

# **KEYNOTE - THE FUTURE OF COMPUTING INFRASTRUTTURE E ARCHITETTURE VERSO IL DOMANI**

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DEVO Lab Director

Datacenter Transformation: esperti a confronto - 15 marzo 2016

# AGENDA

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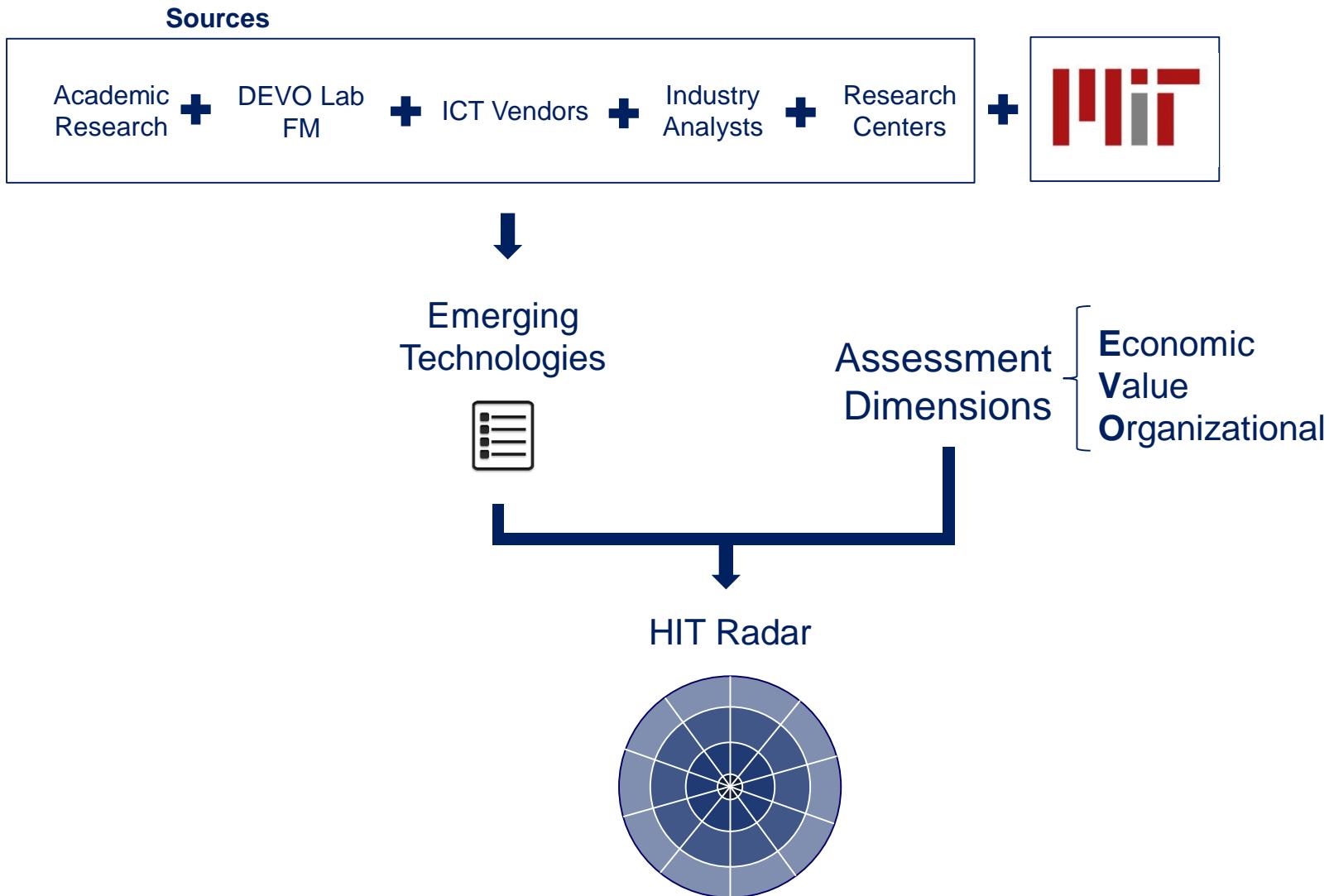
1

**Facilities & infrastrutture: oggi e domani**

2

**Uno sguardo al futuro: CPU, GPU, chip neuromorfici**

# RESEARCH: HIT RADAR



# AGENDA

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1

**Facilities & infrastrutture: oggi e domani**

2

**Uno sguardo al futuro: CPU, GPU, chip neuromorfici**

# IL GREEN DATA CENTER DI ENI

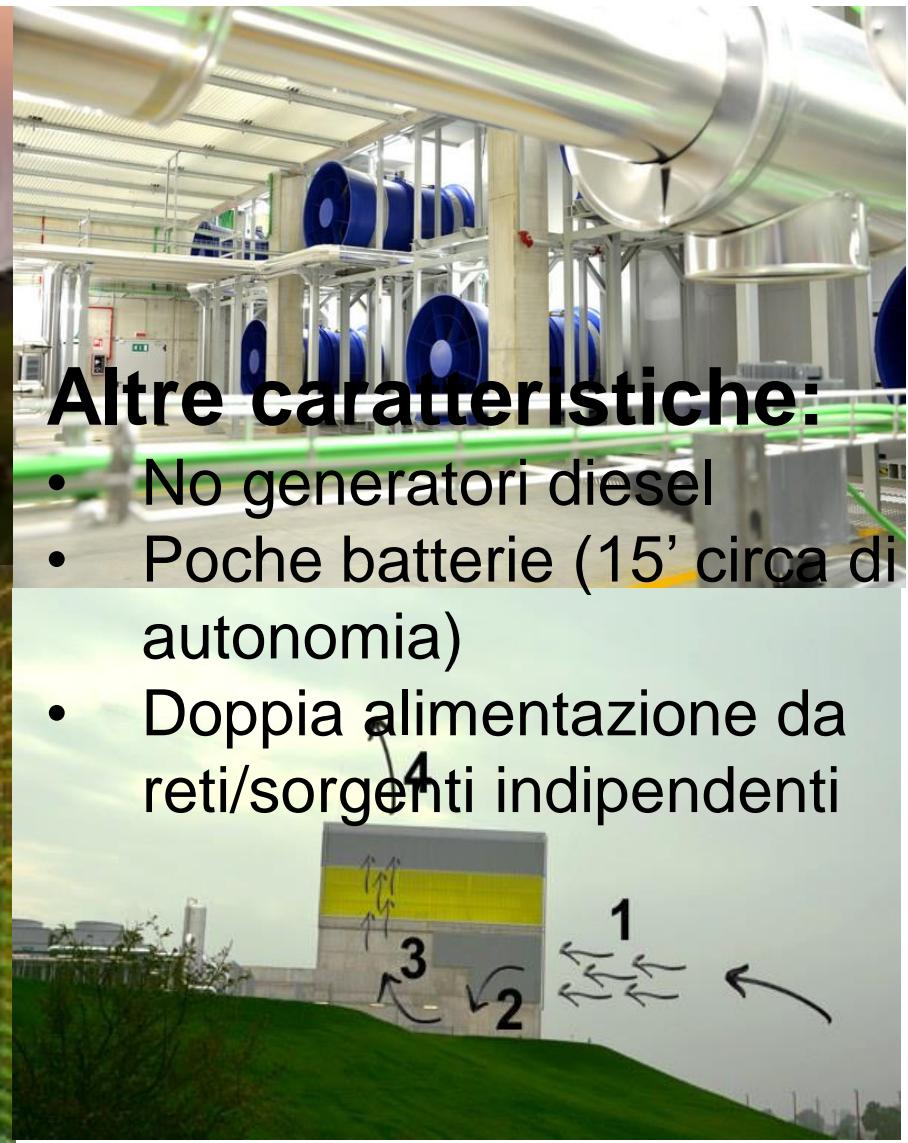
## Caratteristiche:

- PUE misurato medio annuo: 1.14
- Densità energetica 50KW/mq
- 5200mq di sale macchine
- 30MW di potenza utile

# RECORD DI EFFICIENZA ENERGETICA E DENSITÀ DI ENERGIA

## Come:

- Segregazione corridoi di aria calda e fredda
- Temperatura di esercizio 26°, umidità 60%
- UPS statici (60msec switch on)
- Solo Mega UTA di mandata
- Estrazione aria calda con sole ventole nei rack + freecooling
- Trasformatori ( 20.000V -> 380V) a pochi metri dalle macchine



# FACEBOOK - IL NUOVO RECORD: PUE 1.078



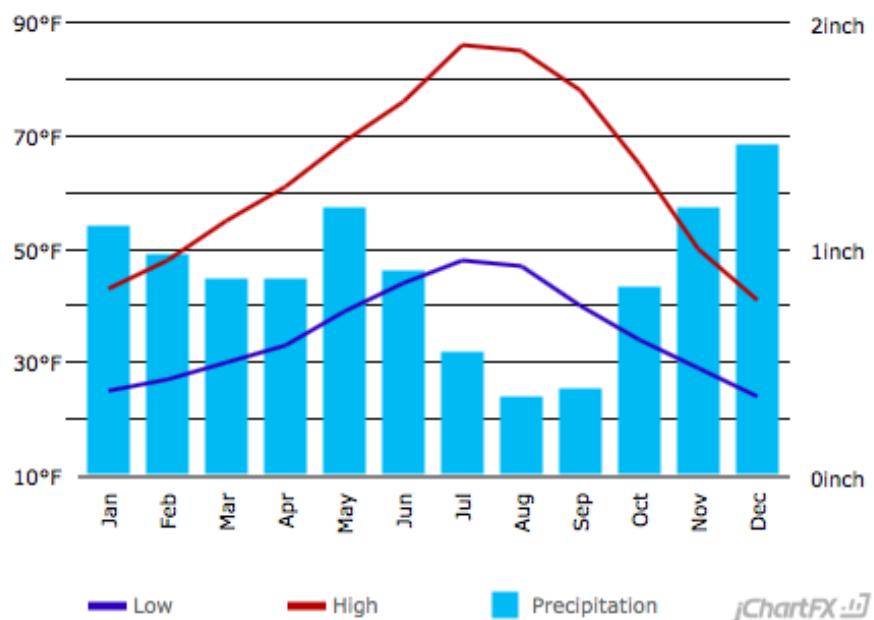
## Come:

- Stessi principi del Green Data Center Eni
- Migliori condizioni ambientali
- Nuovo HW che riduce la dissipazione

# CONFRONTO AMBIENTALE

Mesi												
Gen	Feb	Mar	Apr	Mag	Giu	Lug	Ago	Set	Ott	Nov	Dic	
5,9	9,0	14,3	17,4	22,3	26,2	29,2	28,5	24,4	17,8	10,7	6,4	
-0,9	0,3	3,8	7,0	11,6	15,4	18,0	17,6	14,0	9,0	3,7	0,1	
21,7 (2000)	23,8 (1990)	27,3 (1997)	26,8 (1997)	32,0 (1997)	35,4 (1996)	37,2 (1983)	37,1 (1998)	33,0 (1983)	30,4 (1997)	21,4 (1998)	18,1 (1991)	
-14,4 (1985)	-12,8 (1991)	-7,4 (1971)	-2,4 (1973)	1,2 (1991)	8,0 (1991)	10,1 (1974)	8,4 (1972)	3,0 (1972)	-2,3 (1973)	-6,0 (1983)	-9,9 (1981)	
0	0	0	0	0	4	14	12	1	0			
18	13	4	1	0	0	0	0	0	0	0	0	
58,7	49,2	65,0	75,5	95,5	66,7	66,8	88,8	93,1	122,4			
7	5	7	8	9	8	5	7	6	8			
21	12	5	2	1	1	1	1	4	12			
83	75	70	72	72	71	70	72	74	80			

Prineville Climate Graph - Oregon Climate Chart



jChartFX

# OPEN COMPUTE PROJECT

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**OPEN**  
Compute Project

# OPEN COMPUTE PROJECT

## About OCP

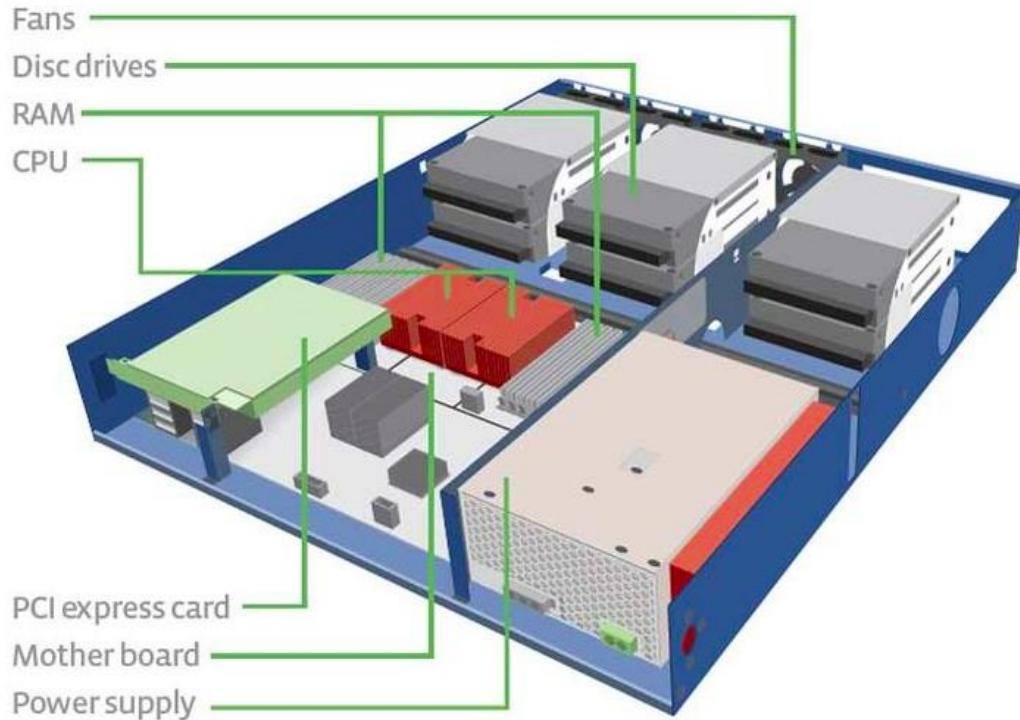
The Open Compute Project (OCP) is a collaborative community focused on redesigning hardware technology to efficiently support the growing demands on compute infrastructure.

Hundreds  
of active members

Collaborating to  
improve  
infrastructure  
design

[www.opencompute.org](http://www.opencompute.org)

# L'ARCHITETTURA



## Un nodo

- 2 xeon
- 128GB Ram
- 20Gbit/s rete
- consumo circa 500W

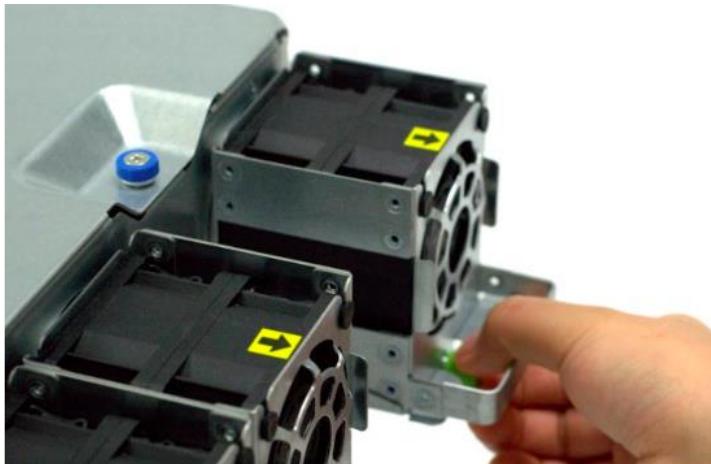
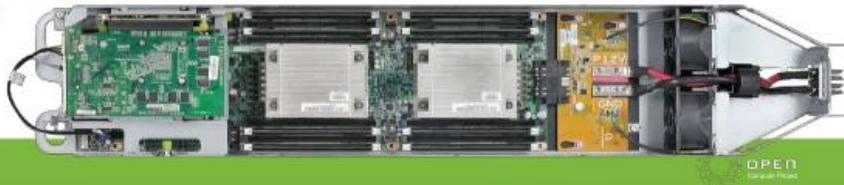
## Un nodo Network Attached Storage

- 1 xeon
- 64GB Ram
- 512G SSD cache
- 6x8TB Dischi, ZFS Raid  
 $Z2 = 32\text{TB utili}$
- 20Gbit/s
- consumo circa 500W

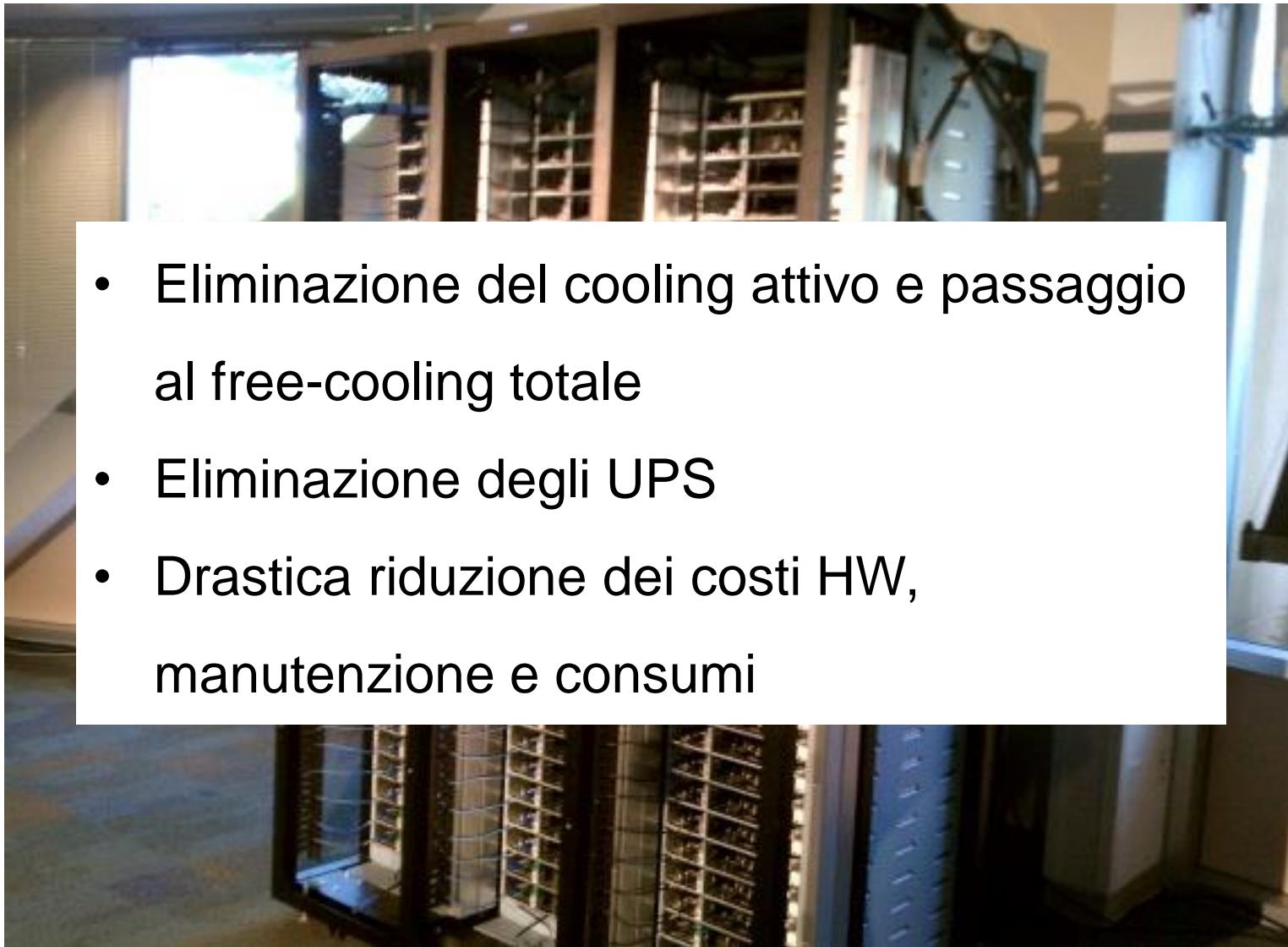
# BOARD – DISCHI – RACK - RAFFREDDAMENTO

## Open Compute v3

- Reuses the “v2” half-width motherboards
- Self-contained sled for Open Rack
- 3-across 2U form factor enables 80mm fans with 45 servers per rack



# UN PROGETTO INTEGRATO DC – INFRASTRUTTURA - SOFTWARE



- Eliminazione del cooling attivo e passaggio al free-cooling totale
- Eliminazione degli UPS
- Drastica riduzione dei costi HW, manutenzione e consumi

# COSTI OPERATIVI



I costi operativi di un Data Center si ripartiscono circa così:

30% spazio

30% impianti elettrici

30% cooling

10% varie

# IPOTESI PER UN NUOVO DATA CENTER

- 
- 45 nodi per rack
  - 1000 nodi CPU + 500 nodi disco
  - Rete (2M€)
  - 35 rack
  - 200 mq netti per i server
  - 200 mq netti per la rete
  - Totali 2500 mq lordi
  - 1 MW di potenza
  - SW: FreeBsd, Linux, OpenStack, ...
  - Costo facility: <10M€
  - Costo HW: <4M€
  - Contingency 30%: 4.2M€

# AGENDA

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1

Facilities & infrastrutture: oggi e domani

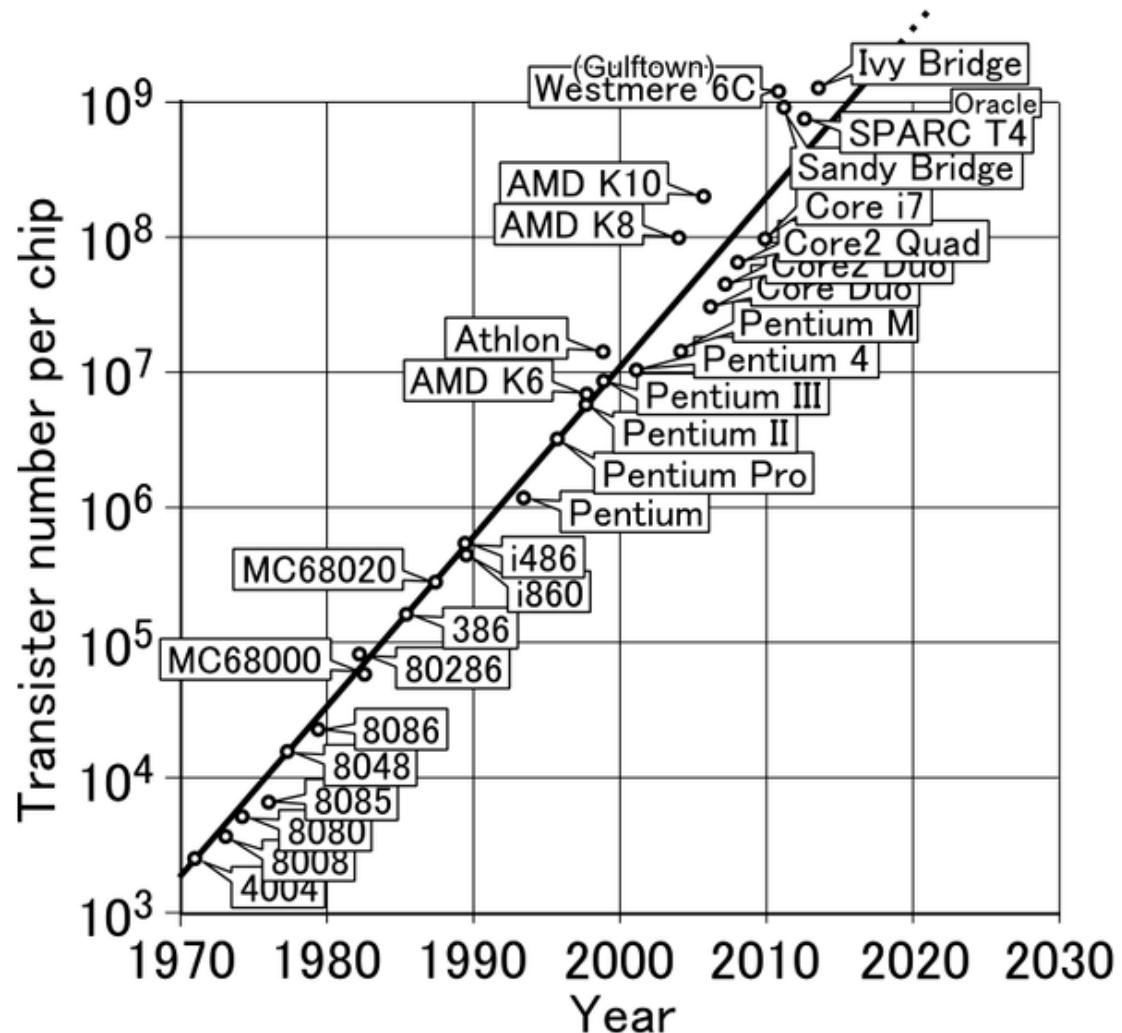
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Uno sguardo al futuro: CPU, GPU, chip neuromorfici

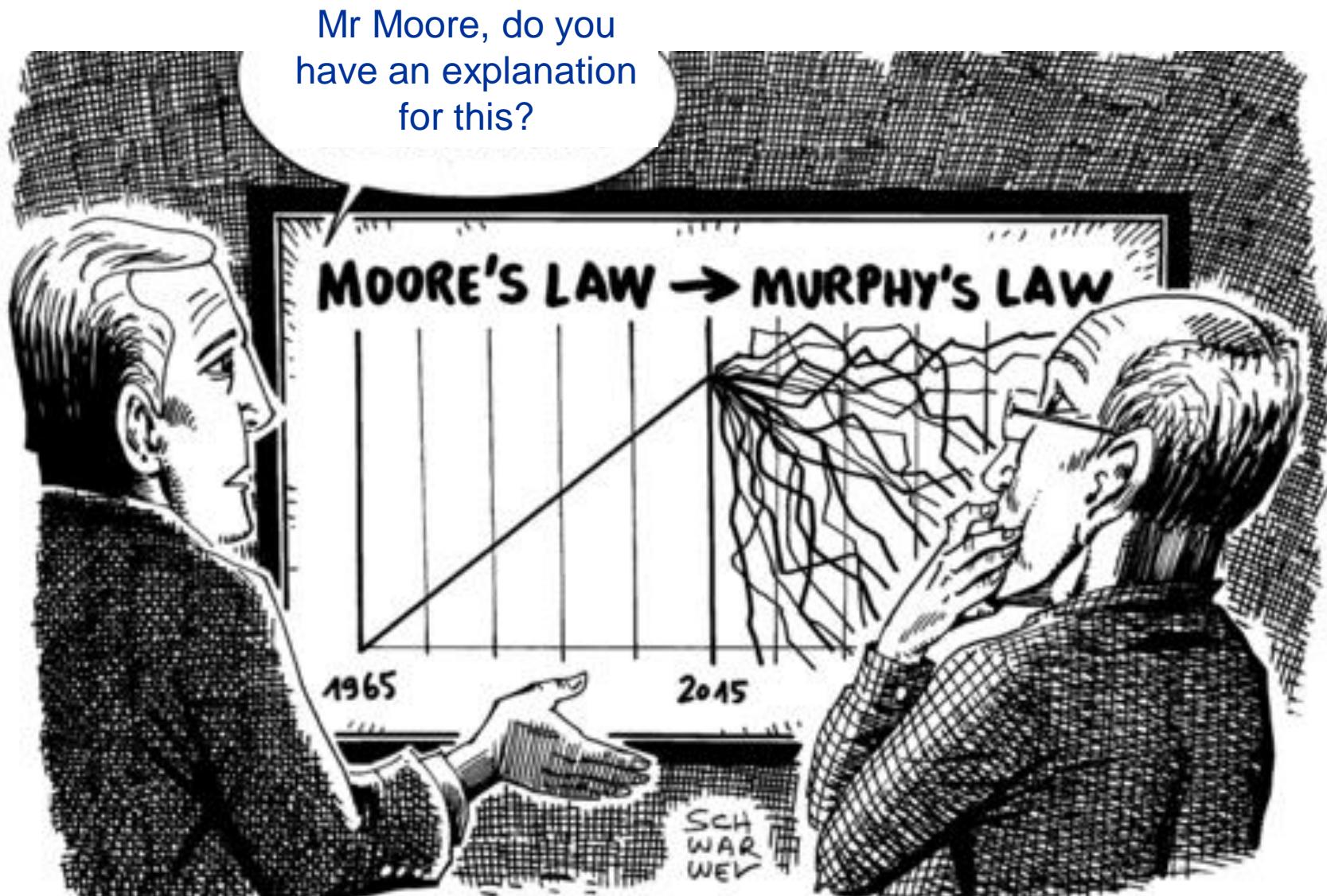
# LA LEGGE DI MOORE

## La legge di Moore

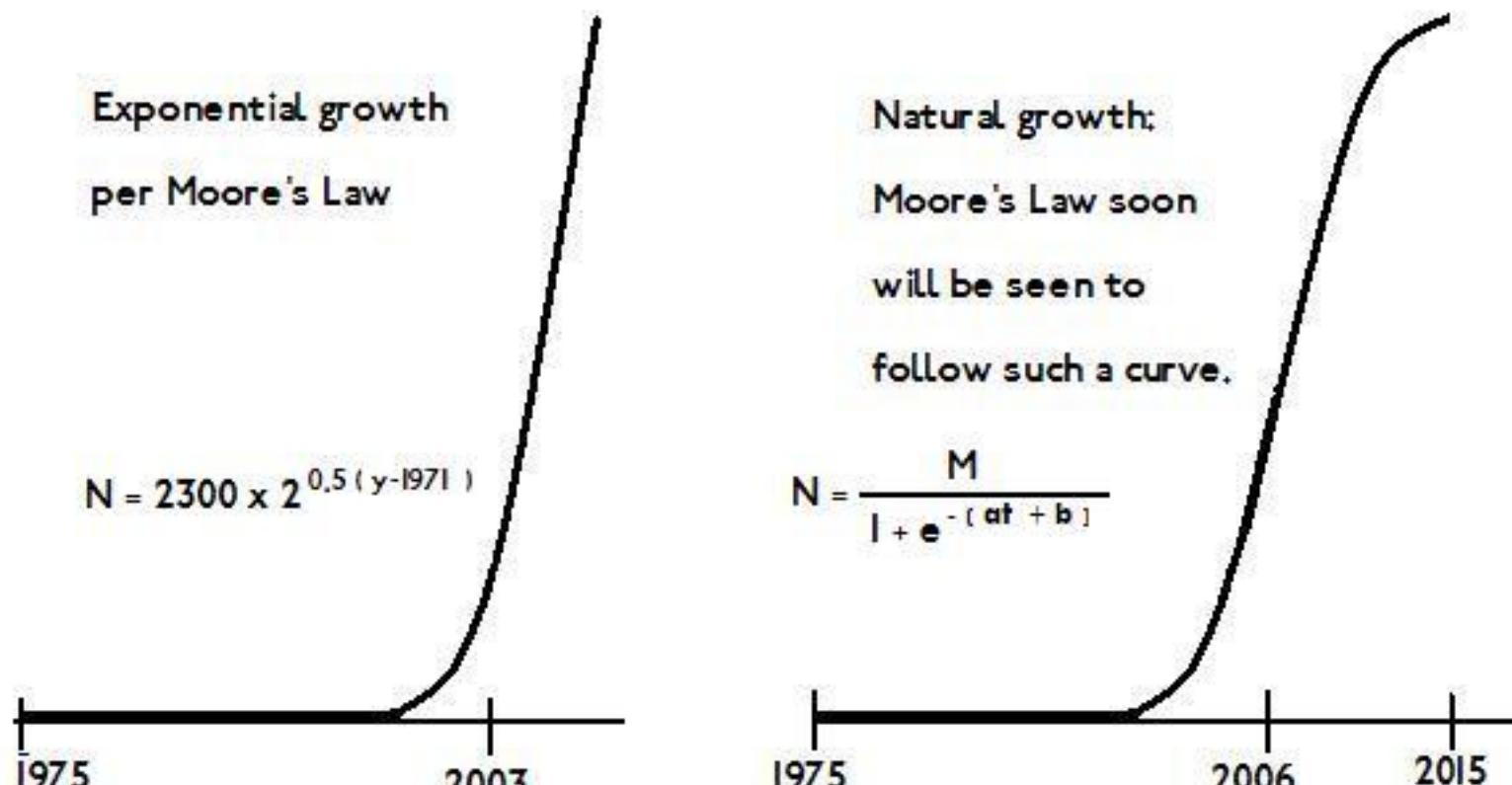
The number of transistors in a dense integrated circuit has doubled approximately every 2 years.



# ...DUBBI SULLA SUA VALIDITÀ ETERNA....



# IL RALLENTAMENTO DELLA LEGGE DI MOORE...



EXponential growth versus natural growth

# ...L'ACCELERAZIONE DEL SUSSEGUIRSI DEGLI EVENTI

Time Before Present	Time to Next Event	Event
37000000000	2400000000	Life
1300000000	750000000	Eucaryotic cells, multicellular organisms
550000000	220000000	Cambrian Explosion (body plans)
330000000	135000000	Reptiles
195000000	113500000	Class Mammalia
81500000	49000000	Primates
32500000	25500000	Superfamily Hominoidea
7000000	3100000	Family Hominidae
3900000	2100000	Human ancestors walk upright
1800000	800000	Genus Homo, Homo Erectus, specialized stone tools
1000000	700000	Spoken language
300000	200000	Homo sapiens
100000	75000	Homo sapiens sapiens
25000	15000	Art, early cities
10000	5000	Agriculture
5000	2490	Writing, wheel
2510	1960	City States
550	325	Printing, experimental method
225	95	Industrial Revolution
130	65	Telephone, electricity, radio
65	38	Computer
27	14	Personal Computer

# ANDAMENTO ESPONENZIALE PREVISTO DA KURZWEIL

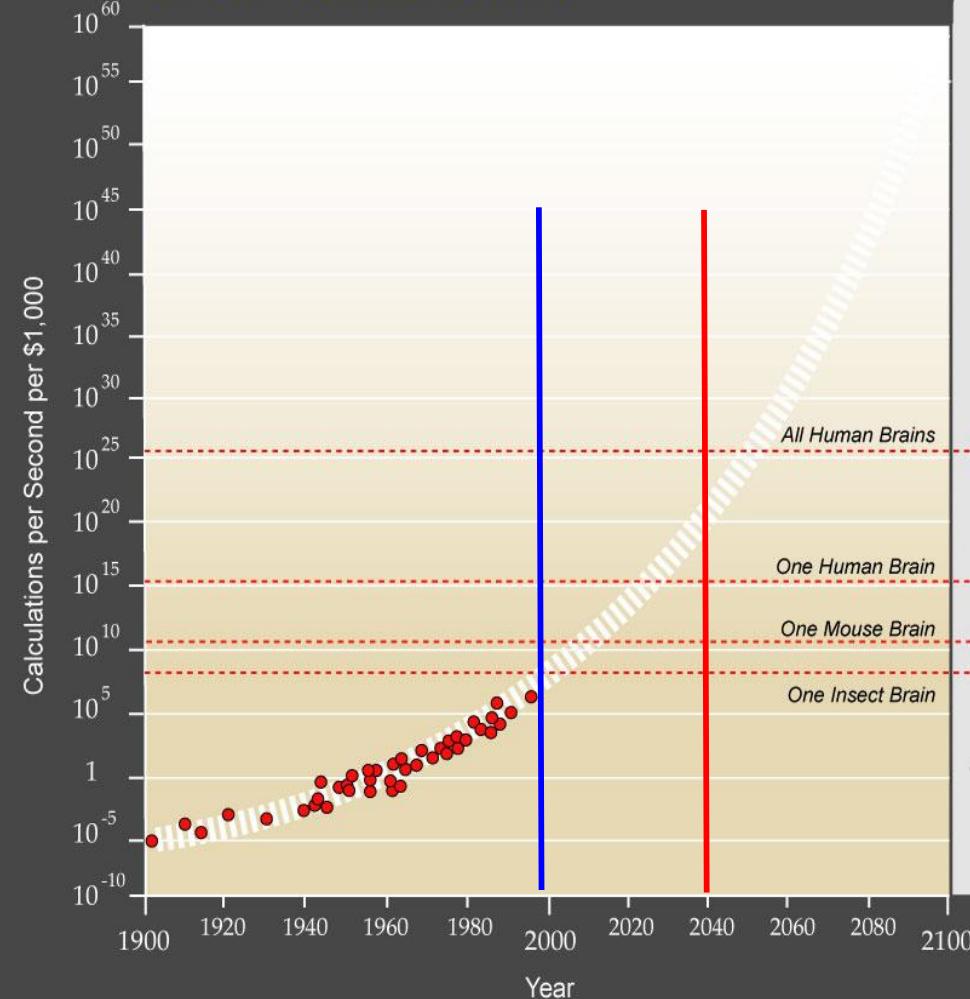
## Kurzweil's Law of Accelerating Returns

A specific paradigm (a method or approach to solving a problem, e.g., shrinking transistors on an integrated circuit as an approach to making more powerful computers) provides exponential growth until the method exhausts its potential. When this happens, a paradigm shift (i.e., a fundamental change in the approach) occurs, which enables exponential growth to continue

## Transhumanism

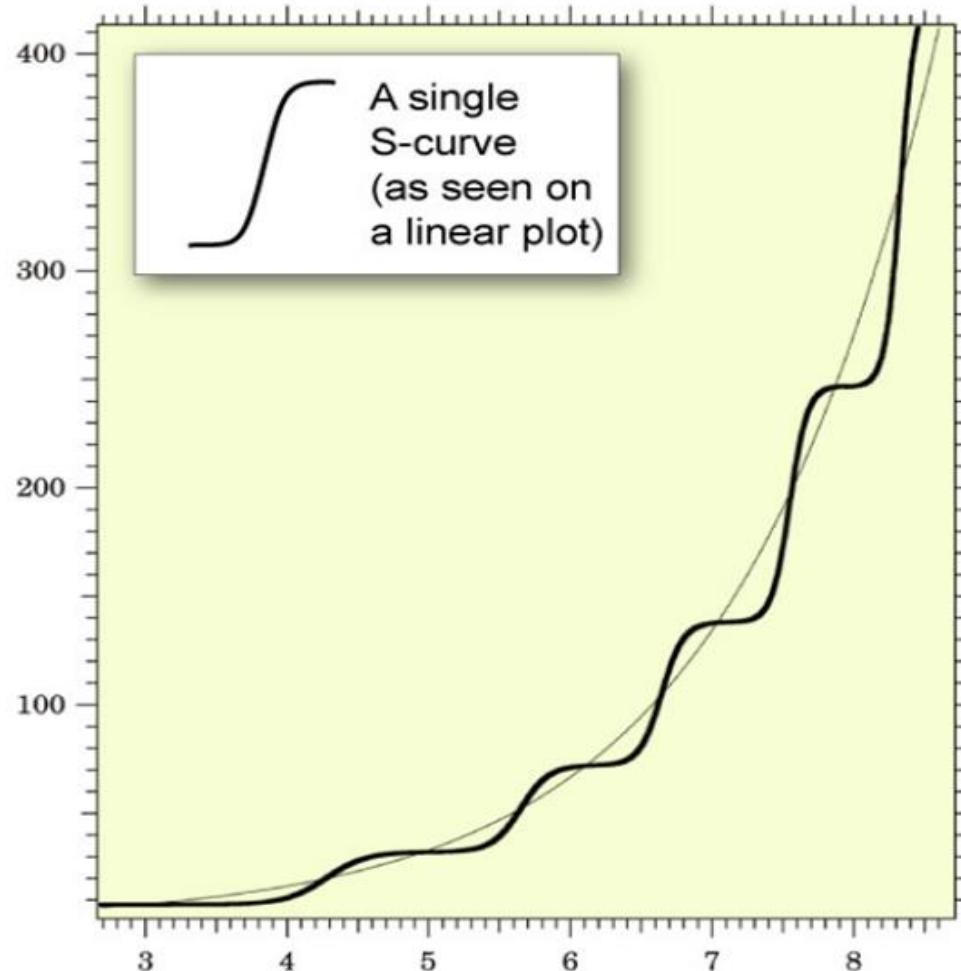
An intellectual movement that aims to transform the human condition by developing and creating widely available sophisticated technologies to greatly enhance human intellectual, physical and psychological capabilities

## Exponential Growth of Computing Twentieth through twenty first century



Logarithmic Plot

# LA SEQUENZA ESPONENZIALE COME CASCATA DI CURVE A “S”





George Bray  
@GeorgeBray

Following



Your mobile phone has more computing power than all of NASA in 1969. NASA launched a man to the moon. We launch a bird into pigs.

50+  
RETWEETS

50+  
FAVORITES

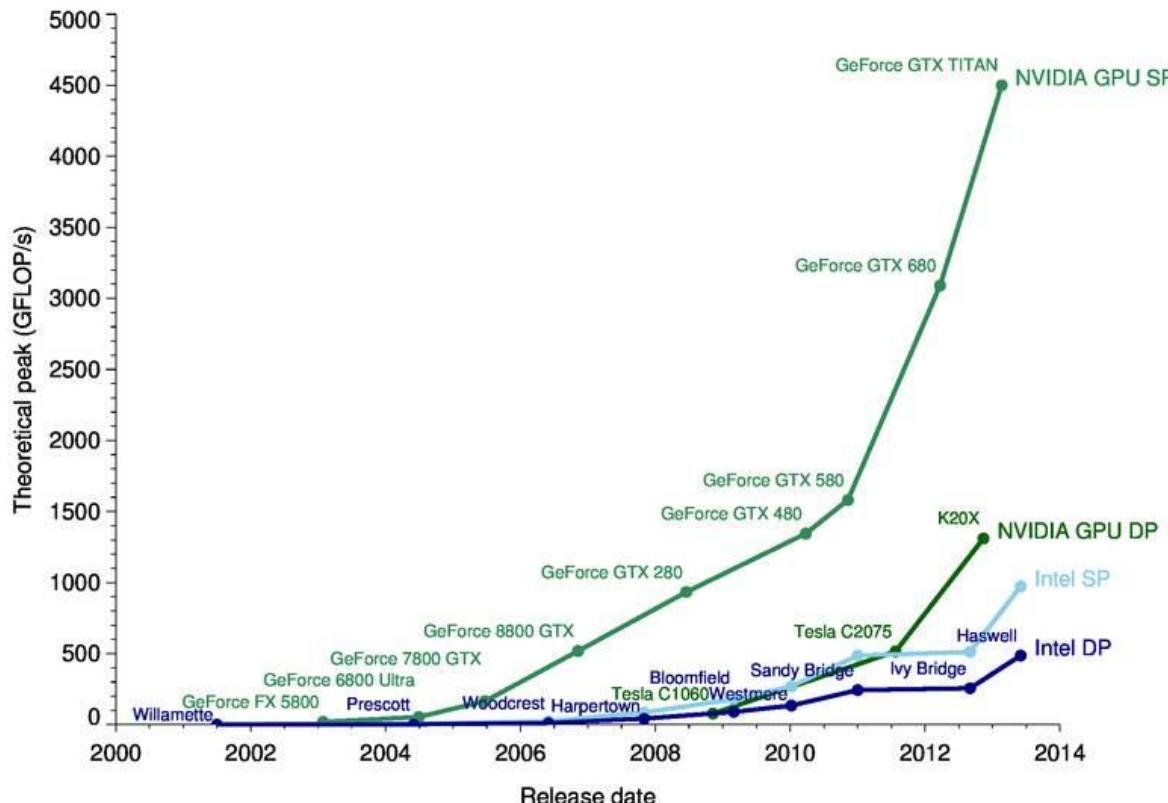


4:12 PM - 22 Mar 11 via web [Embed this Tweet](#)

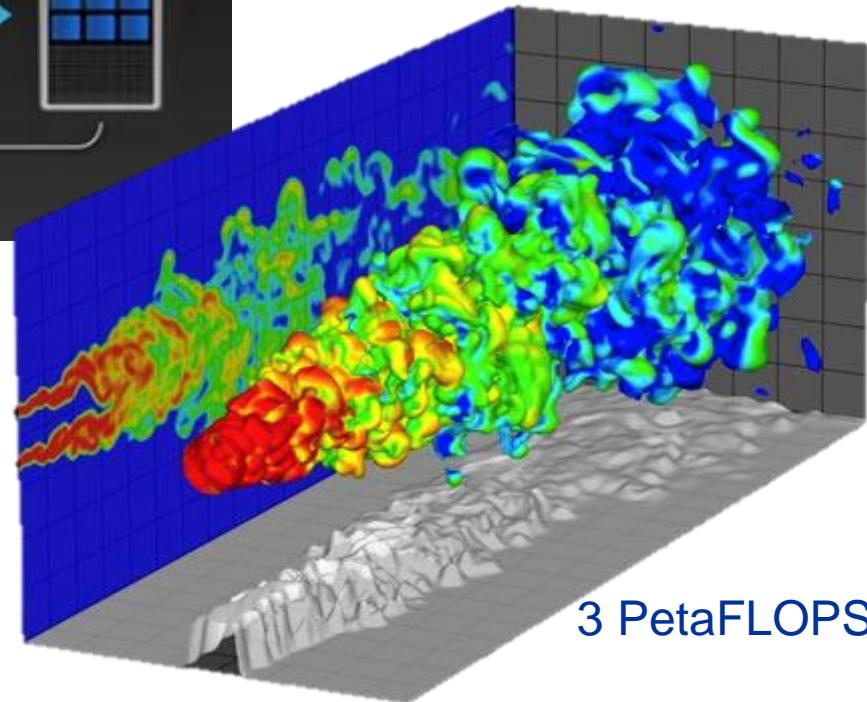
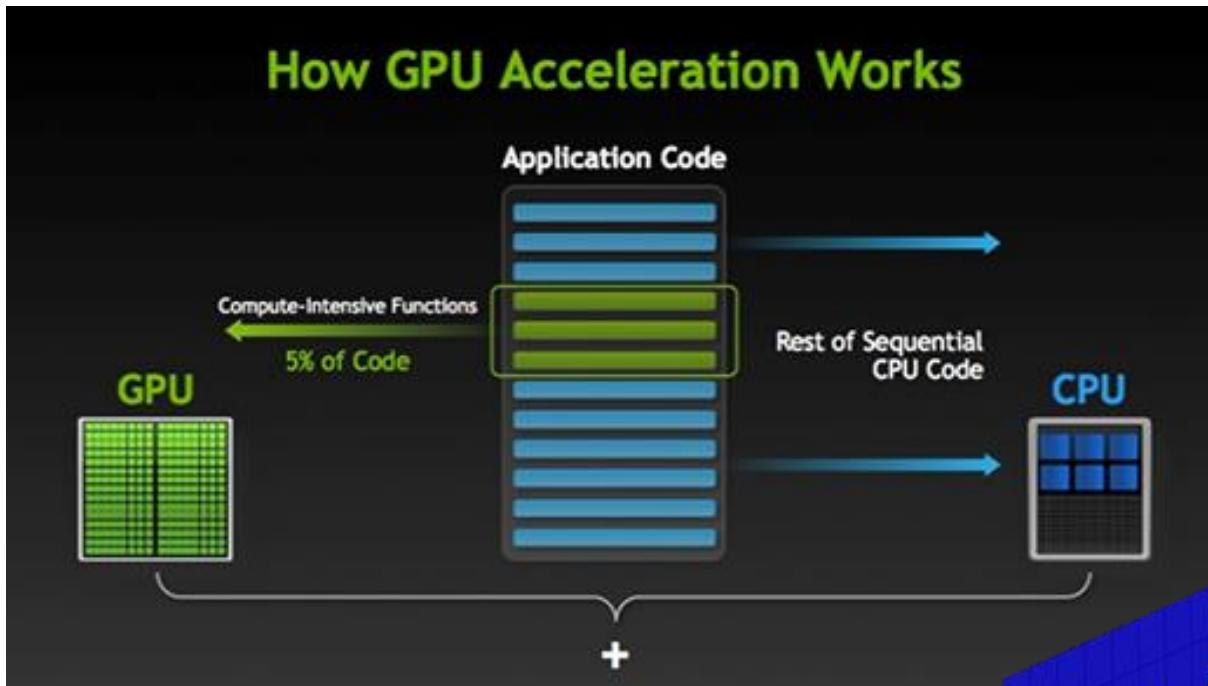
[Reply](#) [Retweet](#) [Star](#)



# IL DIVARIO DI PRESTAZIONI TRA CPU E GPU



# IL RUOLO DELLE GPU: IL CUORE DELLO HPC



Simulazione sismica per la stima di giacimenti di idrocarburi

# COMPUTER CHE VINCONO A DAMA.....

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Chinook vs. Marion Tinsley: 1994



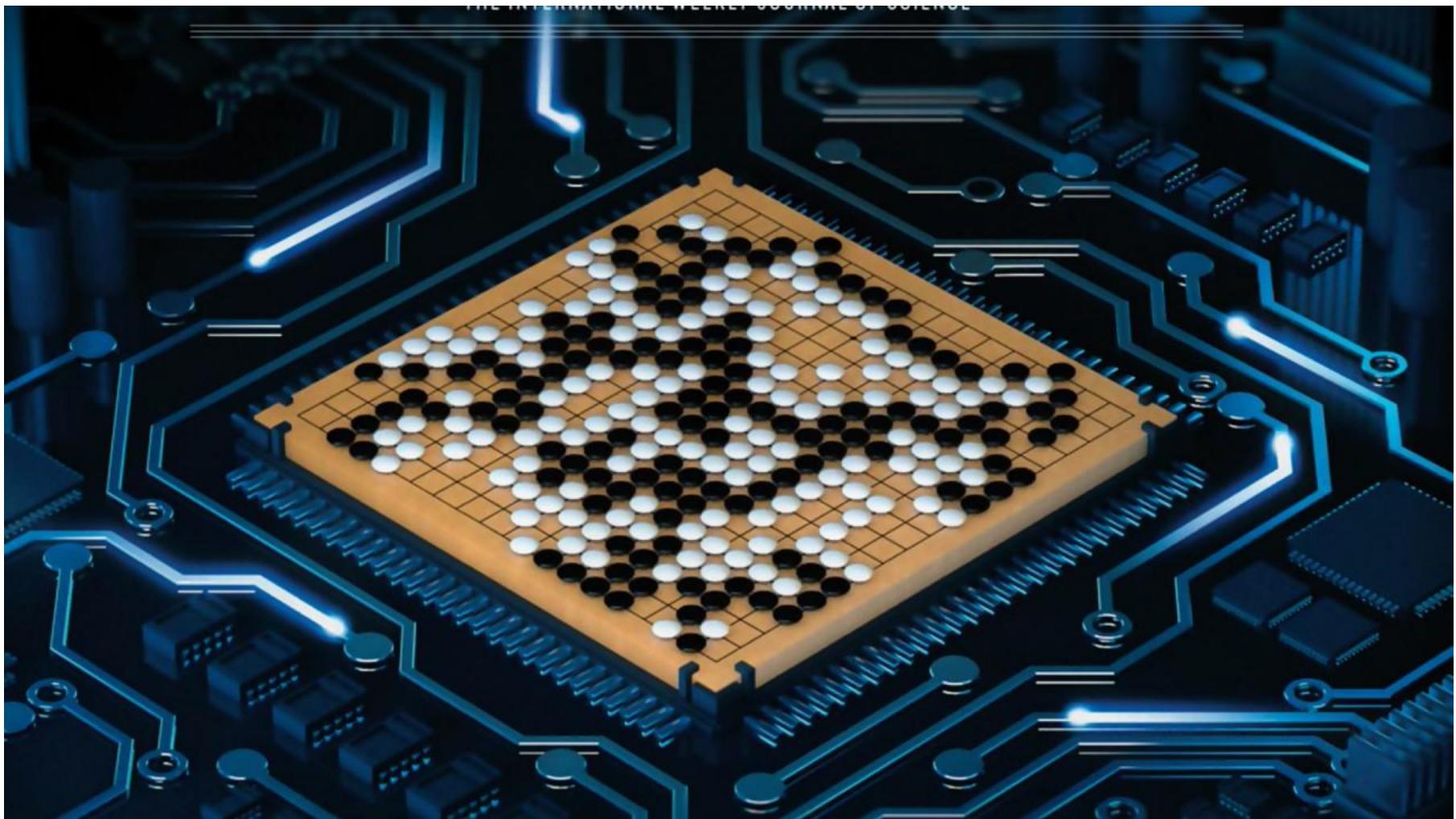
...A SCACCHI.....

IBM Deep Blue vs. Garry Kasparov: 1997



# ....A GO

DeepMind – AlphaGO vs. Lee Sedol: 2016



If a computer can train itself to be the best Go player by watching the best human players, what's to stop it from teaching itself how to be the best at anything else?

*Guy Suter - Notion*

# COGNITIVE COMPUTING (1/4)

IBM Watson vs. Brad Rutter & Ken Jennings: 2011



# COGNITIVE COMPUTING (2/4)

Carnegie Mellon University's NELL – machine learning: 2010 -> ...

## NELL: Never-Ending Language Learning

Can computers learn to read? We think so. "Read the Web" is a research project that attempts to create a computer system that learns over time to read the web. Since January 2010, our computer system called NELL (Never-Ending Language Learner) has been running continuously, attempting to perform two tasks each day:

- First, it attempts to "read," or extract facts from text found in hundreds of millions of web pages (e.g., `playsInstrument(George_Harrison, guitar)`).
- Second, it attempts to improve its reading competence, so that tomorrow it can extract more facts from the web, more accurately.



So far, NELL has accumulated over 50 million candidate beliefs by reading the web, and it is considering these at different levels of confidence. NELL has high confidence in 2,750,904 of these beliefs — these are displayed on this website. It is not perfect, but NELL is learning. You can track NELL's progress below or [@cmunell on Twitter](#), browse and download its [knowledge base](#), read more about our [technical approach](#), or join the [discussion group](#).

# COGNITIVE COMPUTING (3/4)

Carnegie Mellon University's NELL – machine learning: 2010 -> ...

## Recently-Learned Facts

Refresh

Instance	Iteration	date learned	confidence	Like	Retweet
<a href="#">wc_all_rooms</a> is an <a href="#">office building room</a>	982	04-mar-2016	90.0		
<a href="#">franklin_park_zoo_in_boston</a> is an <a href="#">aquarium</a>	979	20-feb-2016	91.4		
<a href="#">n3_nautical_miles</a> is a <a href="#">parlour game</a>	979	20-feb-2016	91.0		
<a href="#">em_poker_instruction_texas</a> is a <a href="#">board game</a>	979	20-feb-2016	100.0		
<a href="#">avone_3gp_video_converter</a> is a <a href="#">consumer electronic device</a>	980	26-feb-2016	100.0		
<a href="#">the_national</a> is a bank <a href="#">in _america</a>	979	20-feb-2016	100.0		
<a href="#">state_university</a> is a sports team <a href="#">also known as utah_state_university</a>	979	20-feb-2016	99.9		
<a href="#">diana</a> got married in <a href="#">n1981</a>	983	11-mar-2016	100.0		
<a href="#">people_participated_in</a> the event <a href="#">traffic_offenses</a>	979	20-feb-2016	93.8		
<a href="#">orchestra</a> was born in <a href="#">chicago</a>	983	11-mar-2016	100.0		

# COGNITIVE COMPUTING (4/4)

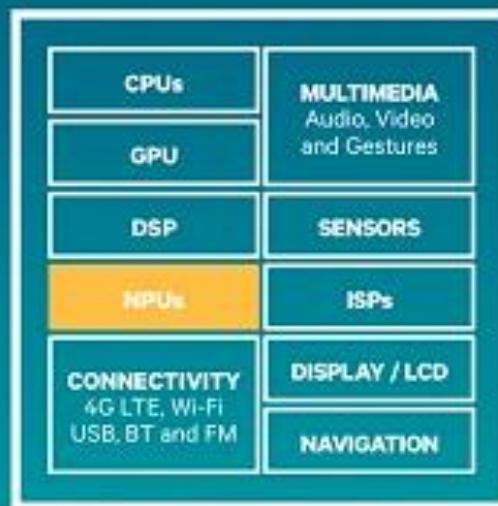
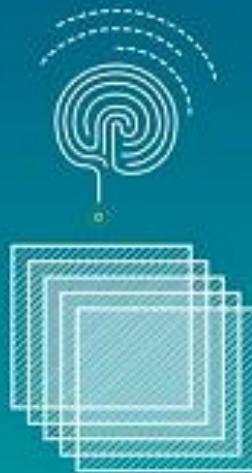
Google Deep Mind – AlphaGO: 2016



# NUOVE ARCHITETTURE: RETI NEURALI FISICHE

## Neural Processing Units (NPUs)

A new class of processors mimicking human perception and cognition



**Massively parallel,  
reprogrammable**

**Comprehensive tools**

**Human-like functions**

# CHIP NEUROMORFICI

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- Carver Mead (1980)
- Stanford University Neurogrid
  - Simulazione di un milione di neuroni e 6 miliardi di sinapsi in tempo reale
- Human Brain Project
  - Tentativo di simulazione di un cervello umano completo in un supercomputer usando dati biologici
- IBM TrueNorth
  - 4096 HW cores che simulano  $2^{20}$  neuroni (circa un milione), ognuno con 256 sinapsi per un totale di  $2^{28}$  sinapsi (circa 268 milioni)
- Qualcomm Zeroth NPU

**Thank You**

TapadhLeat Buznyg Köszönöm Murakoze aDank Grazzi  
Shukriya TapadhLeibh WaadMahadsantahay FaafetaiLava Murakoze aDank Grazzi  
ThintKo TapadhLeibh AsanteSana FaafetaiLava Murakoze aDank Grazzi  
Blagodaram Waita Ngiyabonga Enkosi Nouari  
Rahmat Dhanayavat Takk Enkosi Nouari  
Matondo Matondi Dhanayavat Bedankt Zikomo  
Mercé Mercé Dhanayavat Trugarez Aabhar  
Taiku Taiku Dhanayavat TeşekkürEdirmin Sobodi AabharAaha  
Dakujem Mamun Tanemirt Vinaka Barkal KurreSumanga  
Toda Toda KeYaLeboha Tenki Gracias  
Mersi Anké Nizzik ajr Aguyjé Danke Danke  
Dhanyavadagalu Grandmercé Dhanyavadalu Sulpay Danke Danke  
Gràcies Blagodaria Nandri Spas Padis Gratzijs  
Faleminderit Merkzi Akun EsterikAsko Dankewol Dijsereut  
Efharisto Meharbani Nirringazzjak Bayarlalaa Obrigado Salamat Saha KamSahHamnida Multumesc  
Näjistuke Blagodaria Nandri Spas Padis Gratzijs  
Hvala CoxSagOlun Marahaba Diky Takkyiri  
Arigatō Wado Asante  
Danke Radmet MaloTeOfa Gracie  
Danke Radmet Misadtra Akpe  
Chnorakaloutioum Mlesker Trugere  
Ačiū KopKhunKrap Tau Nanni  
Dankie Danks Barkal Yekeniele  
TänanVäga KhoobChaDeu  
Tak Sagoluñ  
Gracias Ago Tanmit Akiba  
Motashakkeram KopKhunKha