Laboratoire d'Informatique Parallélisme Réseaux Algorithmique Distribuée

UNIVERSITÉ DE VERSAILLES ST-QUENTIN-EN-YVELINES

université PARIS-SACLAY

MAISON DE LA SIMULATION

STATUS OF PAST AND PRESENT COLLABORATIONS; INTRODUCTION TO THE GOAL OF THE WORKSHOP

Nahid.Emad@uvsq.fr

France-Japan-Germany workshop on the Convergence of HPC and Data Science for Future Extreme Scale Intelligent Applications

French Embassy at Tokyo, Japan (6-8 November 2019)

SPPEXA

Convergence of Big Data Analysis, HPC and Applications

*The Fourth Science Paradigm: **Data-Intensive Scientific Discovery**, Tony Hey, Stewart Tansley, Kristin Tolle, Published by Microsoft Research, Oct. 2009, ISBN: 978-0-9825442-0-4*

- Data production is faster than compute capabilities
- Need of extreme scale systems for data-intensive analytics
- Classical simulations are no more the main HPC applications
- Prediction of any kind of events become important requiring more intelligent applications
- The methodology is often based on linear algebra tools

The objective of the workshop is in this context and more specifically to take advantage of combining HPC and data science for proposing extreme scale intelligent applications

OUTLINE

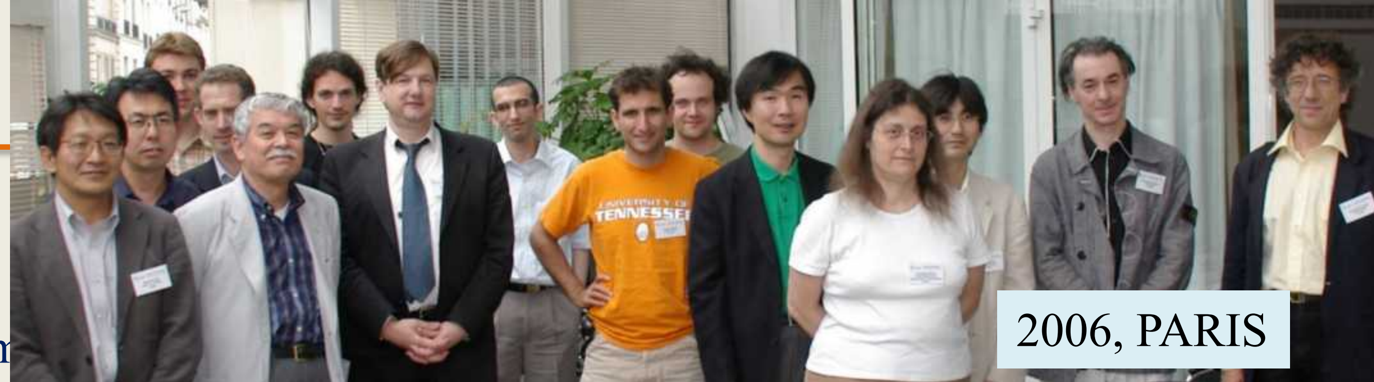
- Past and present collaborations
- Goal of the workshop : HPC & Data Science for extreme intelligent applications
  - Some data-intensive application challenges
  - Programming models and frameworks for high scale computing
- Concluding remarks

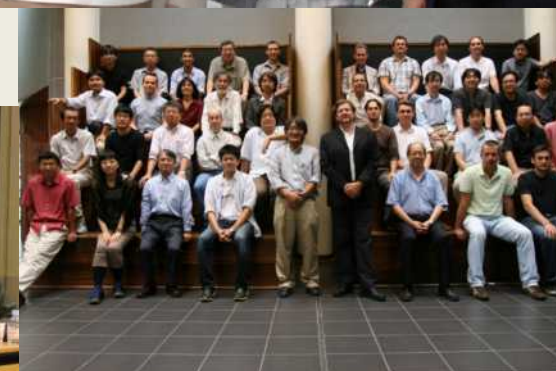
OUTLINE

- Past and present collaborations
- Goal of the workshop : HPC & Data Science for extreme intelligent applications
  - Some data-intensive application challenges
  - Programming models and frameworks for high scale computing
- Concluding remarks

Japanese-French collaboration

Since more that **13 years** several research teams from France, Japan and Germany work together on GRID/P2P computing, Data, HPC, Linear Algebra Applications,…..





2009-2010

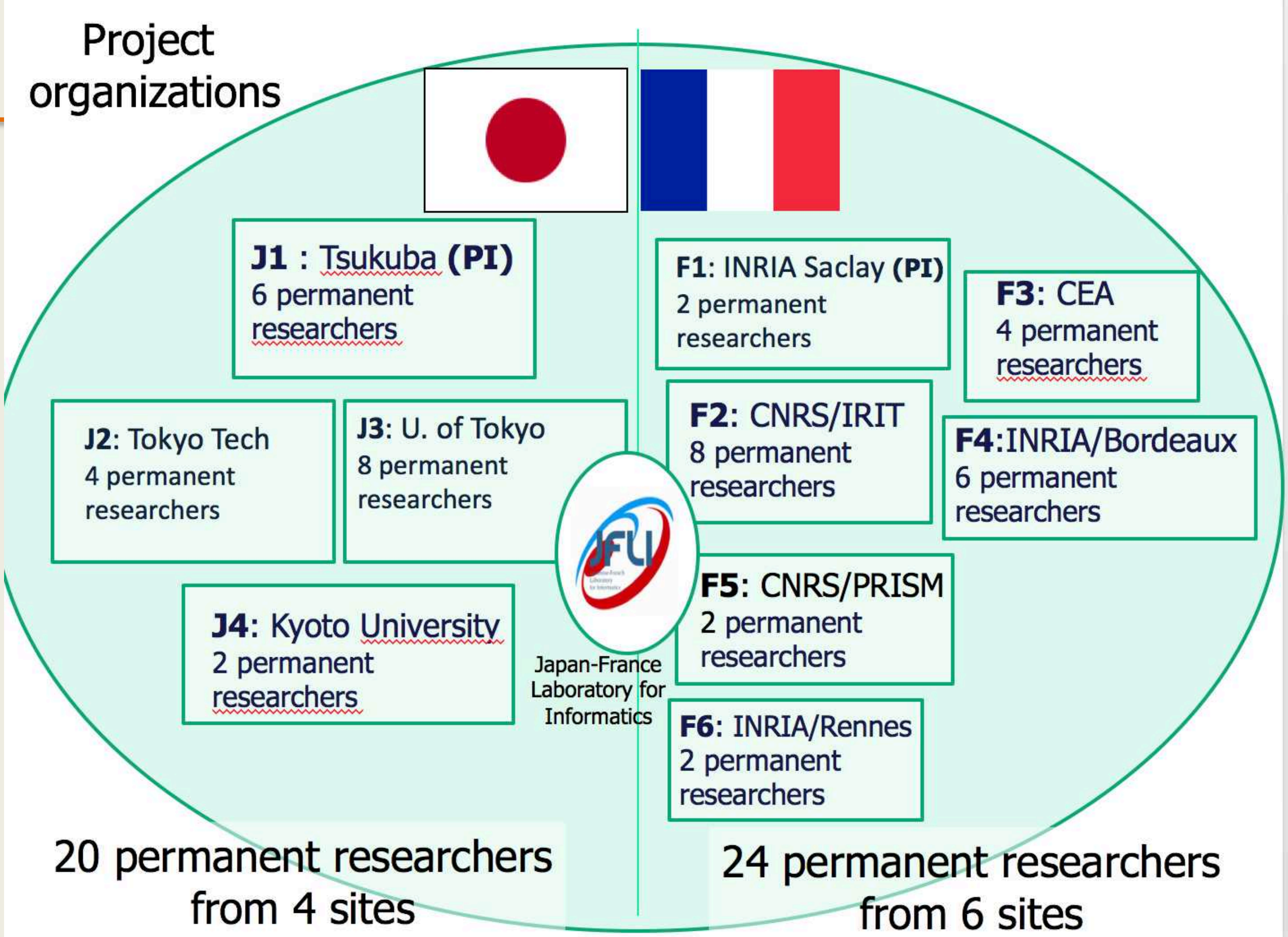
FP3C

AGENCE NATIONALE DE LA RECHERCHE ANR

INFORMATION AND COMMUNICATION TECHNOLOGIES

JST 科学技術振興機構 Japan Science and Technology Agency

ANR-JST FP3C

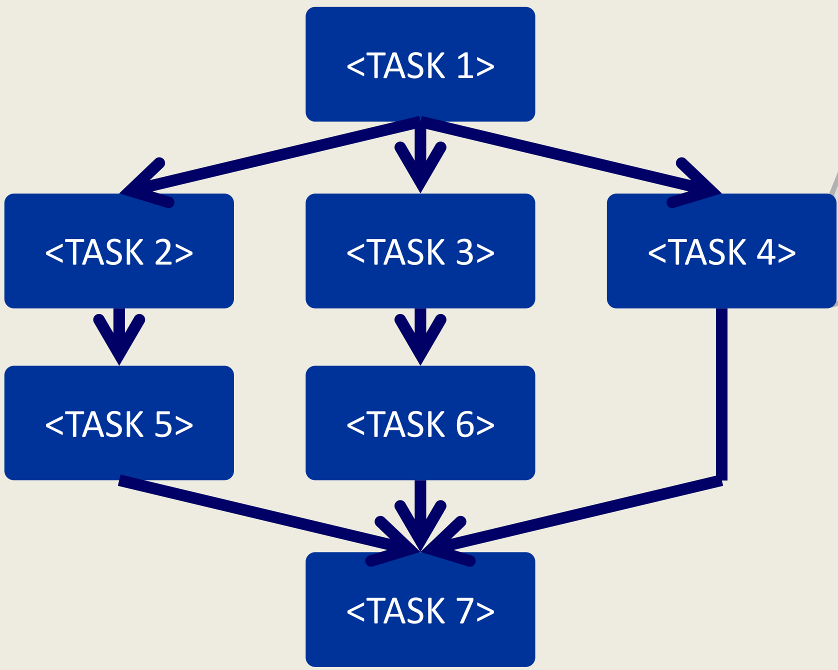


44 permanent researchers

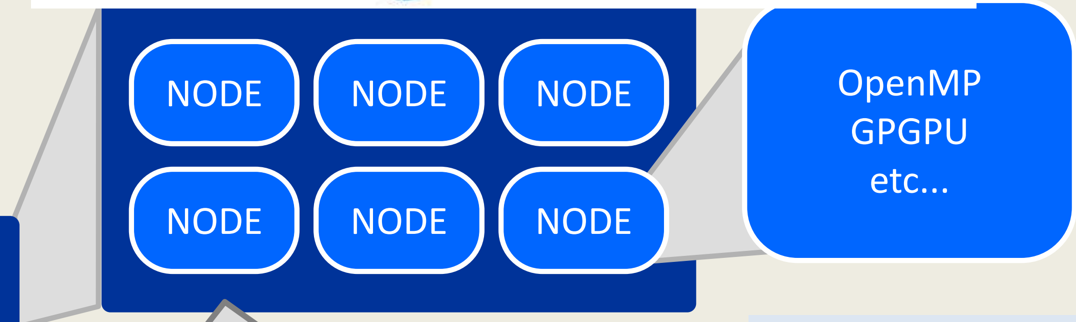
Multi-Level Parallelism
Integration: YML-XMP-StarPU

FP3C Group

N dimension graphs available



YML provides a workflow programming environment and high level graph description language called YvetteML



StarPu on each processor

```
for(i=0;i<n;i++){
    for(j=0;j<n;j++){
        tmp[i][j]=0.0;
#pragma xmp loop (k) on t(k)
            for(k=0;k<n;k++){
                tmp[i][j]+=(m1[i][k]*m2[k][j]);
}}}
#pragma xmp reduction (+:tmp)
```

Each task is a parallel program over several nodes.
XMP language can be used to descript parallel program easily!

On T2K, and on several computers in Japan and France for YML-XMP

Several financial supports :

- INRIA international team
- CNRS-JST (Michel's talk?)
- ANR-JST.
- JFLI (CNRS long term visits)
- French-Japanese college
- Others fellowships
- CEA/RIKEN (Sato & Boillod,'s talk)

MOU between AICS-RIKEN and CNRS

MOU between RIKEN and Maison de la Simulation / University of Paris Saclay
MOU between RIKEN and CRISTAL Laboratory / University of Lille

Since 4 years : German-Japanese-French collaborations on HPC :
some projects supported by DFG, JST and ANR

SPPEXA

Several SPPEXA workshops in France (Versailles, Saclay), Germany (Aachen) and Japan (Tokyo)

The first German-Japanese-French workshop 3 years ago in the French Embassy demonstrates how it is important and successful to develop these collaborations

The second in Germain Embassy consolidated this collaboration and this one would propose future collaborations to develop extrem intelligent applications

S. Maximilien & G.Barraud's talk

SPPEXA Workshops (Tsukuba, Versailles, Aachen, Versailles)

MYX, ESSEX-II, DASH

SPPEXA

Hans-Joachim Bungartz's talk

FP3C AND MYX EXAMPLES

Within FP3C:

Multi-level programing by a combination of

- graph of tasks dependencies of applications (YML, …),
- PGAS model for coarse tasks (XMP, …),
- Scheduling policies (StarPU, …),
- Communications optimization with U&C methods (M/IRAM, Mlanczos, …)

YML/XMP/StarP/MPI/…

Within MYX:

- Application of MUST on YML, YML+XMP, …

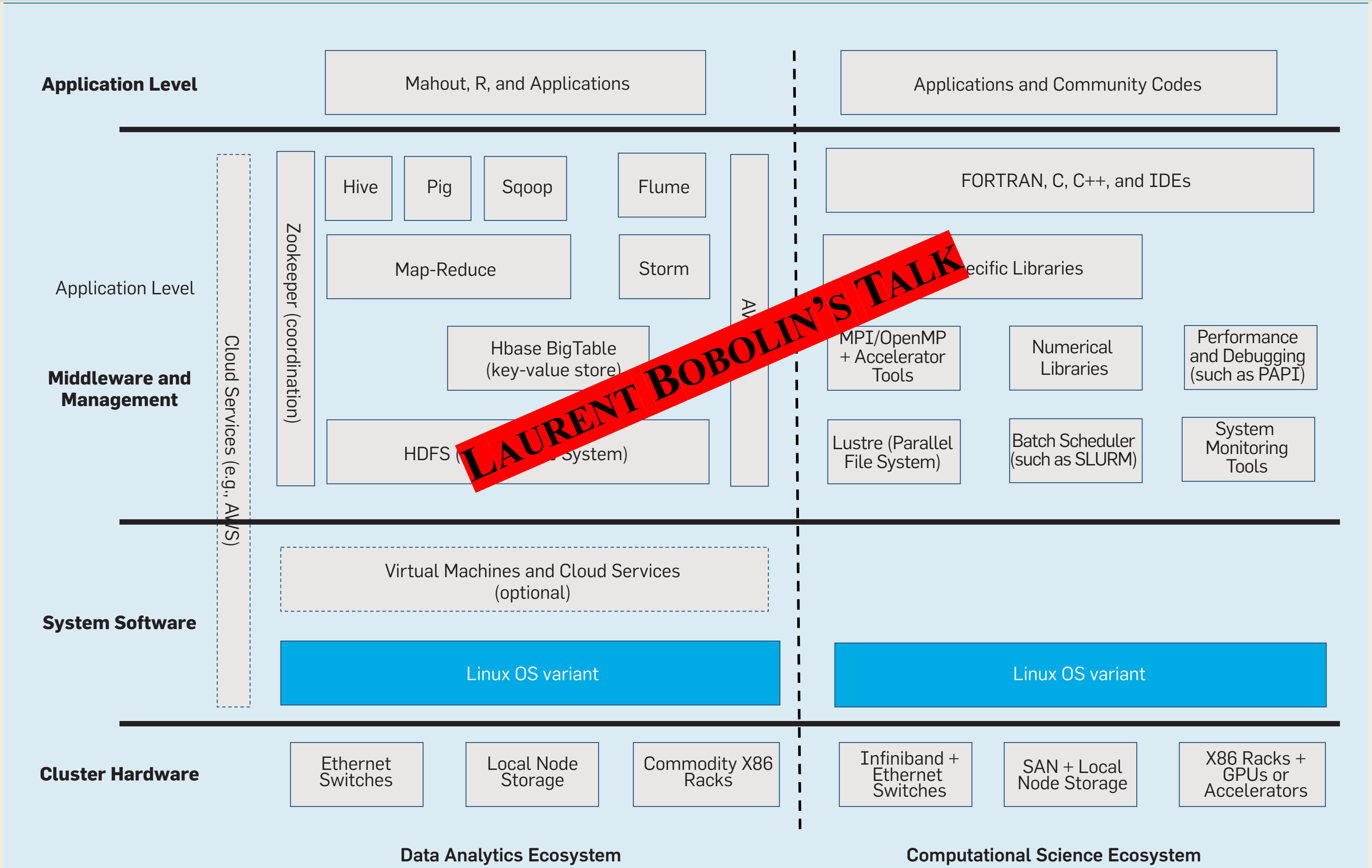
YML/XMP/MPI/MUST/…

Researches on HPC System Architecture/Middelware, Library and Framework Software, Extreme Scale Linear Algebra Computing

OUTLINE

- Past and present collaborations
- Goal of the workshop : HPC & Data Science for extreme intelligent applications
  - Some data-intensive application challenges
  - Programming models and frameworks for high scale computing
- Concluding remarks

BIG DATA ANALYSIS & HPC EVOLUTIONS

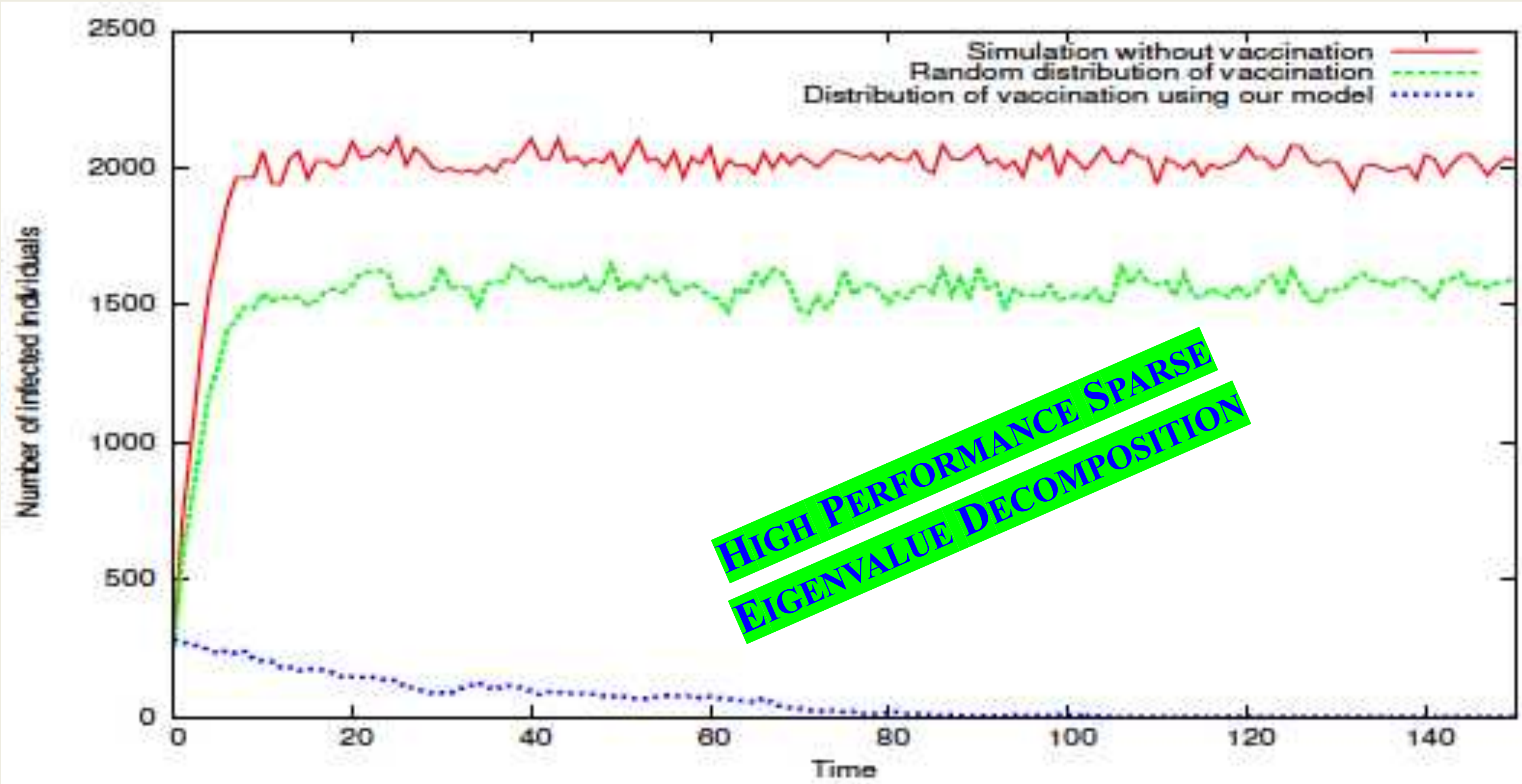


The tools and cultures of HPC and big data analytics diverged, to the detriment of both; unification is essential to address a spectrum of major research domains.

Exascale Computing and Big Data, D. A. Reed and J. Dongarra in Communication of the ACM, July **2015**, Vol 58, N°7.

Big data flu epidemic

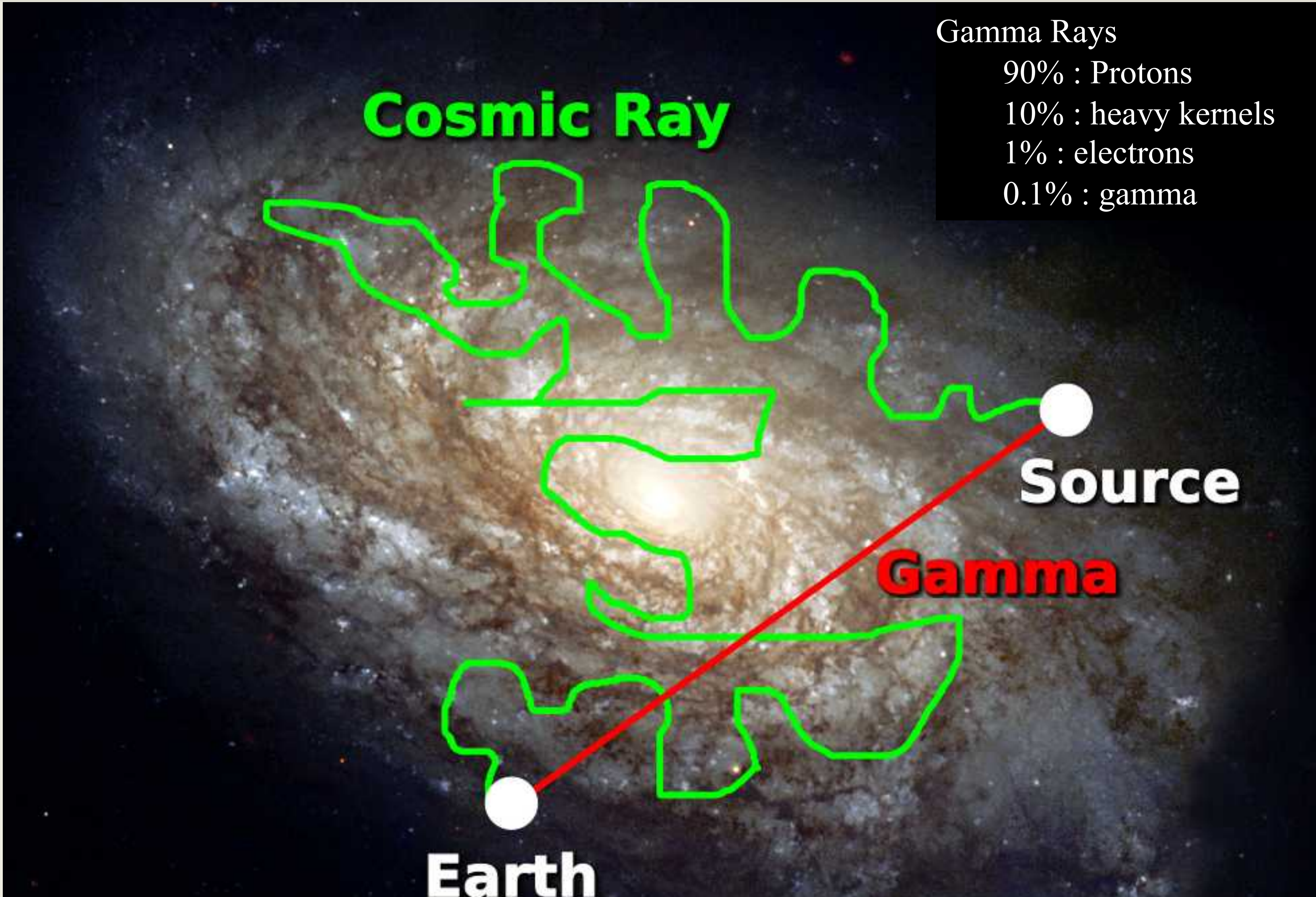
Stochastic simulation (Eigenvalue Decomposition of transition matrix)



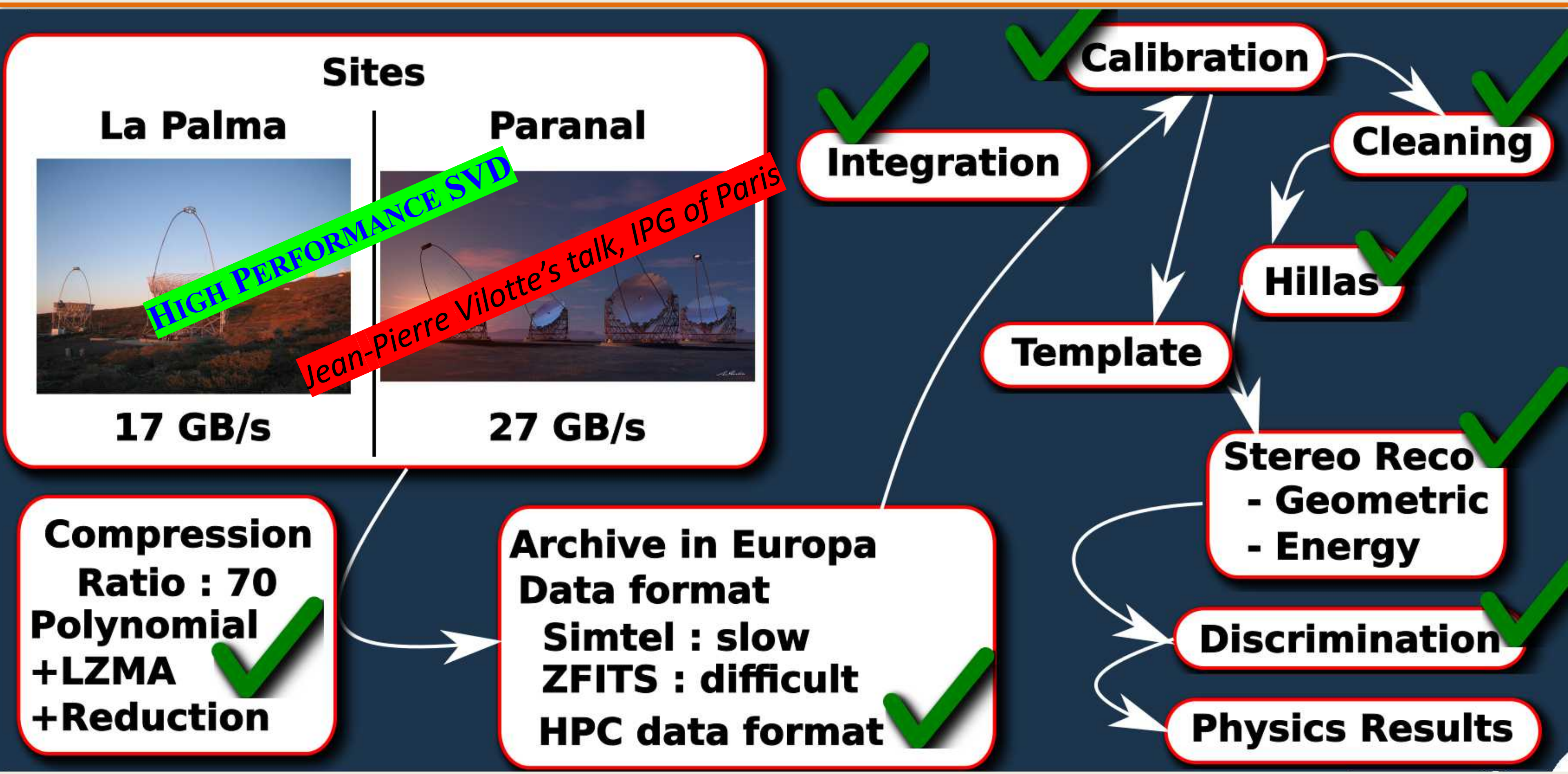
Z. Liu, N. Emad, S. Ben Amor, M. Lamure. PageRank Computation Using a Multiple Implicitly Restarted Arnoldi Method for Modeling Epidemic Spread. International Journal of Parallel Programming, 43(6) :1028–1053, 2015.

BIG DATA APPLICATION: GAMMA RAY DETECTION

Gamma Rays
- 90% : Protons
- 10% : heavy kernels
- 1% : electrons
- 0.1% : gamma



Big data application: Gamma ray detection

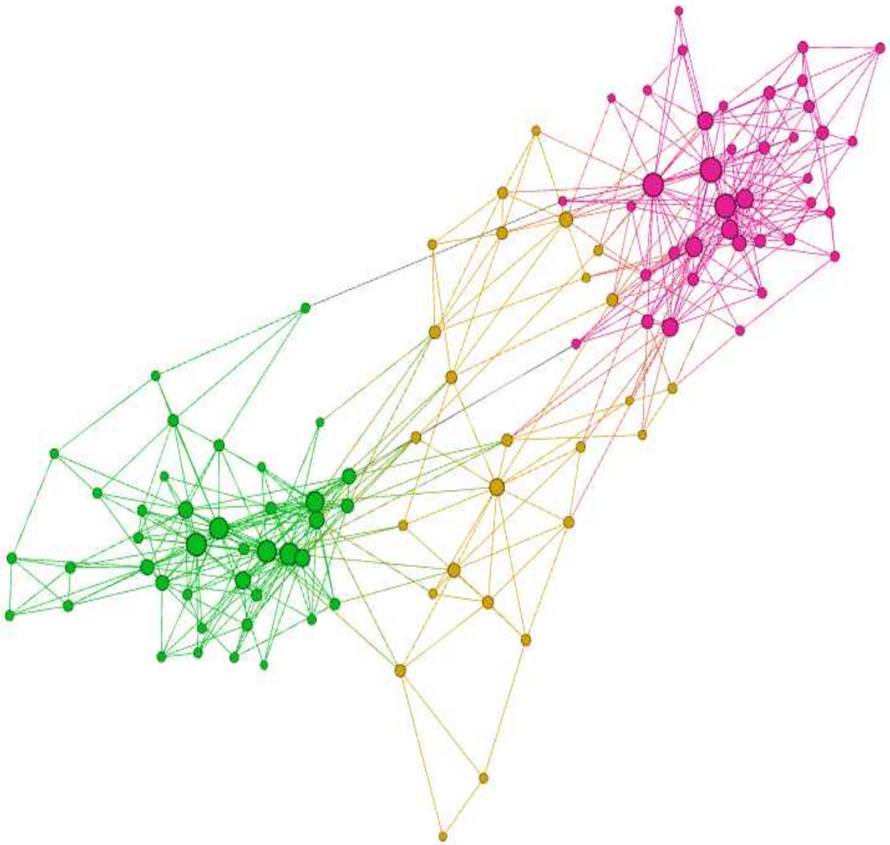


- ***Polynomial data compression for large-scale physics experiments***. *P. Aubert, T. Vuillaume, G. Maurin, J. Jacquemier, G. Lamanna, and N. Emad. CoRR, abs/1805.01844, 2018.*
- ***High Performance Computing algorithms for Imaging Atmospheric Cherenkov Telescopes***. *T. Vuillaume, P. Aubert, G. Maurin, J. Jacquemier, G. Lamanna, and N. Emad. Proceeding of Science, ICRC2017-771, 2017.*
- ***Data Analysis with SVD for Physical Expriments, Application to the Cherenkov Telescope Array***. *P. Aubert, T. Vuillaume, F. Gaté, G. Maurin, J. Jacquemier, N. Emad, and G. Lamanna. In the Proceedings of SIAM PPSC*

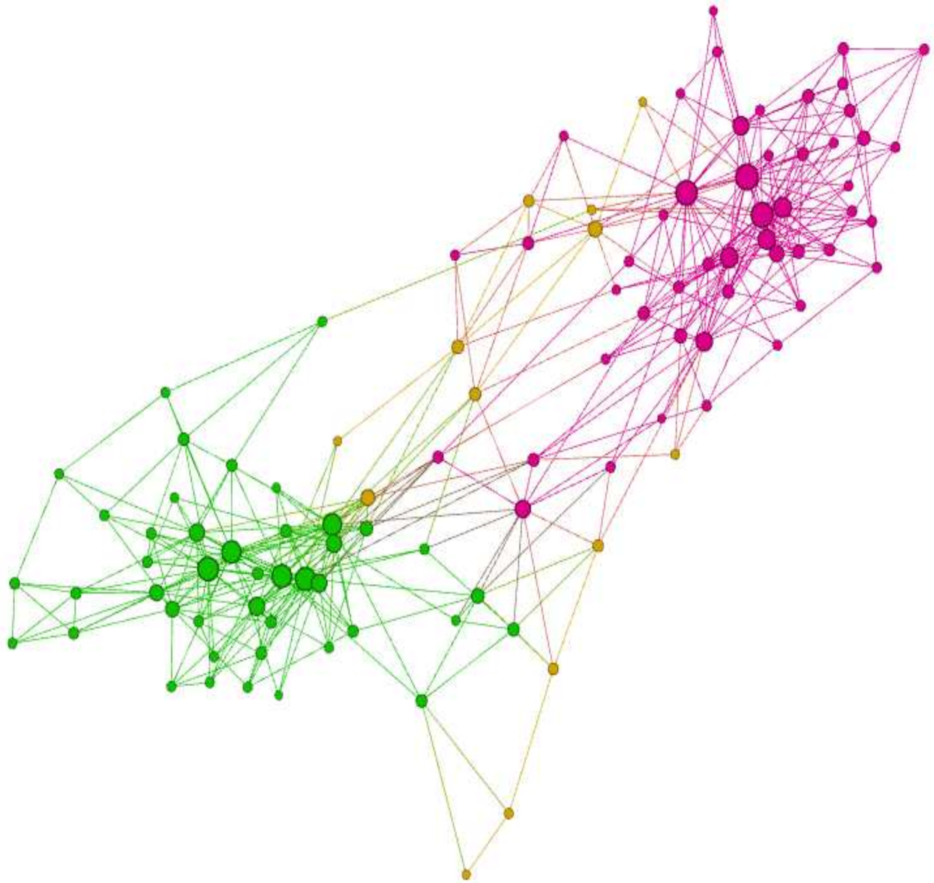
BIG DATA APPLICATION : CLUSTERING PROBLEM

84% hit rate

Spectral Modularity maximization



Ground truth



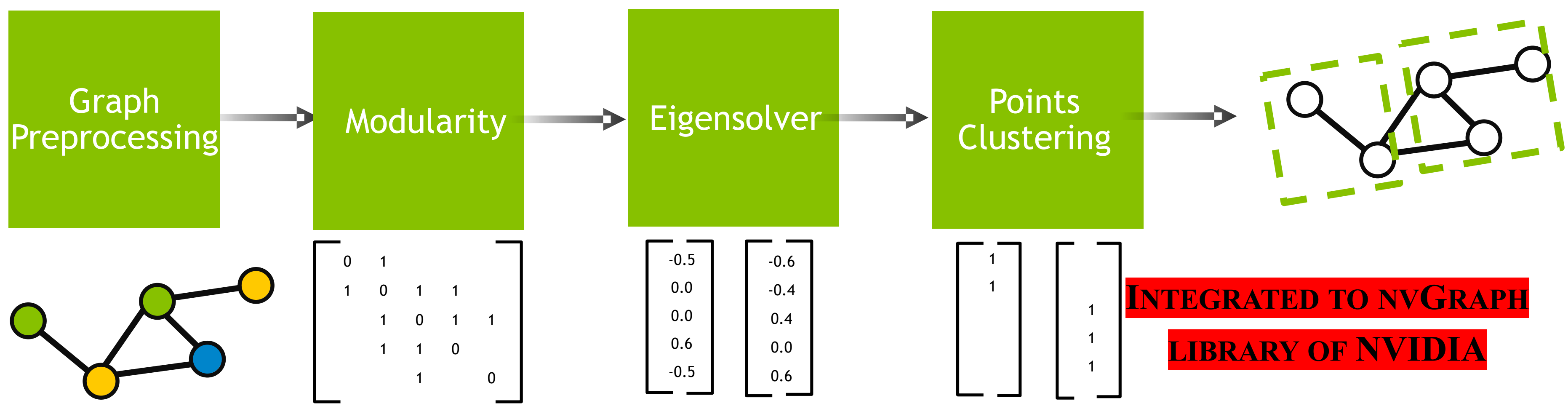
*A. Fender, N. Emad, S. Petiton, M. Naumov, **Parallel Modularity Clustering**, Procedia Computer Science, Volume 108, 2017, Pages 1793-1802*

Modularity maximization clustering

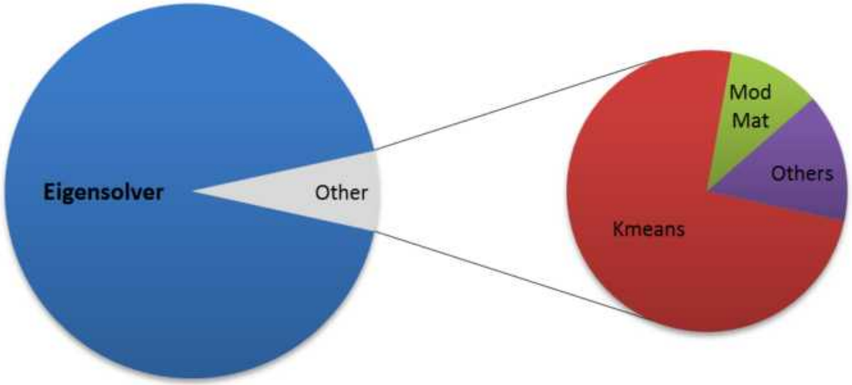
Algorithm:

1: Let $G = (V, E)$ be an input graph and A be its weighted adjacency matrix.
2: Let p be the number of desired clusters.
3: Set the modularity matrix $B = A - \frac{1}{2\omega}\mathbf{v}\mathbf{v}^T$.
4: Find p largest eigenpairs $BU = U\Sigma$, where $\Sigma = \text{diag}(\lambda_1, \ldots, \lambda_p)$.
5: Scale eigenvectors U by row or by column (optional).
6: Run clustering algorithm, such as k-means, on points defined by rows of U.

High Performance Sparse Eigenvalue Decomposition

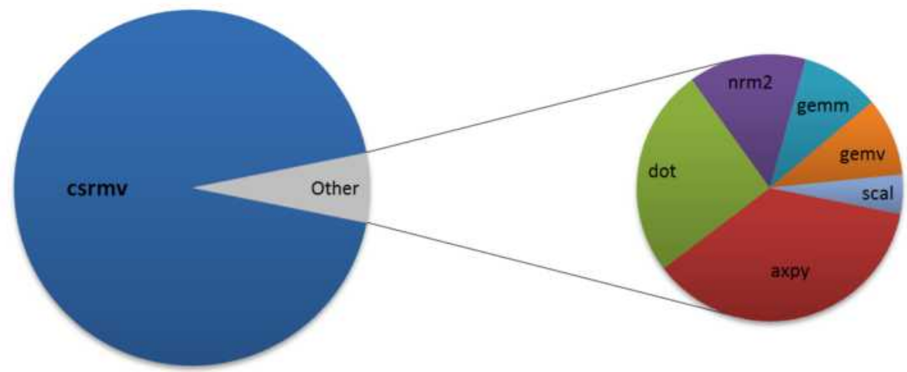


PROFILING: MODULARITY CLUSTERING (EIGENPROBLEM)



The eigensolver takes 90% of the time

The sparse matrix vector multiplication takes 90% of the time in the eigensolver



Joe Eaton (NVIDIA, USA), Nahid Emad (Paris Saclay/UVSQ), Alexandre Fender (UVSQ / NVIDIA), Maxim Naumov (NVIDIA, USA), Serge Petiton (Cristal/MDLS, Lille U)

OUTLINE

- Past and present collaborations
- Goal of the workshop : HPC & Data Science for extreme intelligent applications
  - Some data-intensive application challenges
  - Programming models and frameworks for high scale computing
- Concluding remarks

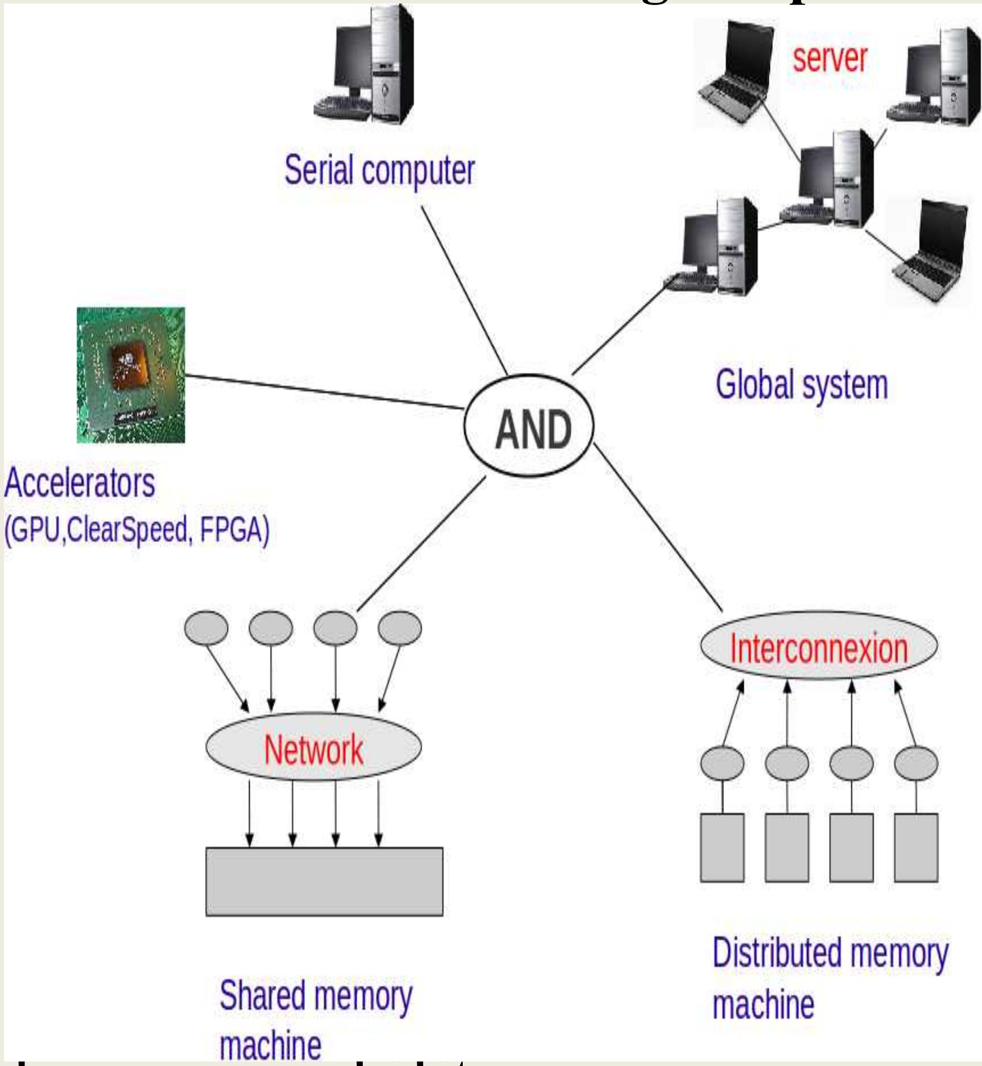
BIG DATA ANALYSIS & HPC

- Exascale supercomputers would be available in near future: how we will program them? What programming paradigms we will use? ➔**Distributed and parallel computing**
- Parallel and Distributed algorithms are efficient if data is available at the right time at the right moment
- New frameworks, languages, compiler, schedulers, … based on their multilevel aspects
- **New programming paradigms for this extreme *computational and data sciences programming***

PROGRAMING PARADIGM: COMPONENT APPROACH

Application design: As a set of off-the shelf and communicating components

Re-use of existing software elements such as libraries in the context of extreme scale computing



Component approach

- ✓ Interoperability
- ✓ Reusability
- ✓ Durability

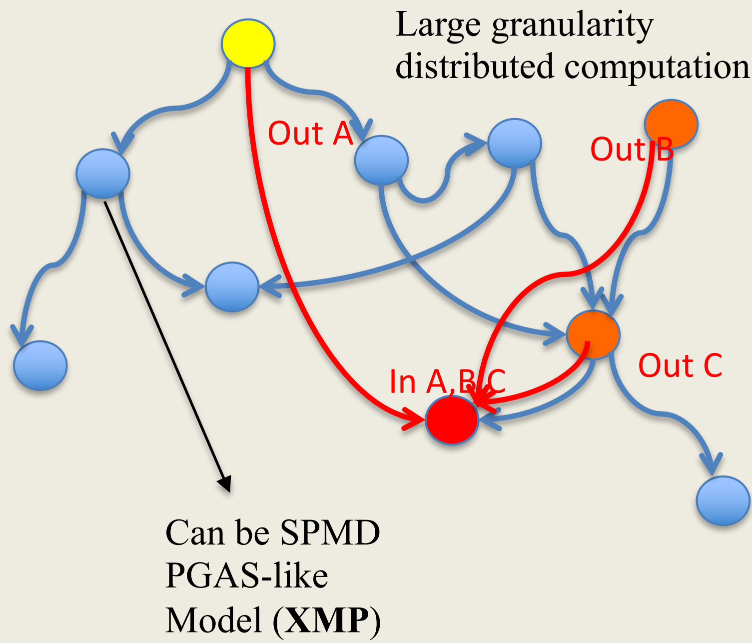
Software & Hardware reusability

PROGRAMING PARADIGM: GRAPH OF TASKS

Application design: As a dependency graph of components

- Graph of very coarse grain components (data flow oriented SPMD, PGAS-like, data-parallelism)
  -limitation of communications to the cores allocated to such components
- **A component can be itself a graph of tasks** and can be descripted by SPMD PGAS-like model
  -on each processor, we can program accelerators
  -on each core multithreaded optimization can be used

Users have to be able to give expertise to middleware, runtime system & schedulers



T. DUFAUD'S TALK

YML: An adapted language and environment (http://yml.prism.uvsq.fr/)

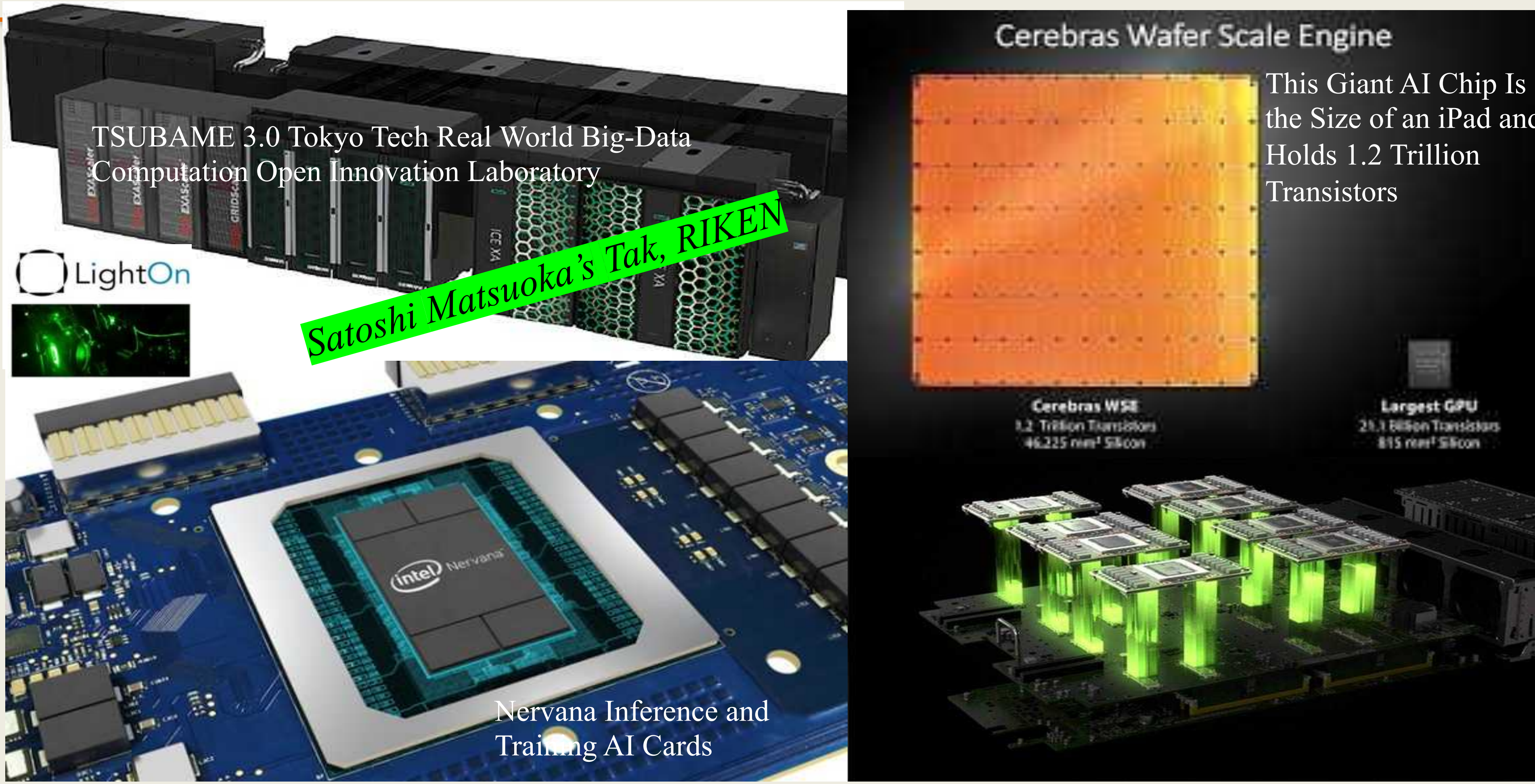
OUTLINE

- Past and present collaborations
- Goal of the workshop : HPC & Data Science & Application
  - Some data-intensive application challenges
  - Programming models and frameworks for high scale computing
- Concluding remarks

CONCLUDING REMARKS

- Extremely efficient and powerful supercomputers (Exascale <202X>, Zetascale?, Yotascale? or quantum computers <204X>) : we have to be able to efficiently program them
- **Intensive-Data Analytics and HPC convergence** impose the design of new applications on those platforms (mixing computational science and data science) -> new applications in "news" domains
- **New programming paradigms for this extreme *computational and data sciences programming***
- Learning and intelligent algorithms
- German-Japanese-French collaborations on these topics are important
- Consortium on such researches with a unique and independent board, and scientific committee, with an important financial support (international "true" review each year), and with industrial partners
- ***Fundamental researches have to be strongly supported***

CONCLUDING REMARKS: AI PROCESSORS AND APPLICATIONS



Excellent performance of AI processors but continued need for development of more and more complex methods and algorithms