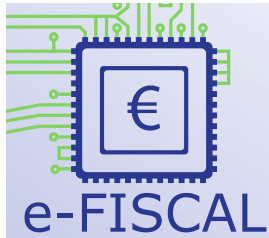# Assessing the Costs of the European e-Infrastructure: Mission Impossible?

Matti Heikkurinen
e-FISCAL Project Consortium/
Emergence Tech Ltd

e-IRG workshop June 11 – 12 Copenhagen
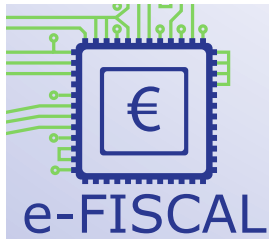Danish EU presidency

Numbers: HTC, HPC and Cloud

- Cloud, commodisation catalysts for cost assessment
  - Inevitable with growing scale – also without catalysts

- Cloud/dedicated cost ratios (literature)
  - Maximums: 7.22 – 5.59, Minimums: > 1.00
    - High utilisation rate!
    - Cloud savings hinted, not shown

- e-Fiscal (very) initial results in line with literature
  - Closer to the lower end of ratios
 - Same order of magnitude for €/CPU hour
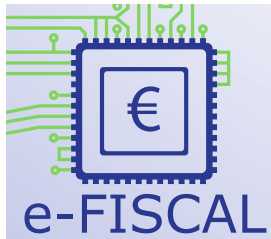
Better numbers: how hard can it really be?

- Measuring costs is easy
  - Track spending
  - Budget for the known future expenditures

- Comparison is easy
  - Death of the distance, death of the location..
  - Everything is virtualised, CPU hour is a CPU hour

- No major surprises tomorrow
  - Mature technologies
 - Mature business models

Everyday example of the challenge

- Evaluate "LaaS offering" (Life as a Service) vs. traditional, personalised "In-housing" living

- LaaS benefits: flexibility, support labor mobility, optimised commuting and zoning,...

- Money has been used for housing for hundreds of years, easy to compare
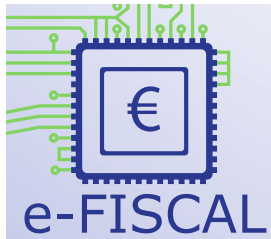
Tracking "in-housing" cost

- Let's ask a sample group their weekly housing costs
  - #1: "who wants to know?"
  - #2: tens of funding sources/person
  - #3: how to deal with gifts, durable consumer goods, rent paid by employer,…

- Need historical data
  - "Grandparents paid 10£ for this table in 1920"
    - Corresponds to £313 - £992 in 2010 pounds
  - Obsolete cost items
    - I paid 500 € (inflation adjusted) to fix my VHS

- Basic challenge with full cost accounting!
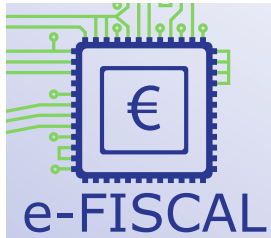
Budget for the future

- Predicting is difficult – especially of the future
  - Estimating the (remaining) useful life?
    - When will my fridge break down?
  - Energy costs?
    - Increasing demand, dwindling supply
  - Legal framework
    - Changes in inspection/maintenance regime
    - Building code (asbestos)
- Easy to both over- and underestimate
- Basic challenges with Total Cost of Ownership (TCO)
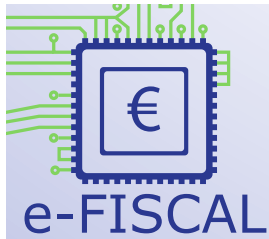
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House is a house?

Be it housing or ICT

- Tracking costs is not easy
  - Past or future

- Comparison is not trivial
  - HPC, HTC, HPC Cloud, HTC Cloud ("house is not a house")

- Future is uncertain
  - Plummeting prices as a rule, but
  - Flood in Thailand -> HD prices double
  - New technologies
  - Energy costs, green regulations
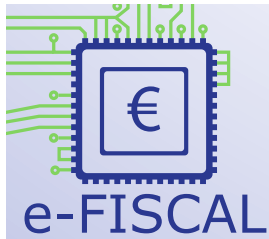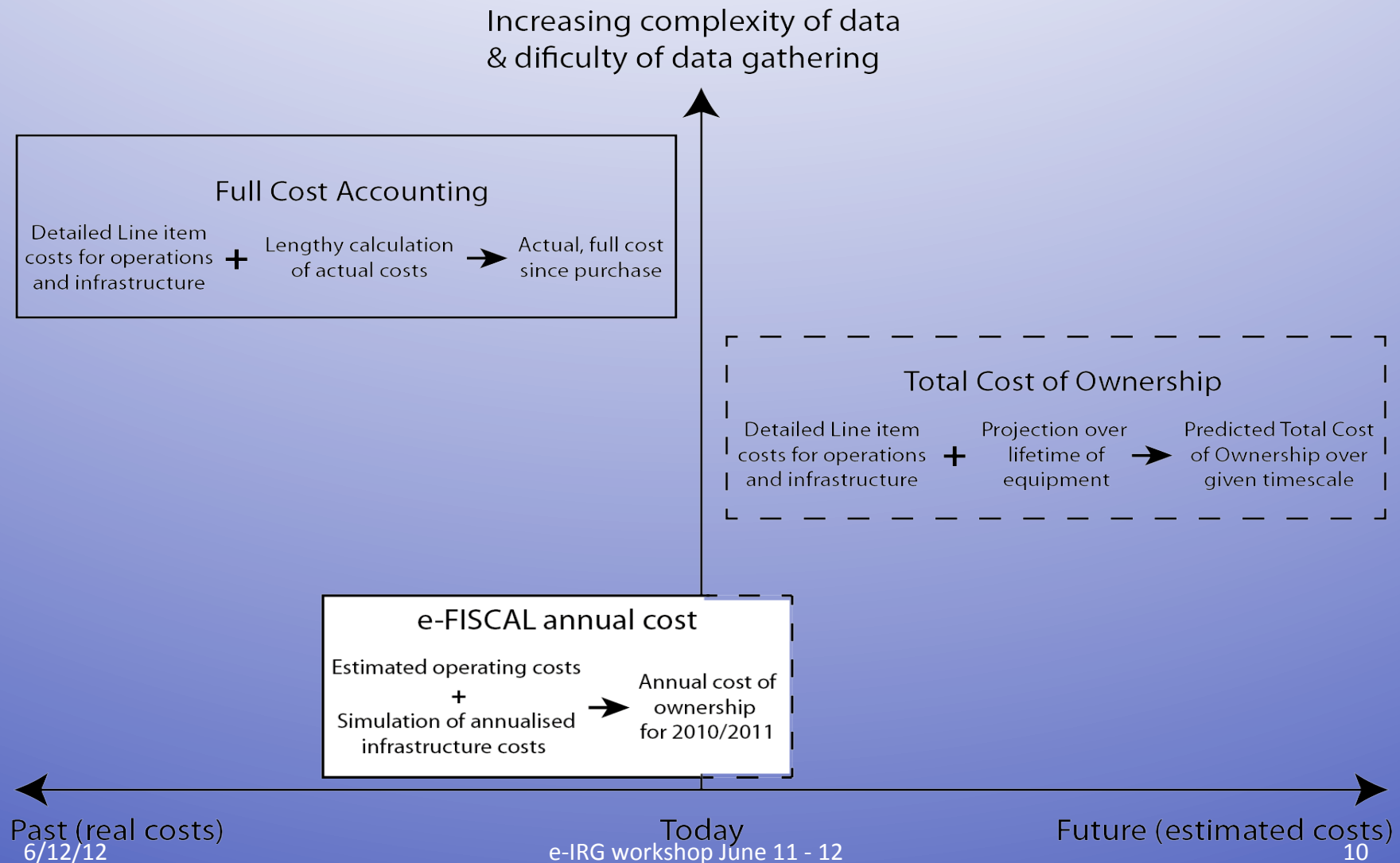
The e-FISCAL approach

- "See the map, determine building costs today"
  - Still need survey data, but considerably less
  - CAPEX can *often* be derived, OPEX needs survey data
  - With ICT we can focus on utility value
    - Old buildings become historic
    - Old computers become recycling challenges
  - We don't need access to everyone's bank accounts, nor a crystal ball.

TCO vs. FCO vs. e-FISCAL

Increasing complexity of data
& dificulty of data gathering

Full Cost Accounting

Detailed Line item costs for operations and infrastructure **+** Lengthy calculation of actual costs **→** Actual, full cost since purchase

Total Cost of Ownership

Detailed Line item costs for operations and infrastructure **+** Projection over lifetime of equipment **→** Predicted Total Cost of Ownership over given timescale

e-FISCAL annual cost

Estimated operating costs
+
Simulation of annualised infrastructure costs **→** Annual cost of ownership for 2010/2011

Past (real costs)   Today   Future (estimated costs)
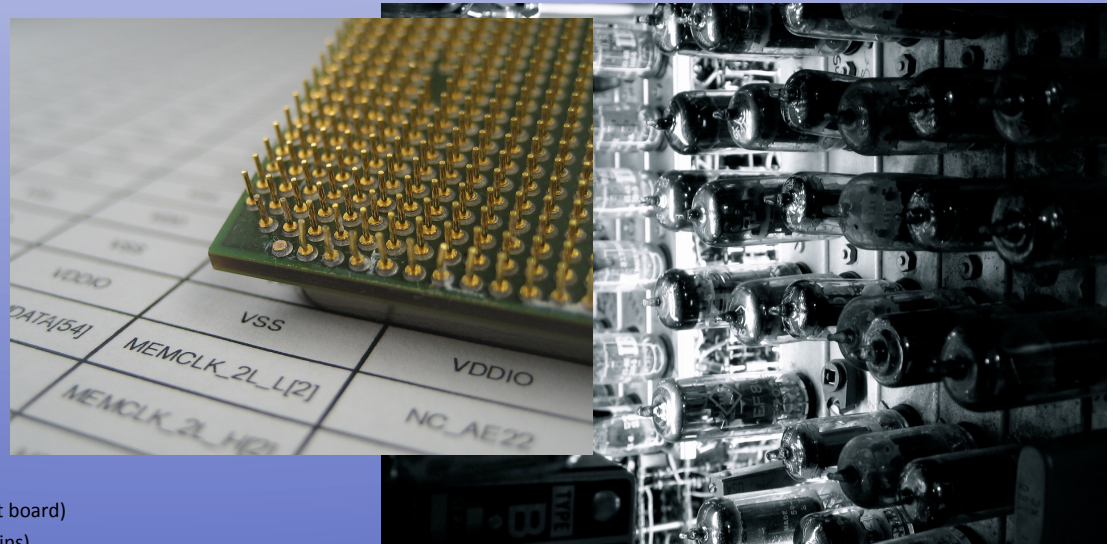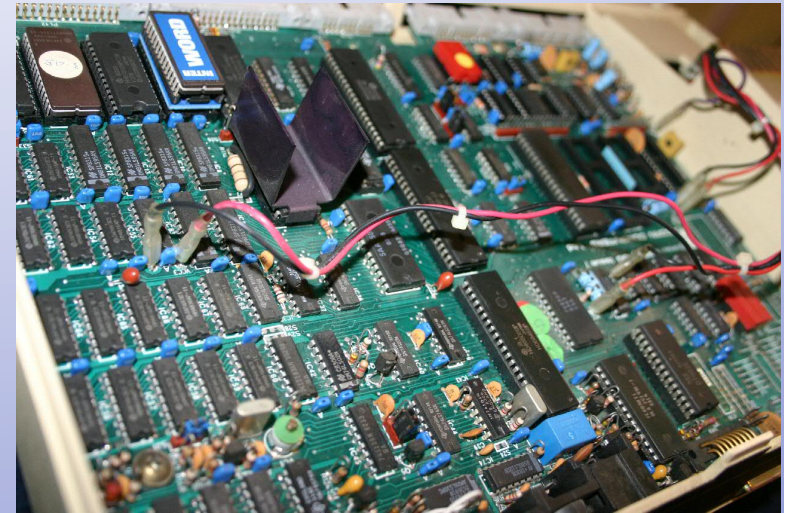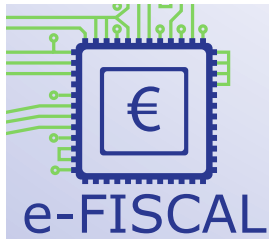
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Moore's law and others

- *Some* technologies change
  - CPUs, storage systems,..
- Rapid changes in use
  - Capacity increase
  - New usage patters
- But laws of physics still apply
  - Energy
  - Buildings
  - Speed of light

6/12/12

e-FISCAL activities

1. State of the art survey
   – Ongoing effort
   – Public repository to engage with experts

2. Benchmarking
   – Small-scale, "sanity check"
   – Uncovered HTC/HPC definitions issue!

3. Survey design and execution
   – Deciding on the level of detail a challenge
     • Both financial and technical!

1 - State of the art

- Magellan final report , US DoE (2011)
  - *DOE centers typically 3-7x less expensive compared to commercial Cloud.*
- *Carlyle et al. , Purdue University (2010)*
  - *Purdue HPC "community cluster" program*
  - *Majority of community: substantially lower out-of-pocket costs per CPU hour*
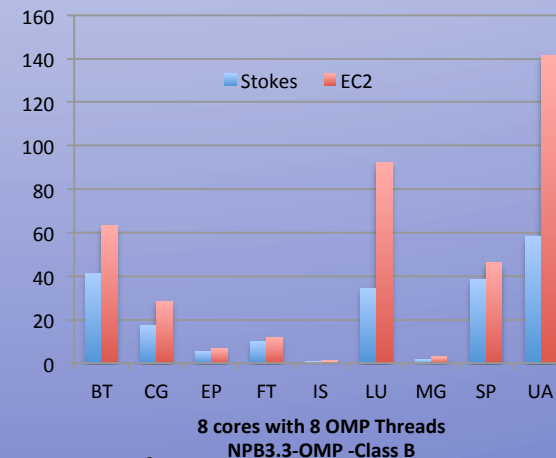   - *High utilisation rate -> lower cost in flat feel environment*

1- State of the art

- Hawtin et al. (2012), Curtis+Cartwright for EPSRC and JISC
  - *Cloud on hourly basis: 1,5 – 2 times the cost per core-hour*
  - *'Reserved Instances ' can reduce the costs to parity or better*
- Marston et al. University of Florida (2011): qualitative analysis of Cloud
  - *Strengths, e.g. reduced infrastructure costs and energy savings as well reduced upgrades and maintenance costs*
  - *Weaknesses, e.g. the loss of physical control of the data that is put on the cloud*
  - *Opportunities vs. threats*

2- Benchmarking

- NAS Parallel Benchmark – Class B (OpenMP and MPI)

Stokes HPC System	EC2 Cluster Compute Instance
24 GB of memory	23 GB of memory
2 x Intel Xeon E5650, hex-core processors	2 x Intel Xeon X5570, quad-core processors
143TB of storage, 64-bit platform	1690 GB of storage, 64-bit platform
ConnectX Infiniband (DDR) interconnect	10 Gigabit Ethernet interconnect

BT and SP using 16 cores rest using 32 cores
NPB3.3-MPI - Class B

8 cores with 8 OMP Threads
NPB3.3-OMP -Class B
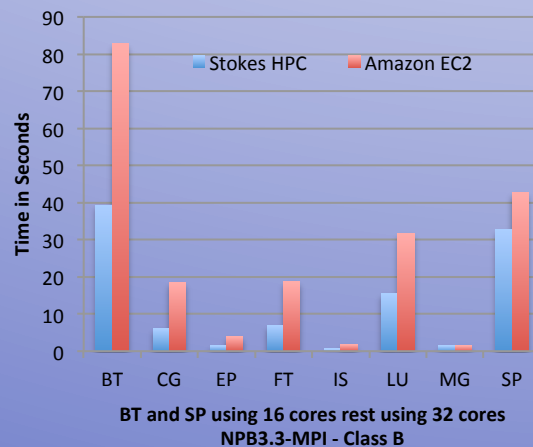
- Average performance loss 37 – 48% (1 to 68% per test)

- Caveat: heterogeneous environments aren't trivial!

3 - Initial cost assessment

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	2010		2011	
	Average	Median	Average	Median
Total yearly cost/ Logical CPU	535.9	258.0	422.7	197.1
Yearly logical CPU minutes	8760	8760	8760	8760
Cost per logical CPU/hour €	**0.1036**	**0.0499**	**0.0837**	**0.0337**

- These shouldn't be compared to Cloud costs today
  - **Outliers**, no performance normalisation, "December resources",...
  - Both the costs and Cloud prices change rapidly – 2010 costs vs. 2012 prices?
- Having said that: EC2 standard instance hourly rate at today's rates:
  - 0.06€ (on-demand), 0.025€ (Linux 3-year reserved instance at 100% utilisation rate)
  - Need to add storage & extra network costs – often not powerful enough

3 - Sample used

	Country Name	Number of questionnaires
1	Belgium	5
2	Bulgaria	1
3	Cyprus	1
4	Finland	1
5	Germany	1
6	Greece	4
7	Hungary	1
8	Ireland	1
9	Latvia	1
10	Norway	1
11	Poland	1
12	Romania	1
13	Spain	6
14	Turkey	1
	Total	**26**

3 - Cost breakdown 2010

Cost break down / logical CPU		2010		2010	
		Average	Median	Average %	Median %
Depreciation Logical CPUs	CAPEX	92,9	60,0	17%	23%
Depreciation storage		26,2	4,2	5%	2%
Depreciation other		29,9	13,5	6%	5%
Software	OPEX	23,39	4,81	4%	2%
Personnel		317,50	133,21	59%	52%
Premises cost		8,09	5,96	2%	2%
Electricity cost		37,94	36,34	7%	14%
Other cost		0,00	0,00	0%	0%
Total yearly cost		535,9	258,0	100%	100%

Cost per logical CPU per cost category (in €) and % for 2010

- CAPEX fairly small, OPEX dominates (70%)

- Electricity: PUE rates good (median 1.51)

- Depreciation rate important for CAPEX (5 years used based on survey)
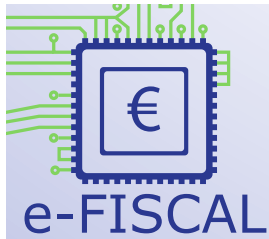
3 - Cost breakdown 2011

Cost break down / logical CPU		2011 Average	2011 Median	2011 Average %	2011 Median %
Depreciation Logical CPUs	CAPEX	88,6	44,9	21%	23%
Depreciation storage	CAPEX	19,2	3,5	5%	2%
Depreciation other	CAPEX	26,9	10,2	6%	5%
Software	OPEX	21,06	3,63	5%	2%
Personnel	OPEX	232,39	99,17	55%	50%
Premises cost	OPEX	6,04	4,93	1%	3%
Electricity cost	OPEX	28,48	30,77	7%	16%
Other cost	OPEX	0,00	0,00	0%	0%
Total yearly cost		422,7	197,1	100%	100%

Cost per logical CPU per cost category (in €) and % for 2011

- Multi-core technology has a visible impact
- Cloud approach would still most likely need personnel
  - Carlyle: Cloud does not lessen the need for system administration tasks

Conclusions

- Both cost of dedicated HTC/HPC and price of Cloud services dropping
  - "Not quite" Moore's law
- Cost only one of the factor influencing the choice
  - Convenience, flexibility
  - Intangible factors
  - Non-standard requirements
  - Risk management
- Cost assessment process
  - Painful and laborious
  - Essential
  - Useful (insights, learning experience)

Cost assessment challenges

- Fundamental cost uncertainty principle
  - Partially addressed by e-FISCAL methodology
- Sufficient data rapidly, efficiently
  - Issue for the service provider community
  - Be sensitive to changes "sufficient"
  - Find a trusted party?
- Use the data for policy formation
  - Gain and maintain trust of users, funding agencies
  - Relevance: link cost to value (CPU hours/Nobel price)
  - Forums like e-IRG in an important role
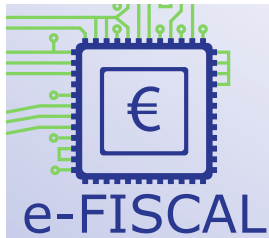
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e-FISCAL Summer Workshop

■ 3-4 July 2012, Samos Island, Greece

http://www.efiscal.eu/2nd-workshop

@ Samos Summit 2012 event series

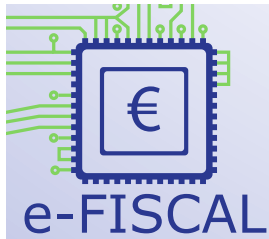http://samos-summit.blogspot.com

- 70 registrants (around 30 already expressed interest for e-FISCAL)

- Case studies on Costs-Green IT from:
    - Belgium, Greece, Spain, Poland
    - And LIFEWATCH ESFRI project

- Talks from Intel (tbc) & 451Group

- Benchmarking efforts (HPC vs. Amazon)

- EGI and PRACE talks
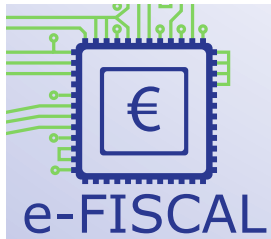
Thank you!

Questions, comments?

Project in a nutshell

- **Project acronym:** e-FISCAL
- **Contract n°:** RI-283449 (CSA-SA)
- **Start date:** 01/08/2011
- **Duration:** 18 months (end 31/1/2013)
- **Total budget:** 392.523 €
- **Total funded effort in PMs:** 33.75
- **Partners:**
  - AUEB-RC, EGI.eu, NUI Galway, ETL
- **Web site:** www.efiscal.eu