystal sizes.

Use Case 2: Nanoindentation of graphene membrane

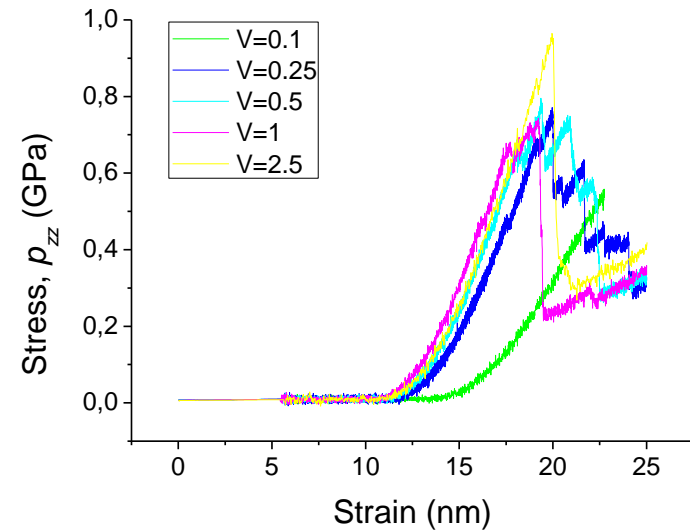
Application: LAMMPS-over-DCI (LAMMPS wrapped in DC-API by SZTAKI)

Science Community: nanotechnologies – 2 user groups (5 end users): IMP + SPM&RS-Centre (Centre of scanning probe microscopy and resonance spectroscopy, Kyiv, Ukraine).

Scientific Aim: MD simulation of nanoindentation was performed for monolayer graphene membrane in an atomic force microscope.



Visualization of nanoindentation:
red color — mobile graphene atoms,
yellow color — fixed graphene atoms,
gray color – nanoindenter atoms.



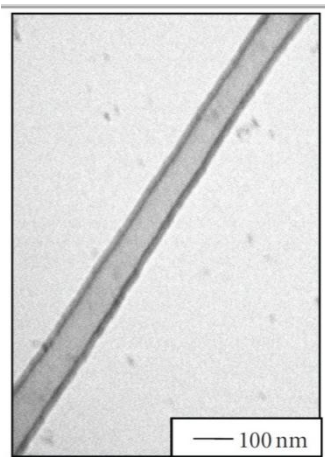
Stress-strain dependencies for different speeds (A/pm) of the nanoindenter.

Use Case 3: Thermal stability of boron nitride nanotubes

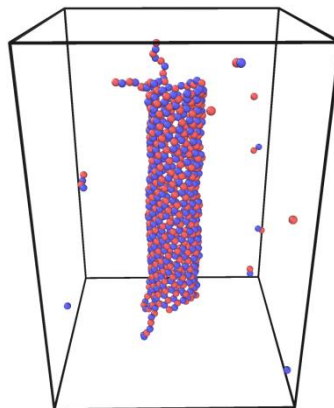
Application: LAMMPS-over-DCI (LAMMPS wrapped in DC-API by SZTAKI)

Science Community: nanotechnologies, materials science – 2 user groups (4 end users): IMP + IPMS (Frantsevich Institute for Problems in Materials Science, Kiev, Ukraine).

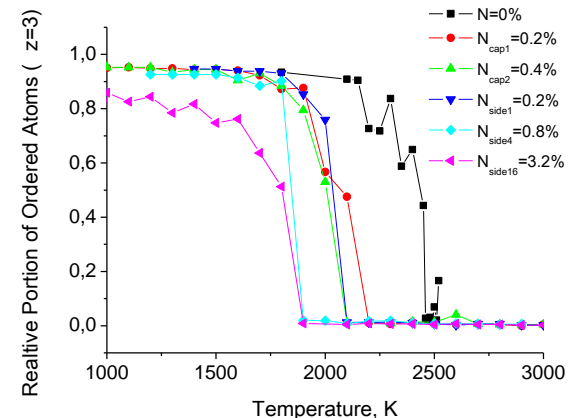
Scientific Aim: MD simulation of boron nitride nanotubes (BNNT) with exceptional physical properties, which are a prerequisite for their wide practical applications in the future.



example of boron nitride nanotube (TEM-image)³

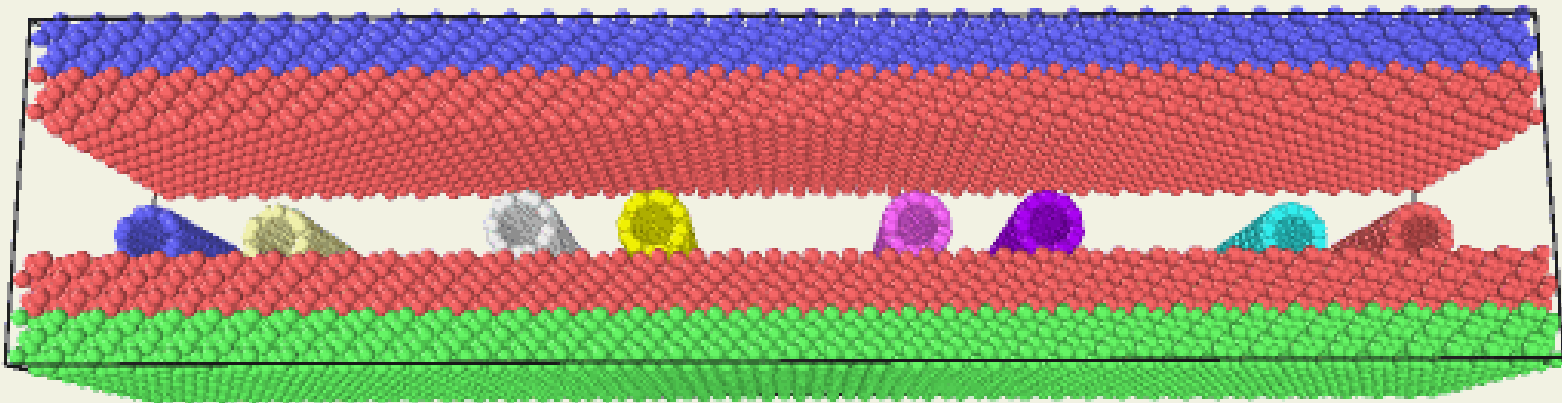


Collapse of NTNB (after 0.1 ns, nitrogen atoms are shown by red color, boron atoms — by blue color).



Dependence of decay temperature on the vacancies concentration and location (cap or side) in BNNT

Use Case 4: Manipulations with carbon nanotubes



Detachment of m-CNTs after application of driving force per atom $\mathbf{F=0.17\ eV/\text{\AA}}$ and usage of the second Si-substrate (“stamp”) in the presence of s-CNTs:
two m-CNT c(6,6); two s-CNT c(7,5), two s-CNT c(9,2), and two m-CNT c(10,0) (from left to right).

Publications

1. Change of Scaling and Appearance of Scale-Free Size Distribution in Aggregation Kinetics by Additive Rules, *Physica A: Statistical Mechanics and its Applications* (2014) DOI: [10.1016/j.physa.2014.06.028](https://doi.org/10.1016/j.physa.2014.06.028), [preprint at arxiv.org](#).
2. IMP Science Gateway: from Portal to Hub of Virtual Experimental Labs in Materials Science, International Workshop on Science Gateways (IWSG-2014) (Dublin, Ireland), [preprint at arxiv.org](#).
3. The Oscillatory Nature of Internal Stress Relaxation due to Self-Organization of the Defect Substructure in Nanocrystals, IV Int. Conf. "Nanoscale Systems: Structure, Properties, Technologies" ("Наноразмерные системы: строение, свойства, технологии") (Kyiv, Ukraine, 2013/11/22), [poster \(PDF\)](#).
4. Thermal Stability of Boron Nitride Nanotubes, IV Int. Conf. "Nanoscale Systems: Structure, Properties, Technologies" ("Наноразмерные системы: строение, свойства, технологии") (Kyiv, Ukraine, 2013/11/22), [poster \(PDF\)](#).
5. Elastic Properties and Strength of Graphene under Nanoindentation Conditions, IV Int. Conf. "Nanoscale Systems: Structure, Properties, Technologies" ("Наноразмерные системы: строение, свойства, технологии") (Kyiv, Ukraine, 2013/11/22), [poster \(PDF\)](#).
6. Complex Workflow Management and Integration of Distributed Computing Resources by Science Gateway Portal for Molecular Dynamics Simulations in Materials Science, Proc. Third International Conference "High Performance Computing" HPC-UA 2013 (Ukraine, Kyiv, October 7-11, 2013), 148-155, [PDF](#).
7. Usage of IMP Science Gateway for Molecular Dynamics Simulations of Various Metal-Organic Nanostructures, Computer Science and Information Technologies, CSIT 2013 (Armenia, Yerevan, September 23-27, 2013), 399-402, [color electronic version \(high quality\)](#); [black-white printed version \(low quality\)](#).
8. Application of the Science Gateway Portal on the Basis of WS-PGRADE Technology for Simulation of Aggregation Kinetics and Molecular Dynamics Simulations of Metal-Organic Nanostructure, International Workshop on Science Gateways (Zurich, Switzerland), 03-05 June, 2013, [PDF](#).
9. From Quantity To Quality: Massive Molecular Dynamics Simulation of Nanostructures under Plastic Deformation in Desktop and Service Grid Distributed Computing Infrastructure, Computer Science, 14, No.1 (2013) DOI: [10.7494/csci.2013.14.1.27](https://doi.org/10.7494/csci.2013.14.1.27).
10. Application of Desktop Grid Technology in Material Science, Proc. of 5th International Conference "Distributed Computing and Grid-technologies in Science and Education" GRID'2012 (Dubna, Russia) pp.123-129, [color electronic version \(high quality\)](#); [black-white printed version \(low quality\)](#).

Example 1:

SLinCA@Home IMP Desktop Grid

size: small (even nano)

history: short (2009-2014-...)

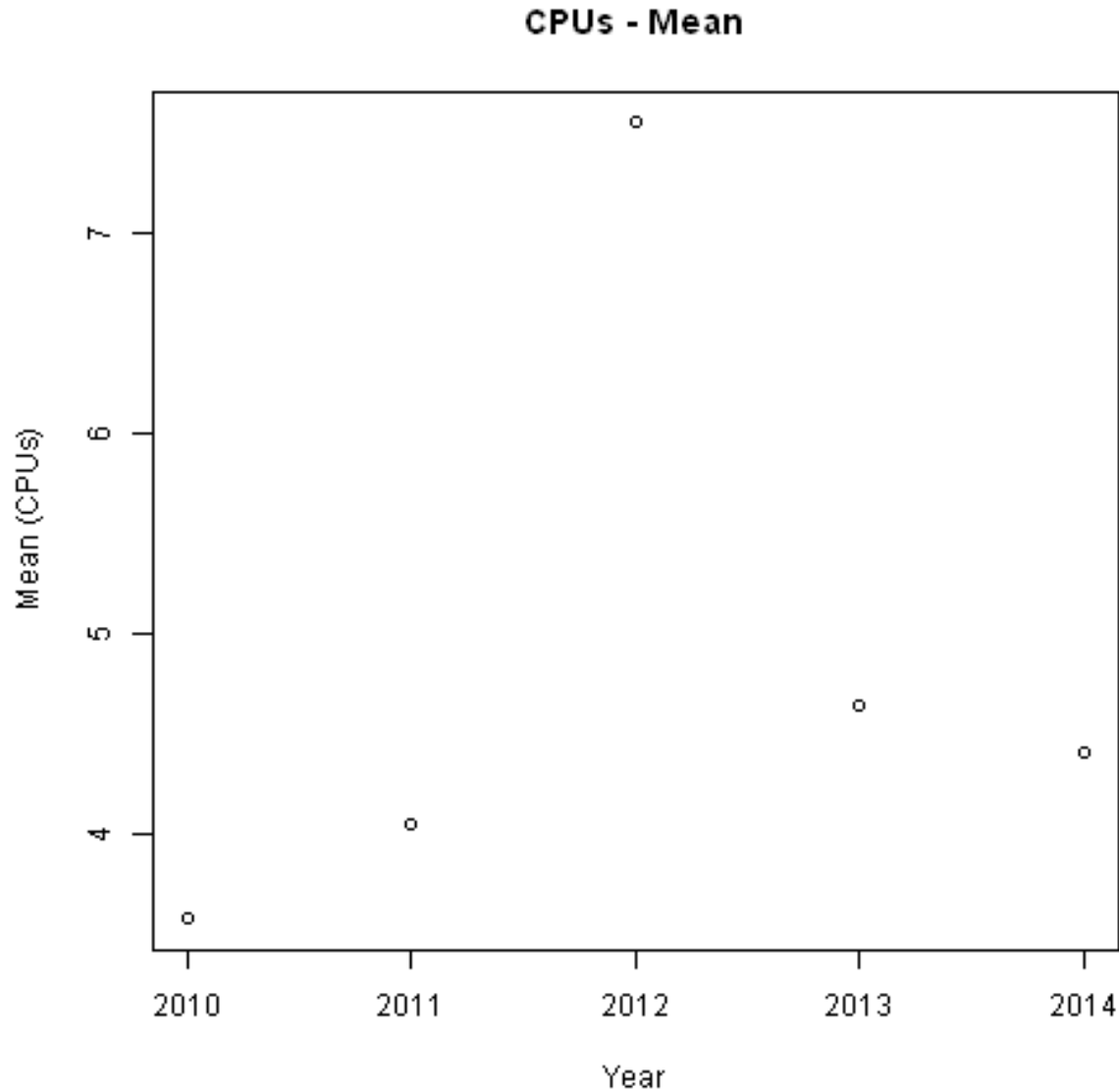
hosts: CPU

Let's measure

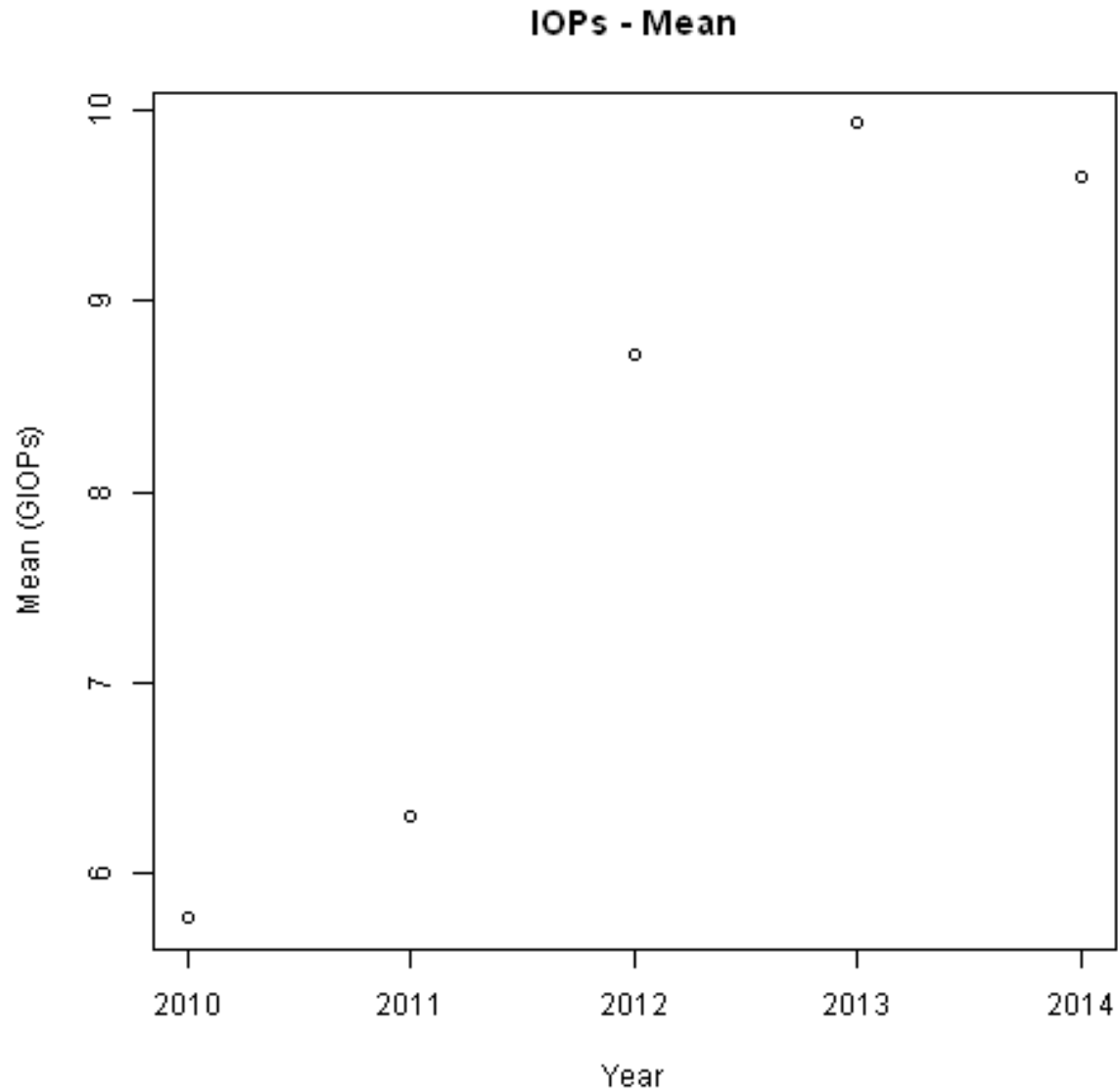
its averaged (per host)

performance characteristics...

IMP SLinCA@Home DG - CPUs/host

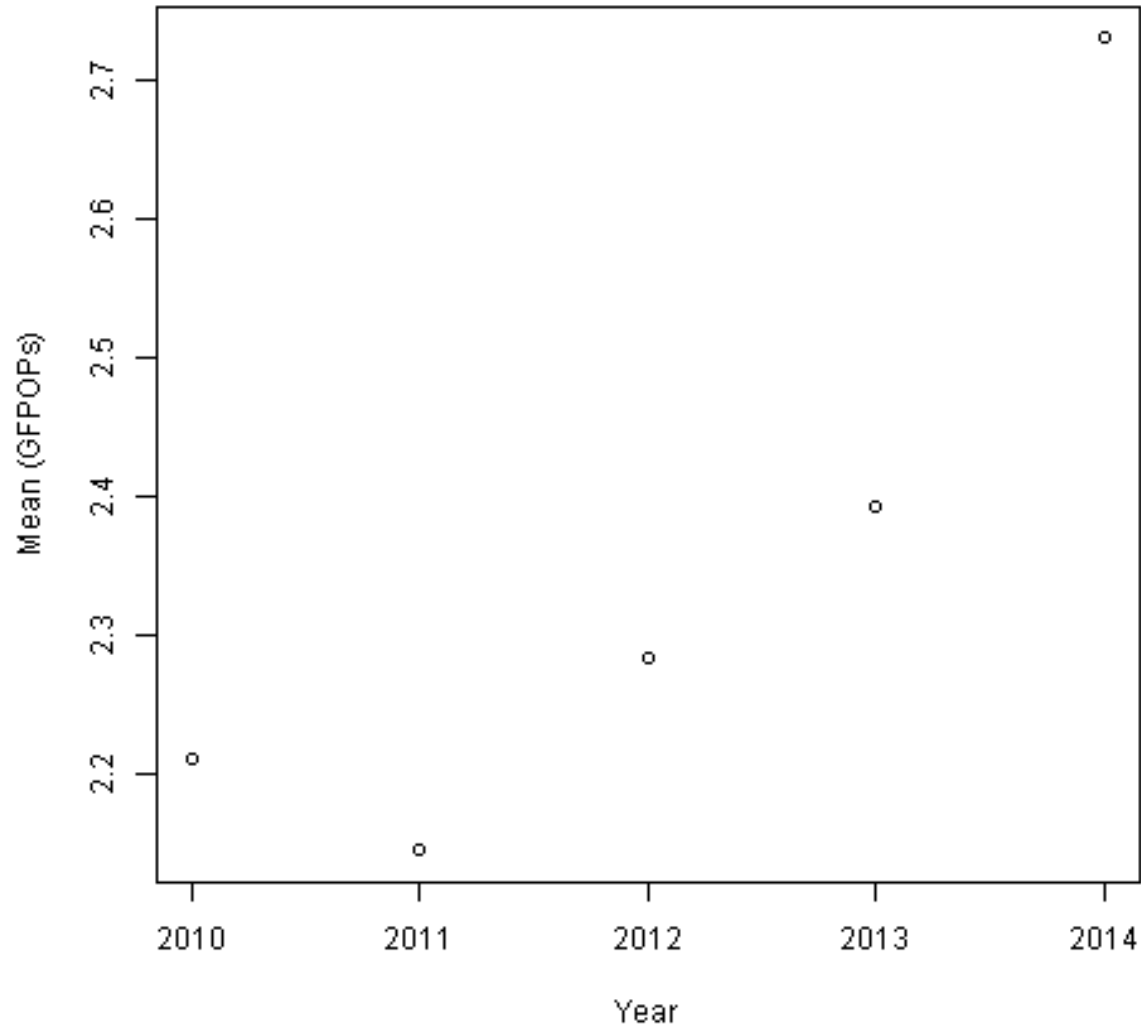


IMP DG - Performance - IOPs

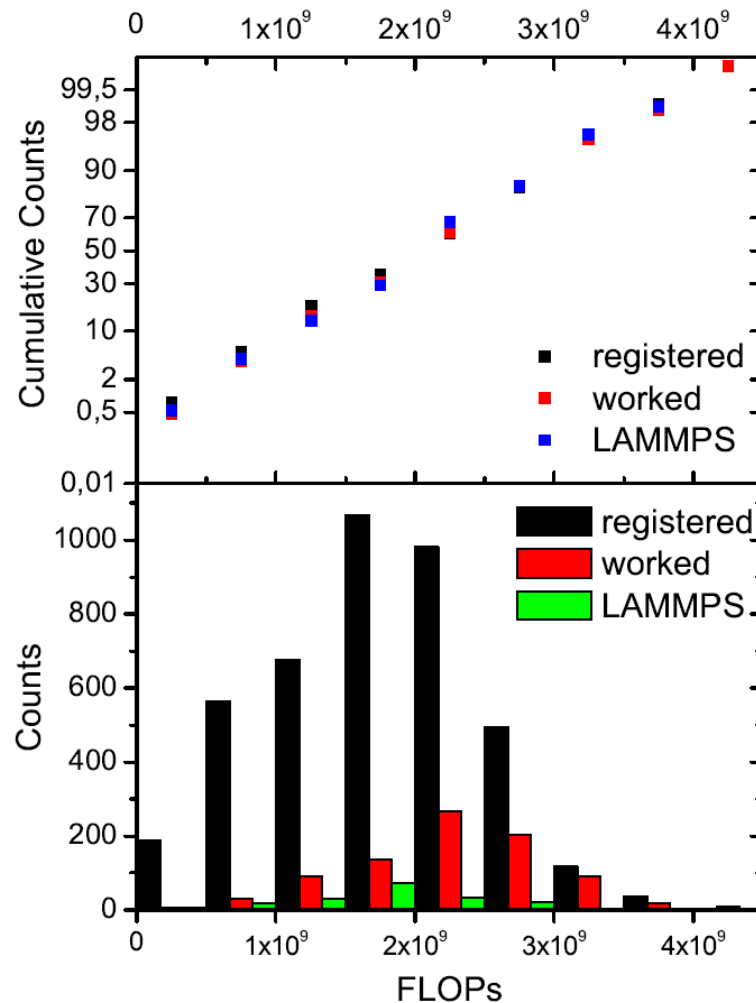


IMP DG - Performance - FLOPs

FPOPs - Mean



Distribution of Performances



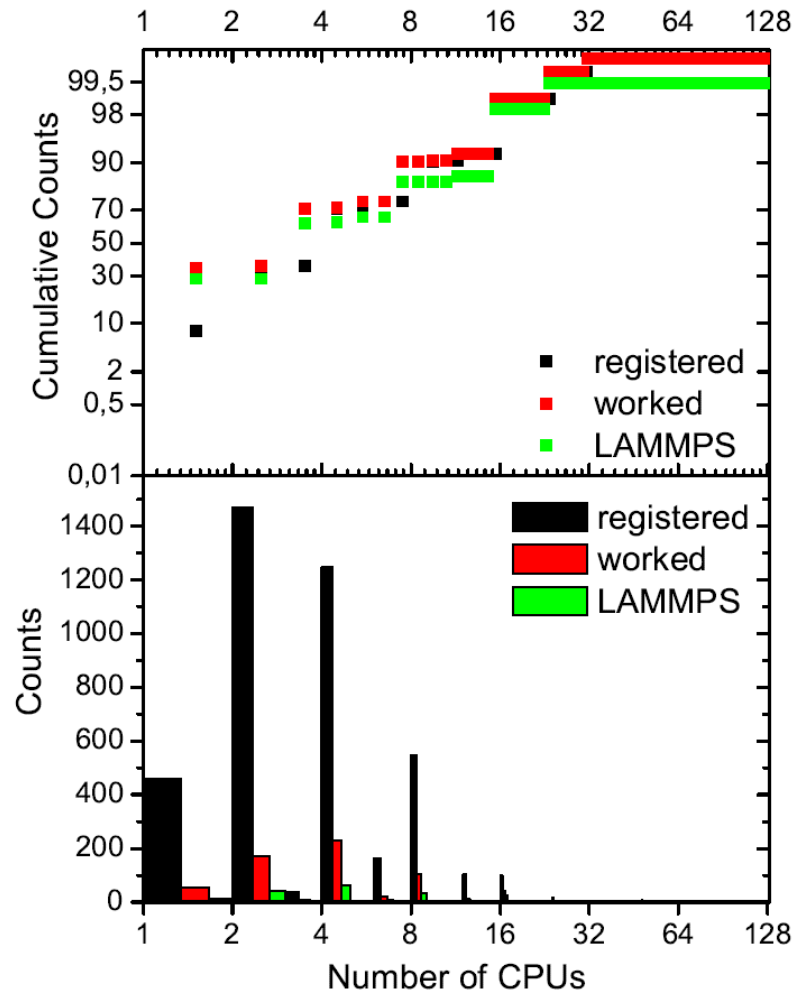
It seems to be **normal**,
BUT
it is more close to **Weibull!**

And Weibull was observed
also at Ibercivis BOINC project

From private communication  with Alejandro Rivero (in 2012), manager of Volunteer Computing at Ibercivis (2007 to 2011)

Floating Point Operations Per second (FPOPs) in linear-probabilistic coordinates among the registered hosts (black), the worked hosts (red), and the hosts used for LAMMPS-application (green)

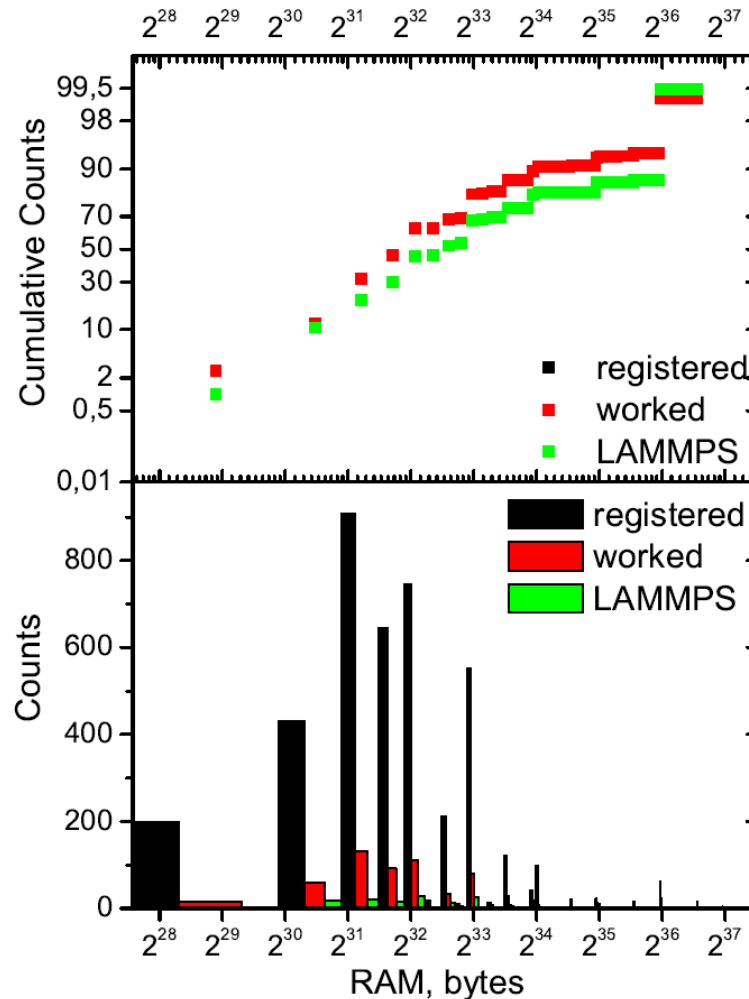
Distribution of CPUs per Host



It seems to be **log-normal**

CPUs per host in the logarithmic-probabilistic coordinates (right) among the registered hosts (black), the worked hosts (red), and the hosts used for LAMMPS-application (green)

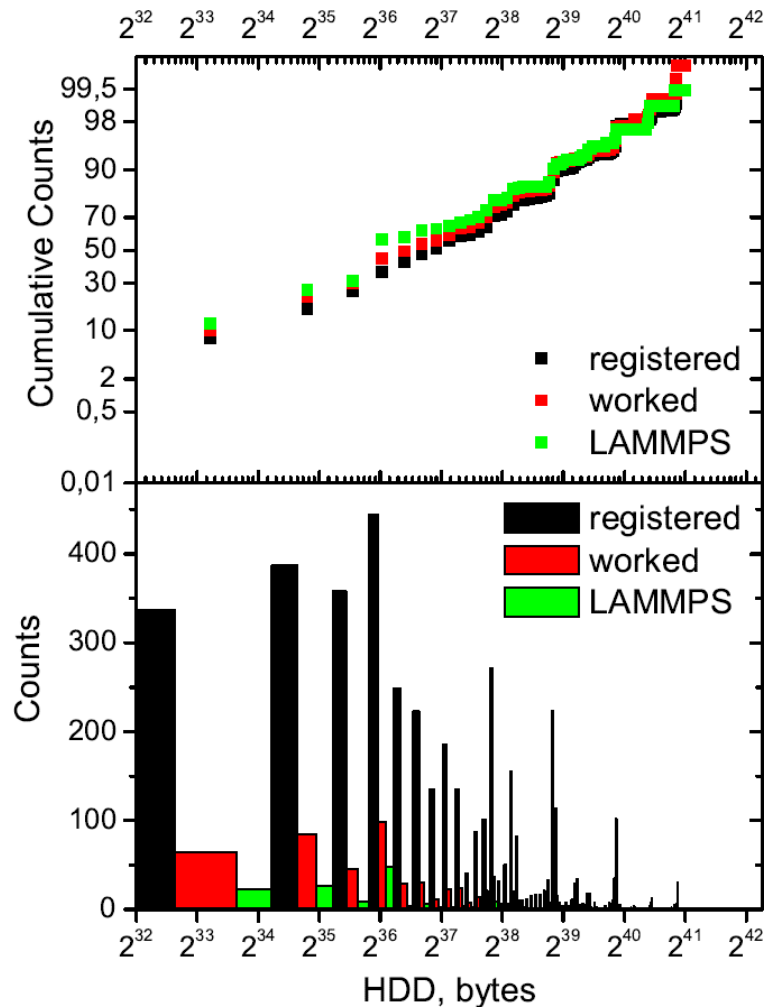
Distribution of RAM sizes



It seems to be **log-normal**...
at least for low values

RAM sizes for the registered hosts
(black), the worked hosts (red), and the hosts used for LAMMPS-application (green)

Distribution of HDD sizes



It seems to be **log-normal...**
at least for low values

HDD sizes for the registered hosts

(black), the worked hosts (red), and the hosts used for LAMMPS-application (green)

Example 2: SZTAKE Desktop Grid

size: large,
history: long,
hosts: CPU

SZTAKI Desktop Grid



Number of users: **126538** Number of hosts: **105221**
Estimated performance of last 48 hours: **1333.382 GFlop/s**
Peak performance: **3.4 TFlop/s**

Proud participant of 

International Desktop Grid Federation

Supported by IDGF-SP

<http://desktopgridfederation.org>

About SZTAKI Desktop Grid

SZTAKI Desktop Grid is operated by the [Laboratory of Parallel and Distributed Systems](#) at the [Hungarian Academy of Sciences](#), Budapest, Hungary.

The SZTAKI Desktop Grid and its applications are partly supported by the ongoing [IDGF-SP](#) project. The work leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° RI-312297. The experts of the [International Desktop Grid Federation](#) provide further support for the SZTAKI Desktop Grid infrastructure, its applications, and its integration into the [European Grid Infrastructure](#).

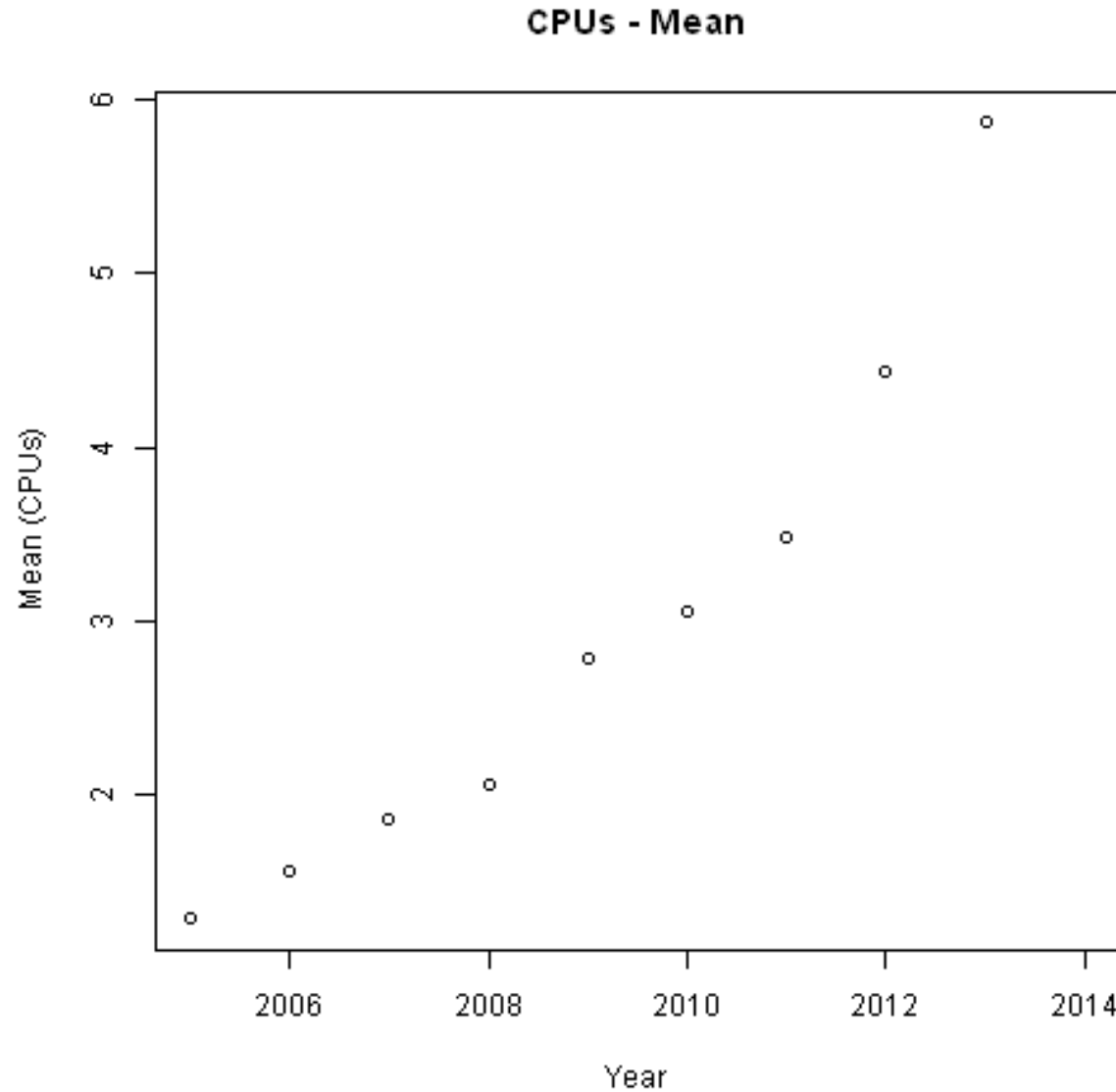
Join SZTAKI Desktop Grid

Applications being run by SZTAKI Desktop Grid

Application	Field	Information	Launch	Results
Zeta-Search	Mathematics	Описание	Nov, 2013	Results
KOPI beta	Linguistics	Description (EN), Description (HU)	Sep, 2011	
BinSys	Mathematics	Description (EN), Description (HU)	Jun, 2005	Results
UC-Explorer	Physics	Описание	Feb, 2009	

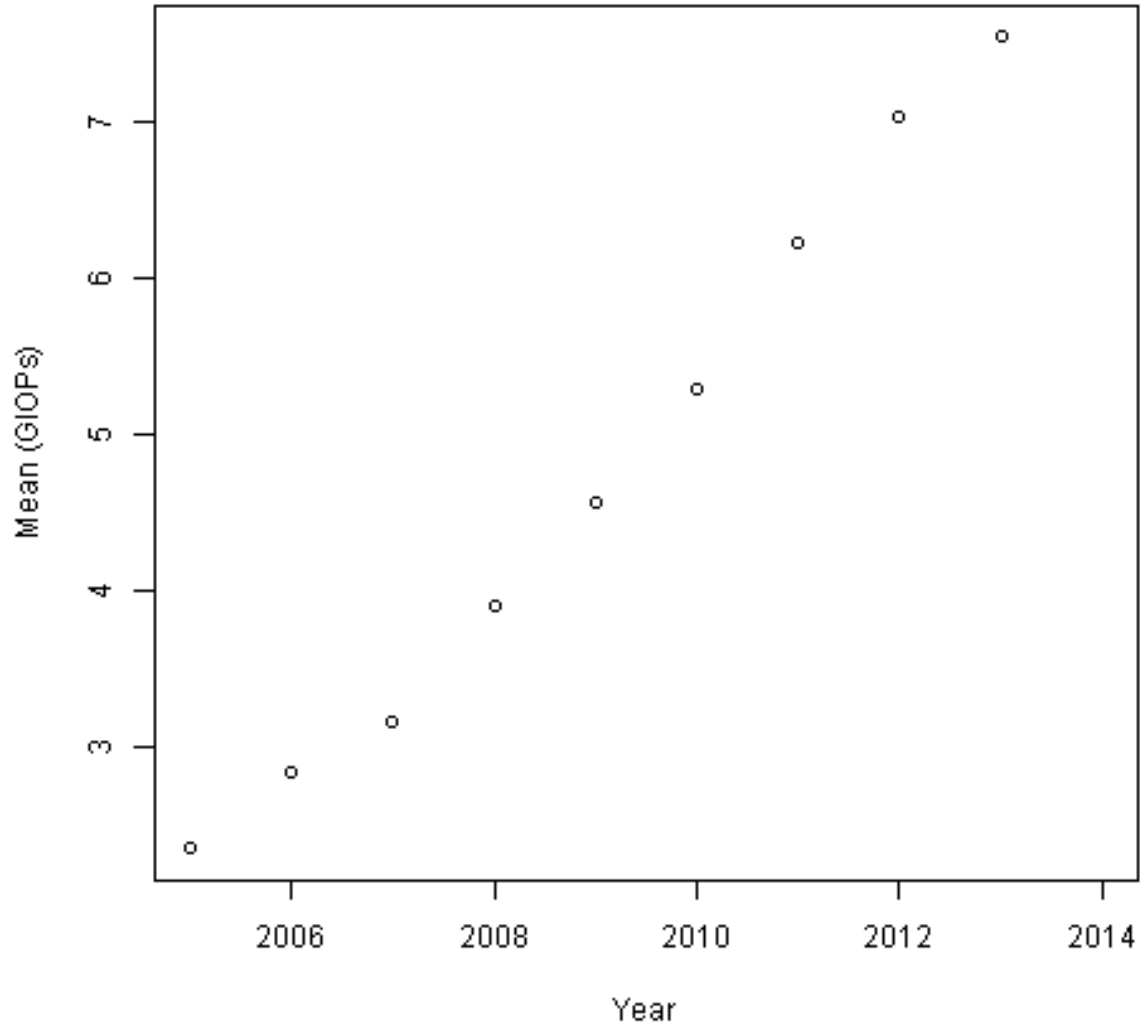
<http://szdg.lpds.sztaki.hu/szdg/>

SZTAKI DG - CPUs/host

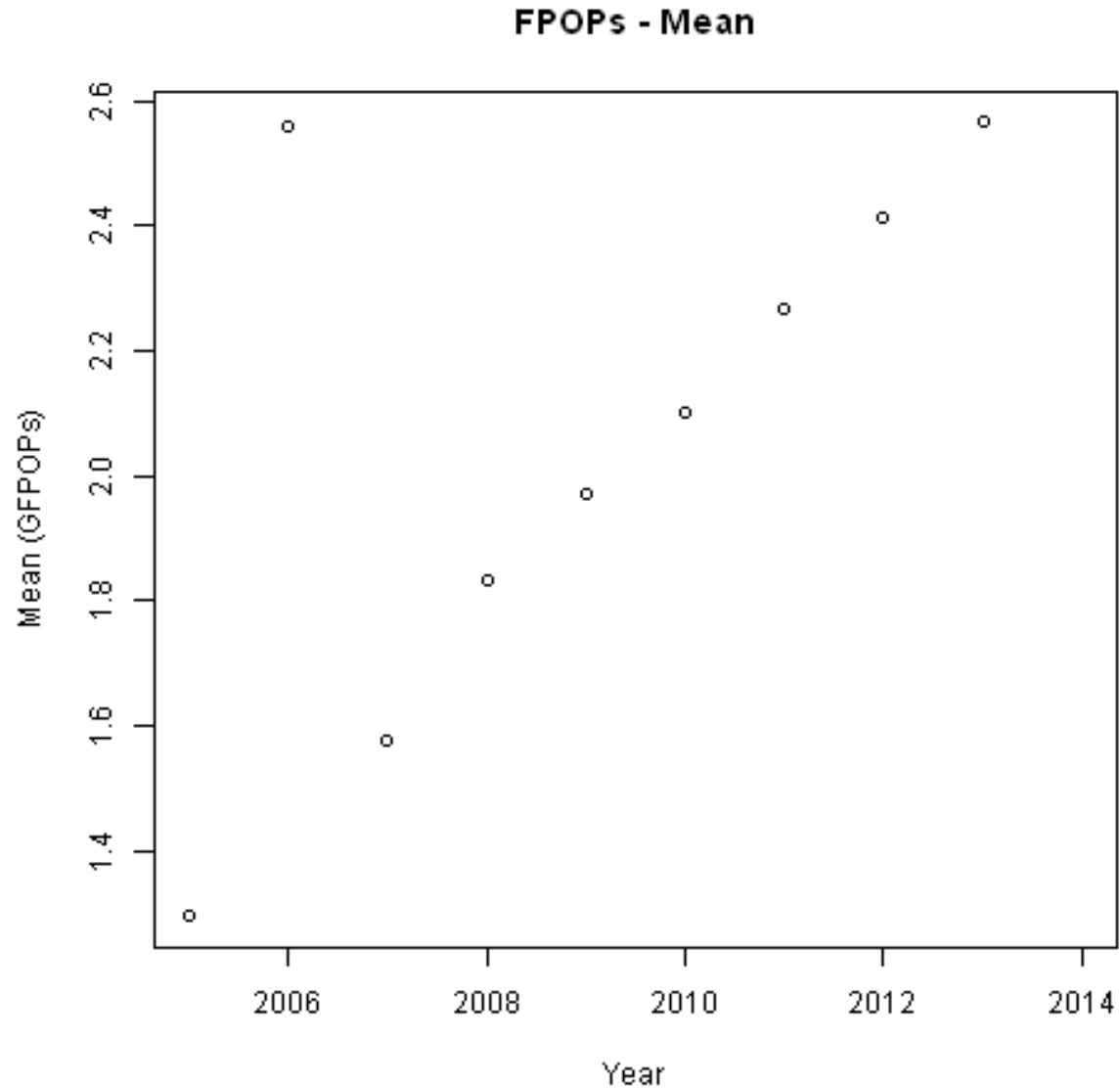


SZTAKI DG - Performance - IOPs

IOPs - Mean



SZTAKI DG - Performance - FLOPs



Example 3: Ibercivis Desktop Grid

size: large,
history: long,
hosts: CPU

Ibercivis

ibercivis

News

Join

Participants ▾

Сообщество ▾

Sign in


Ibercivis boinc

Ibercivis is a research project that uses Internet-connected computers to do research in physics, material science and biomedicine.

You can participate by downloading and running a free program on your computer.

Ibercivis is based at several institutes and universities, like Zaragoza, CETA-CIEMAT, CSIC, Coimbra. More info about the different projects at:

[Ibercivis main page](#)

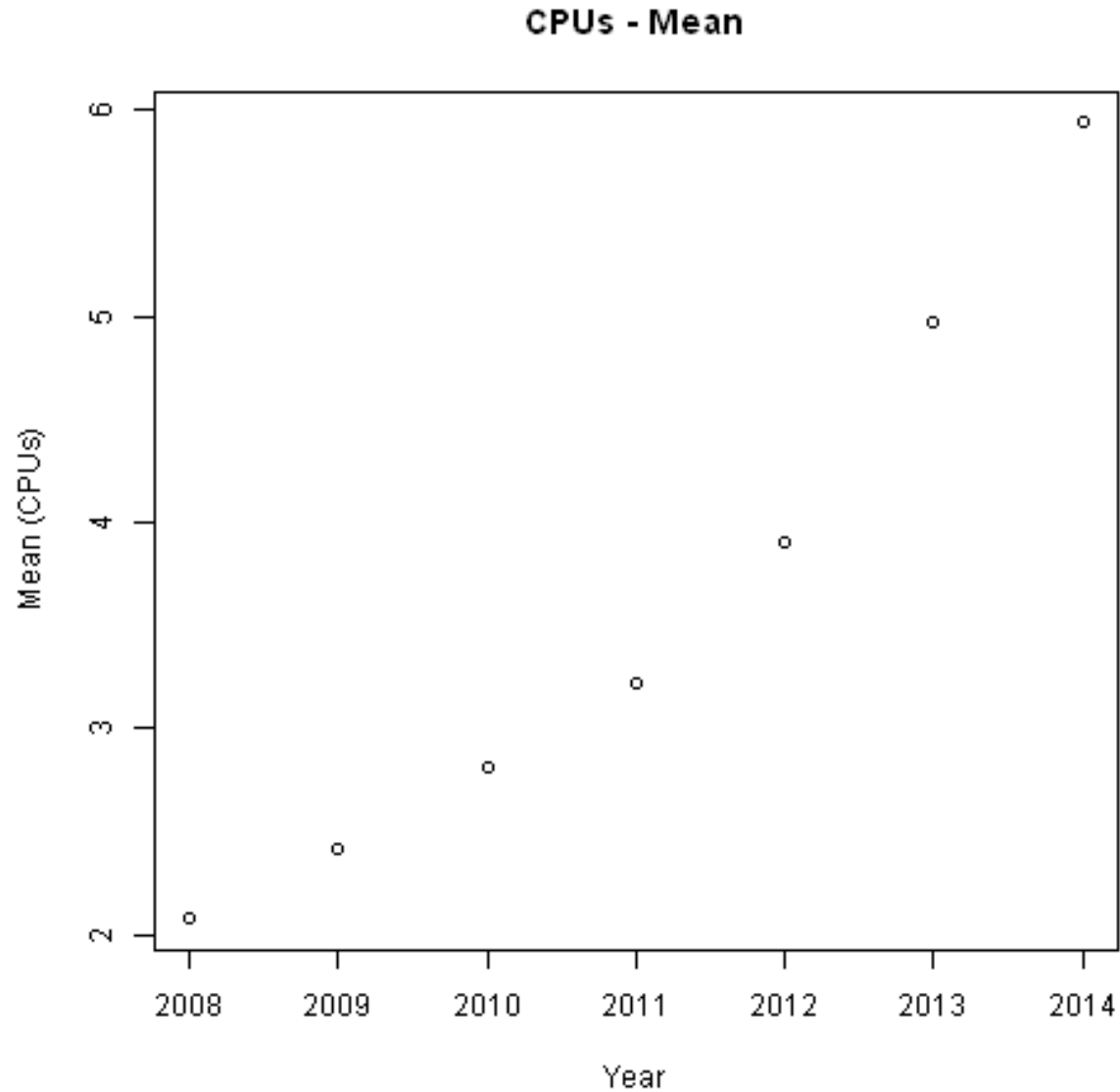


Biosoft

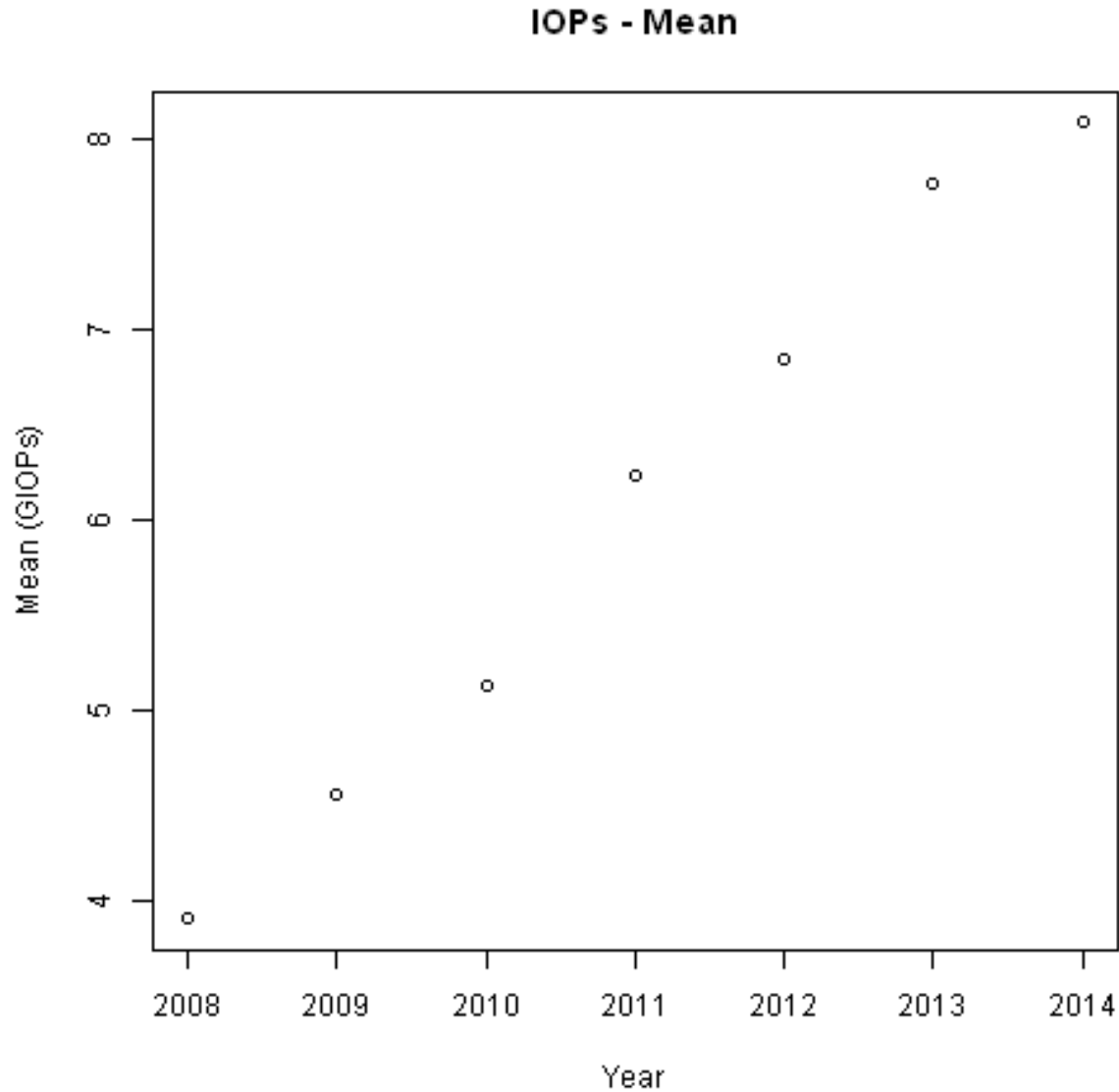
Se pretende generar modelos tridimensionales válidos para reproducir y predecir los comportamientos reales en la degradación de fibras poliméricas nanométricas que encierran algunos fármacos.

<http://registro.ibercivis.es/>

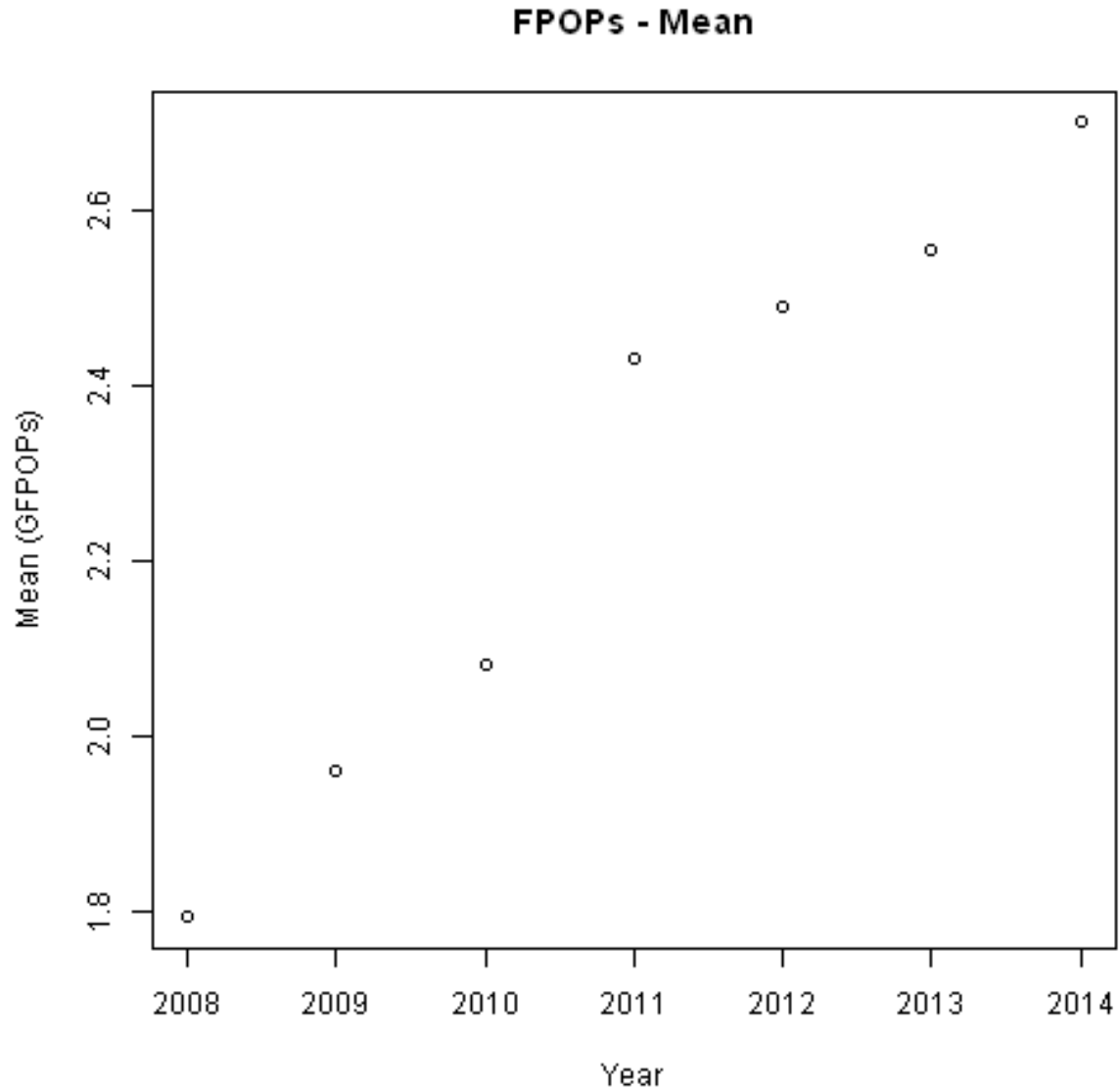
Ibercivis - CPUs/host



Ibercivis - Performance - IOPs



Ibercivis - Performance - **FLOPs**



Example 4: EDGeS Desktop Grid

size: medium,
history: short,
hosts: CPU

EDGeS



Project Performance:

Number of users: **36764**

Number of hosts: **28911**

Estimated performance of last 48 hours: **1257.723 GFlop/s**

About EDGeS@Home

The aim of the EDGeS@Home project is to support the execution of selected and validated scientific applications developed by the [IDGF](#) and [EGI](#) communities.

This umbrella BOINC project supports several communities with applications: [AutoDock](#) - Molecular docking simulations used by Chemists/Biologists, [Biome - BGC](#) and [Biome-BGC](#) [MuSo](#) is executed by scientists from [BIOVEL](#), [Riemann Zeta](#) Research application supports the work of [mathematicians from ELTE](#), [GBAC](#) is used by the [WeNMR](#) community. DSP is used for functional testing.

The EDGeS@Home Desktop Grid and its applications are partly supported by the ongoing [IDGF-SP](#) project. The work leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-

Join EDGeS@Home

- [Прочтите наши правила и политику](#)
- This project uses BOINC. If you're already running BOINC, select Attach to F If not, [download BOINC](#).
- When prompted, enter **<http://home.edges-grid.eu/home/>**
- If you're running a command-line or pre-5.0 version of BOINC, [create an acc](#) first.
- If you have any problems, [get help here](#).

Proud participant of



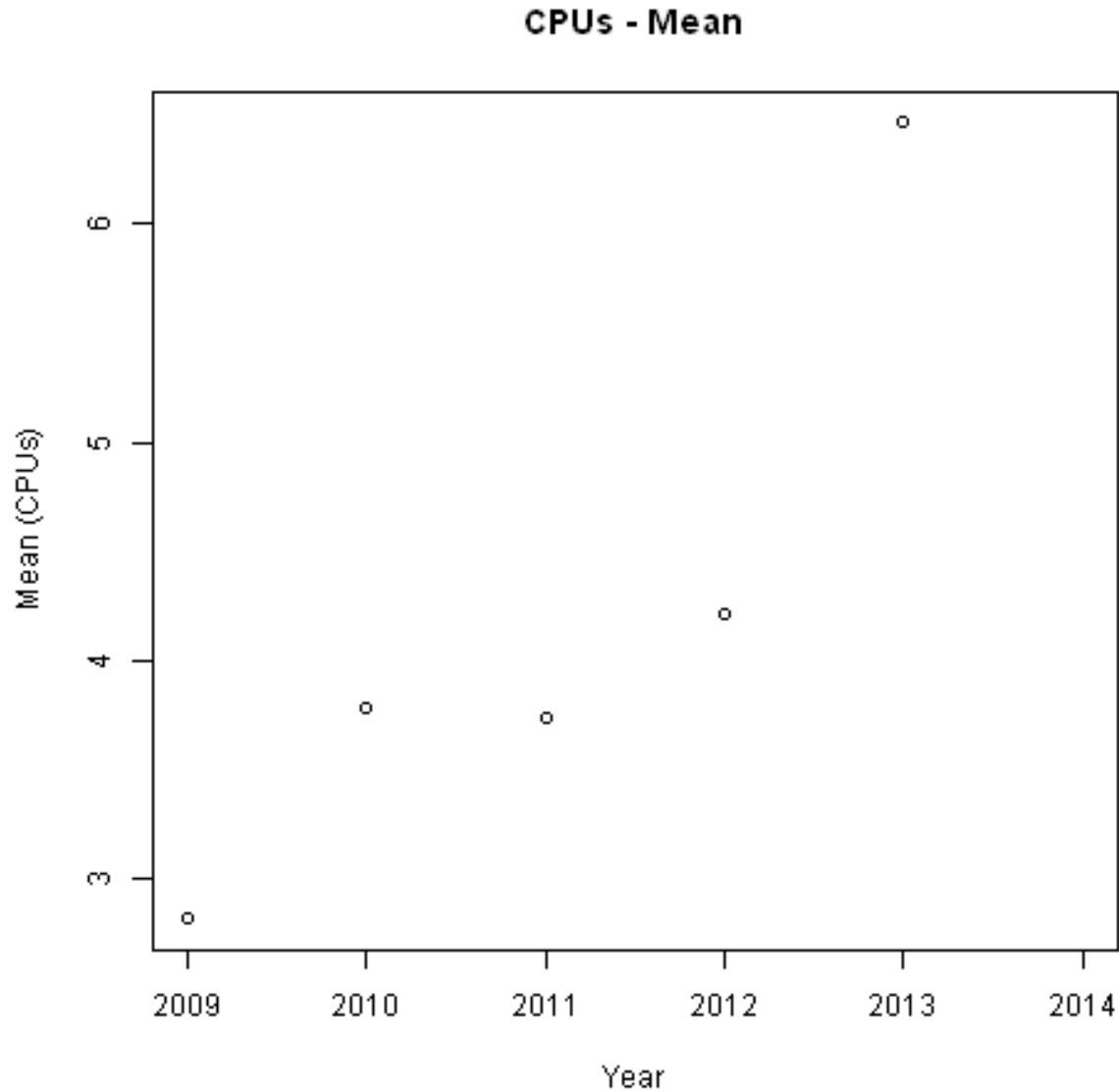
International Desktop Grid Federation

Supported by IDGF-SP

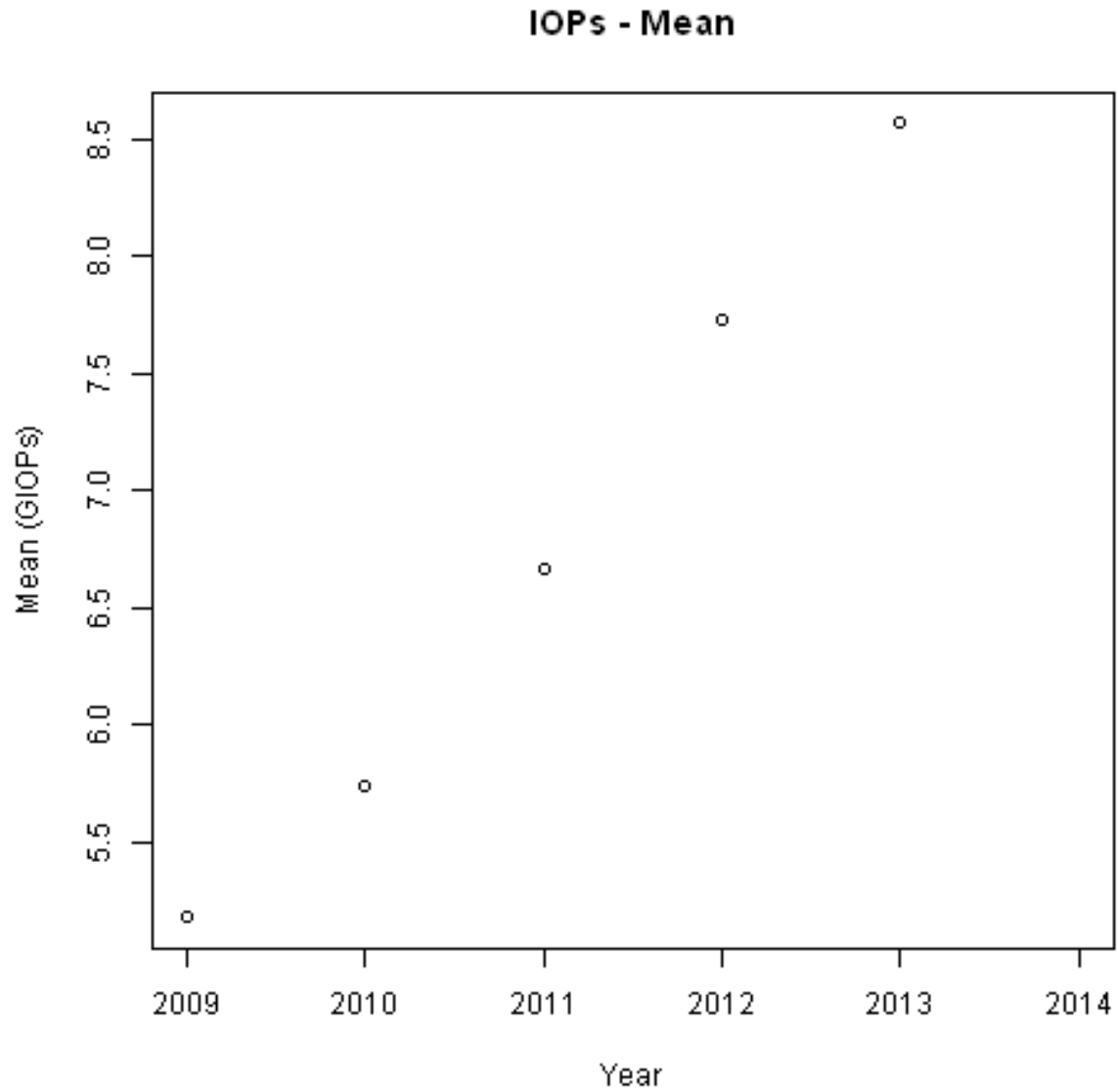
<http://desktopgridfederation.org>

<http://home.edges-grid.eu/home/>

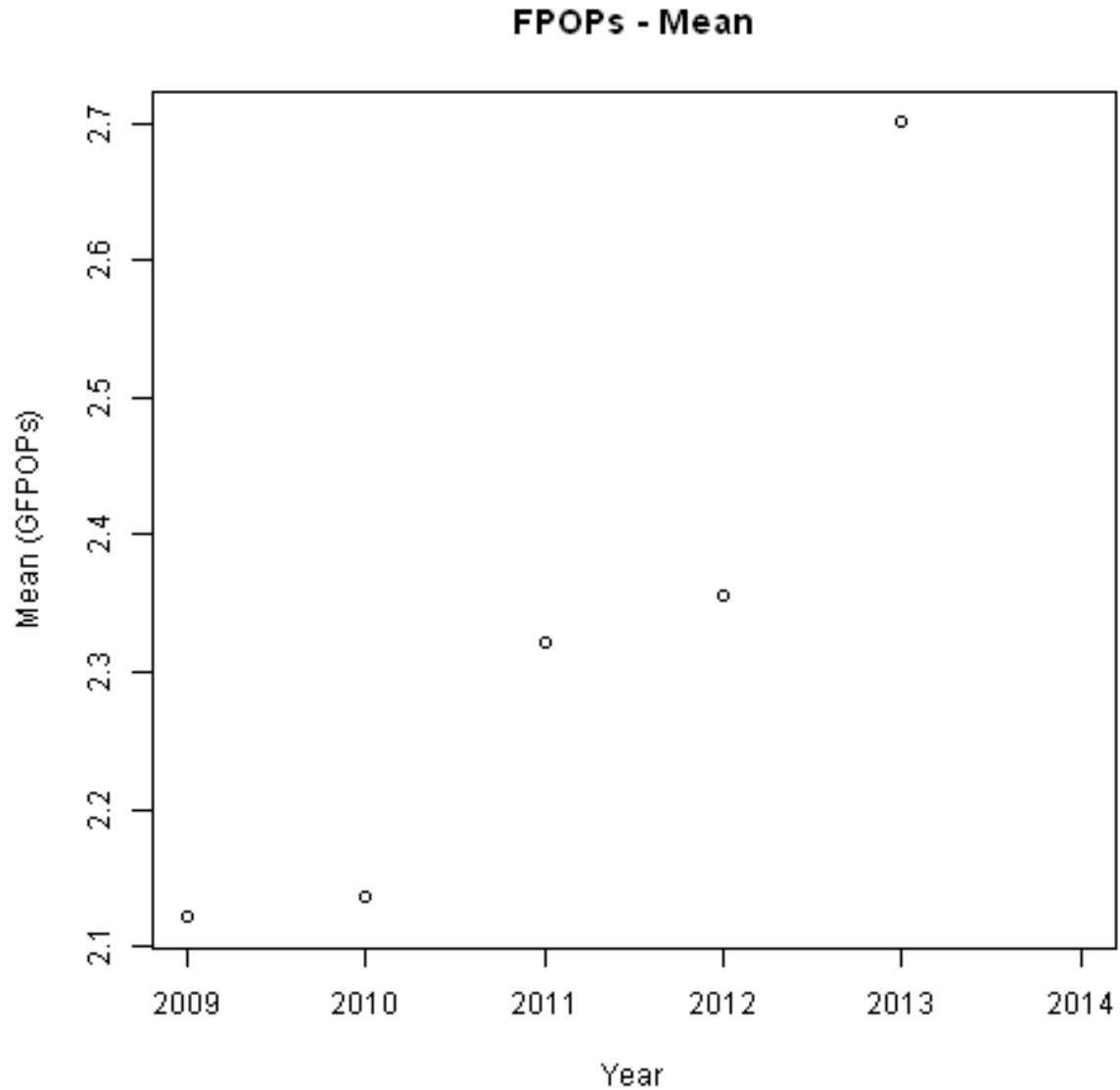
EDGeS DG - CPUs/host



EDGeS DG - Performance - IOPs



EDGeS DG - Performance - FLOPs



Example 5: GPUGRID

size: medium,
history: medium,
hosts: GPU

GPUGRID

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GPUGRID.net

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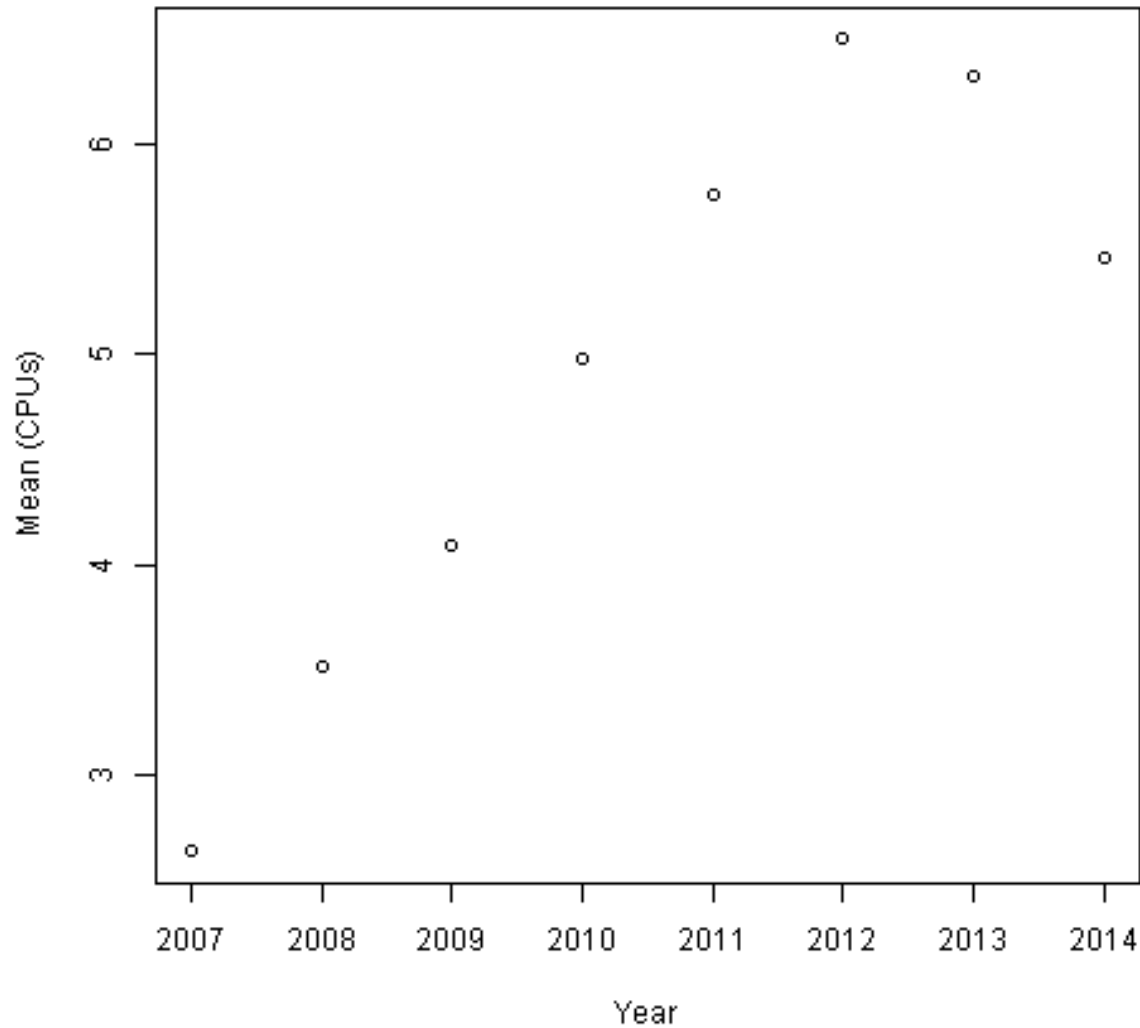
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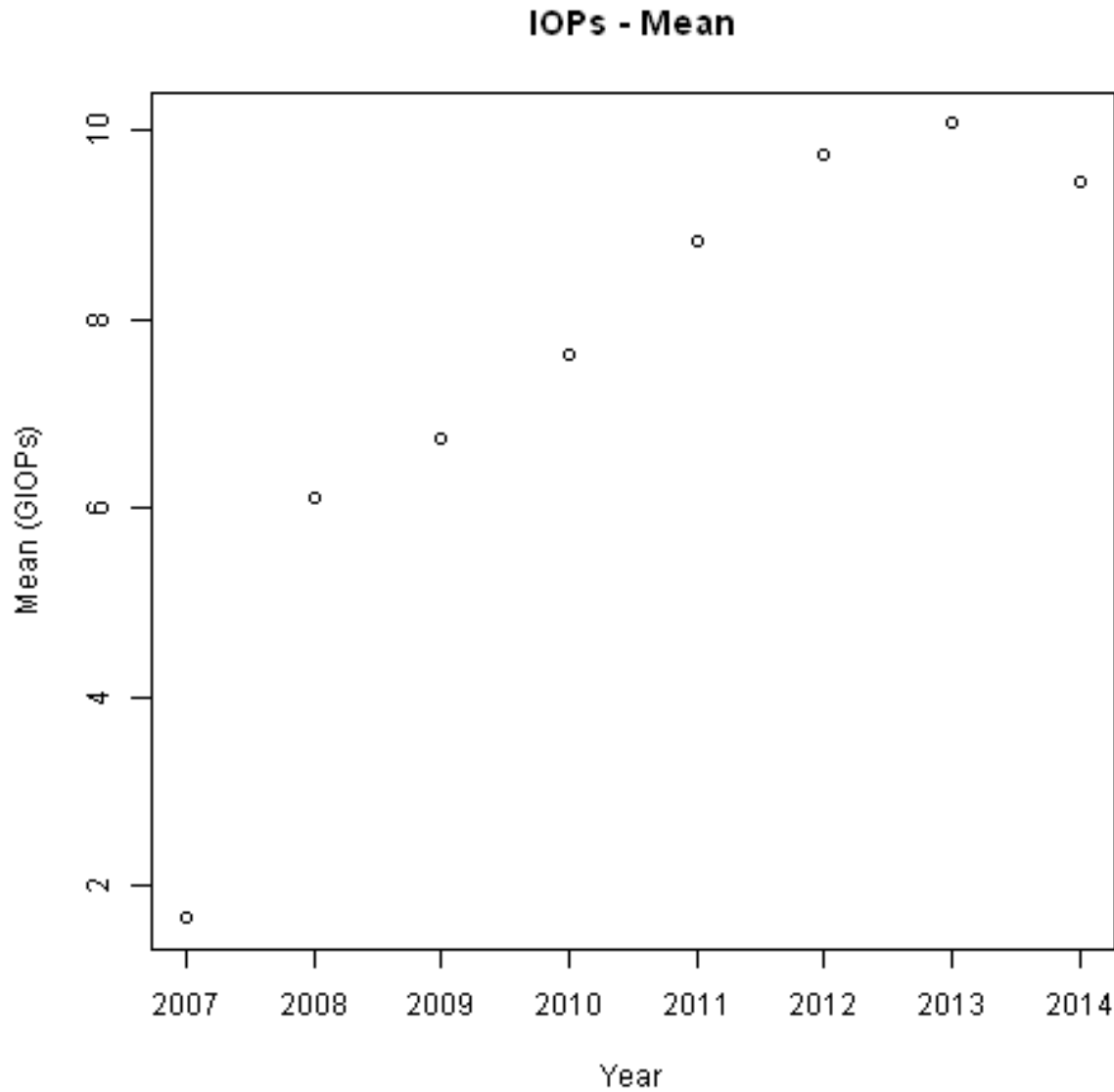
<http://www.gpugrid.net/>

GPUGRID - CPUs/host

CPUs - Mean

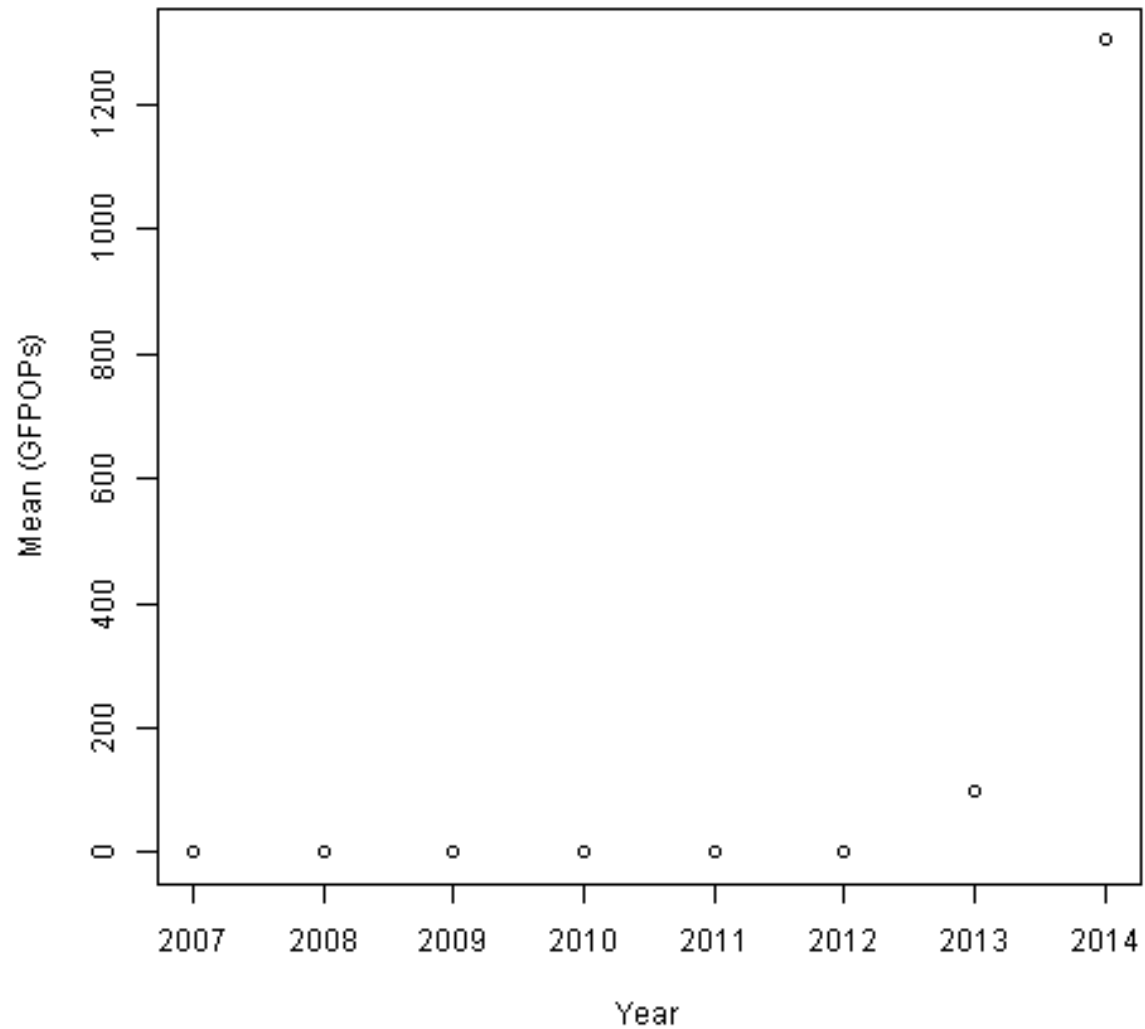


GPUGRID - Performance - IOPs



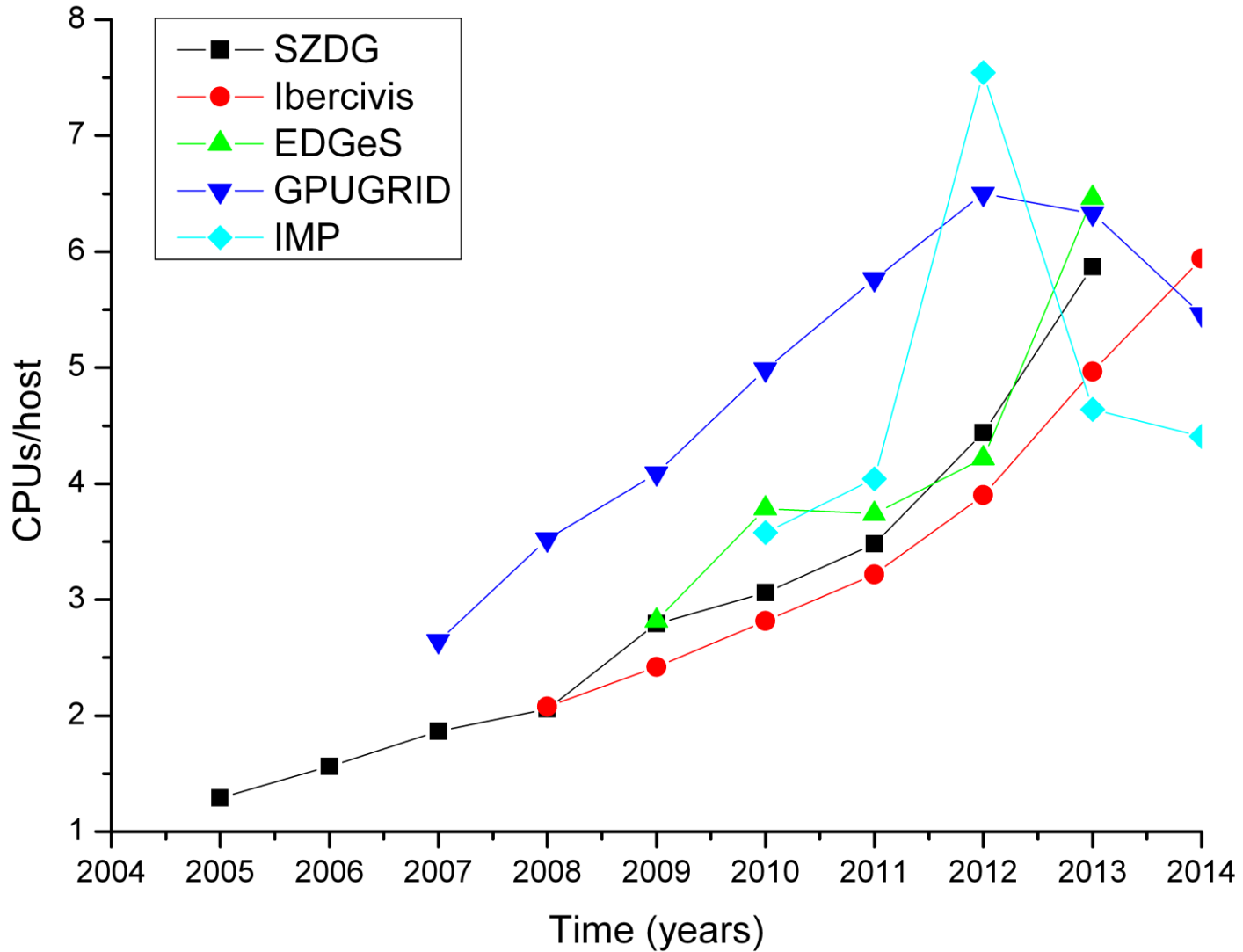
GPUGRID - Performance - FLOPs

FPOPs - Mean

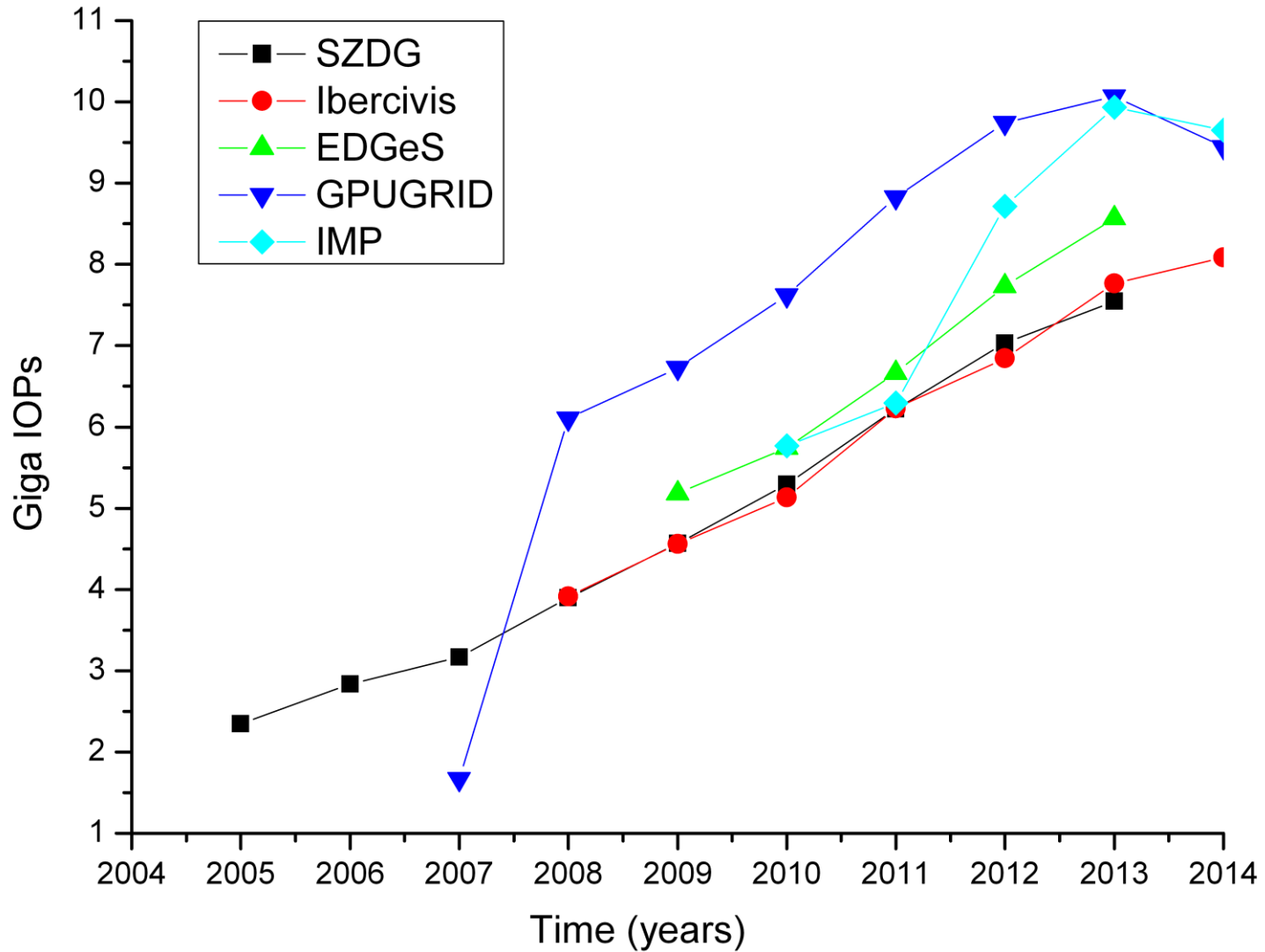


Summary
as to the examples

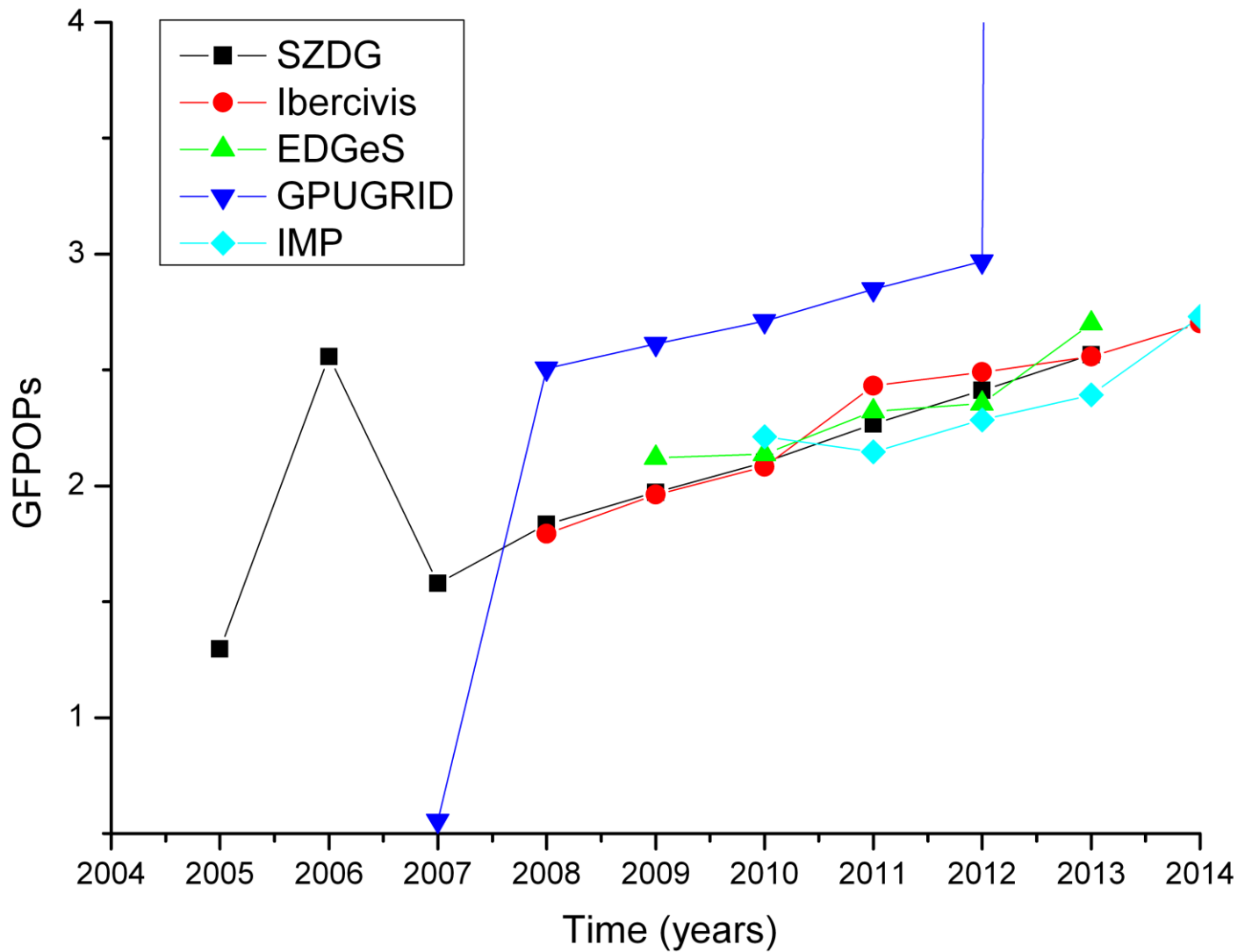
CPUs/host



IOPs



FLOPs



Progress of FPOPs and IOPs

FPOPS:

Community	Increase	Time Range	Speedup
SZDG	1,27	8	0,159
EDGeS	0,58	4	0,145
Ibercivis	0,91	6	0,152
GPUGRID	0,46	4	0,115

MEAN: 0,14±0,02 (GFPOPs/year)

IOPS:

Community	Increase	Time Range	Speedup
SZDG	5,2	8	0,65
EDGeS	3,36	4	0,84
Ibercivis	4,17	6	0,695
GPUGRID	3,96	5	0,792

MEAN: 0,74±0,09 (GFPOPs/year)

Summary on Progress of Computing Power in BOINC Projects

- Several BOINC **projects of different kinds** (big-small, long-short, CPU-GPU, geography) **demonstrate the similar progress** of CPUs/host, FPOPs, IOPs, therefore they can be considered as some subsets of the global PC computing community.
- The **longest** (>6 years) and **largest** (>10000 hosts) **BOINC projects are very similar** in these aspects and **can be considered as “statistically representative samples”**
- The **actual increase of global computing power** (in IOPS/FPOPs) **averaged over communities is very slow** (0,74/0,14 per year) in comparison to Moore’s law (2x each 2 years)
- This metrics – let’s title it like **BOINC Law** (or **Anderson’s ☺ Law**) - can be considered as extension of Moore’s Law (?)

BUT

- **These results are previous and should be confirmed by future ...**

Future Actions – **other (much bigger) communities**

- e.g. ABC (big size >160 MB)

...

then go to

...

- WCG (huge size >2.5 GB)
- SETI (biggest size >4 GB, longest history >11 years)
- LHC (biggest hype, because of Higgs bozon)...

Future Actions – It should be **better (much deeper) analysis**

To take into account:

- actually **working** hosts,
- host subsets **for some applications** (low sense, but it can be interesting for load balancing, planning, scaling, ...),
- **weights** on credits earned (if it has sense?)
- “finer-grain” time series (from **years to months** and weeks?)

Future Actions – **other (much wider) metrics**

- Higher moment (2nd – std, 3rd – skewness, 4th - kurtosis, ...) analysis,
- Bootstrapping analysis,
 - Scaling analysis
 - ...



Thank you
for your attention!