To Cloud or Not To.

An exploration of the economics of clouds and cyber-security.

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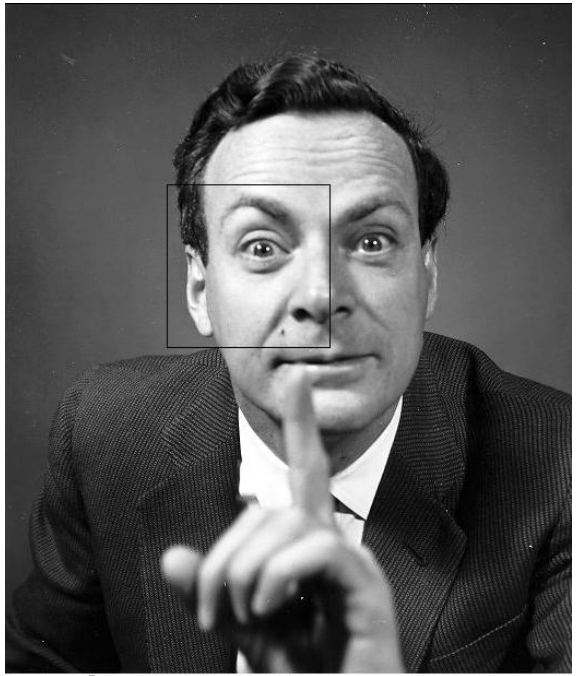
Microsoft Research FacultySummit

National Science Foundation WHERE DISCOVERIES BEGIN

STONY BROOK COMPUTER SCIENCE

ver 2.2 widescreen

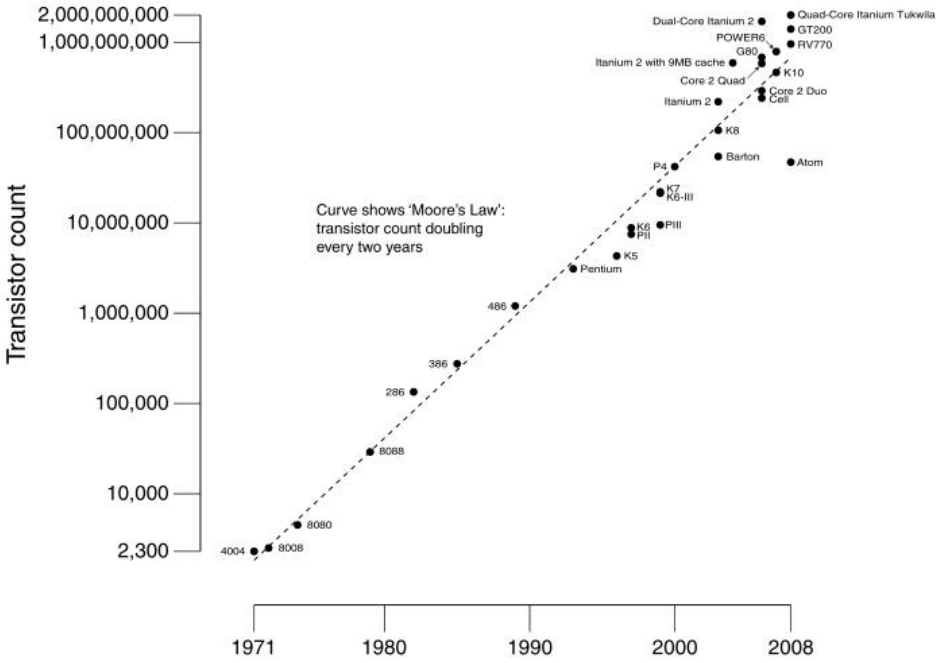
Feynman Moment

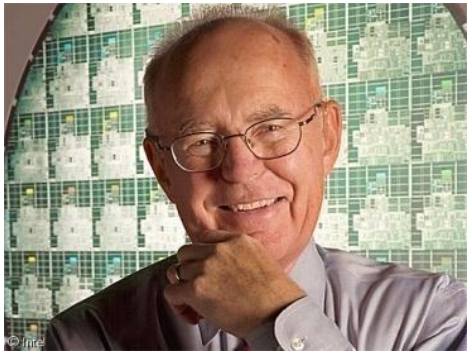


"I have experience only in teaching graduate students […] and as a result […] I know that I don't know how to teach."

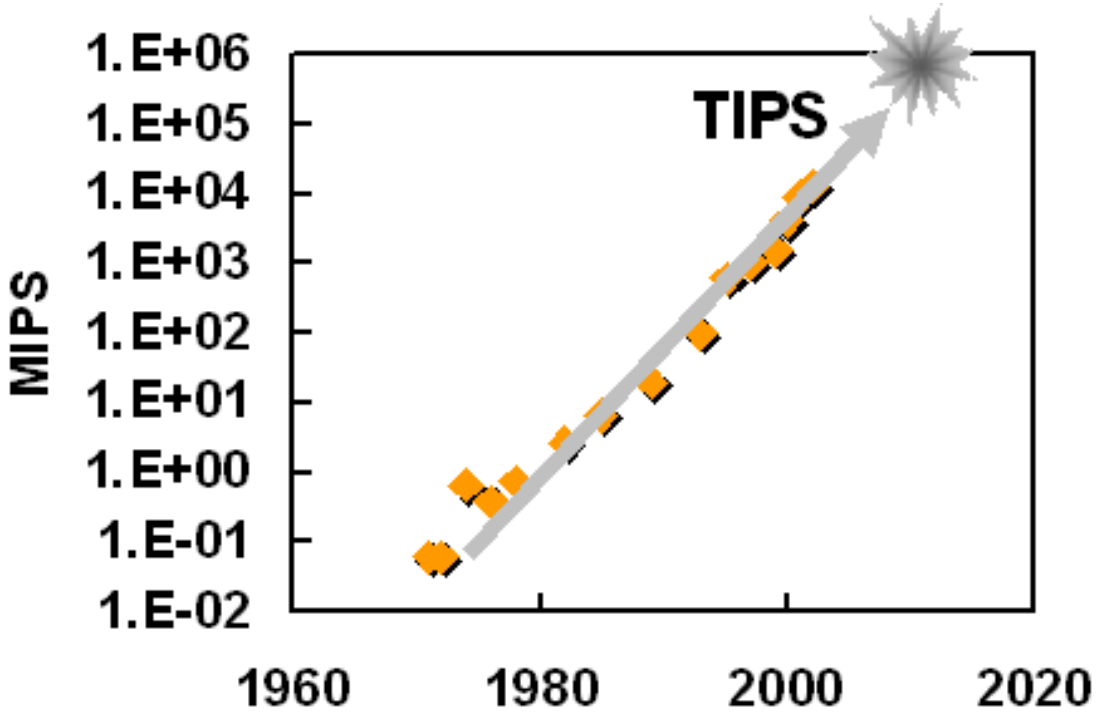
please interrupt and engage!

Density


Transistor count
2,000,000,000
1,000,000,000
100,000,000
10,000,000
1,000,000
100,000
10,000
2,300
1971
1980
1990
2000
2008
Curve shows 'Moore's Law': transistor count doubling every two years
4004
8008
8080
8088
286
386
486
Pentium
K5
PII
K6
PIII
K7
K6-III
P4
Barton
K8
Itanium 2
Core 2 Duo
Cell
Core 2 Quad
Itanium 2 with 9MB cache
K10
G80
POWER6
RV770
GT200
Dual-Core Itanium 2
Quad-Core Itanium Tukwila
Atom

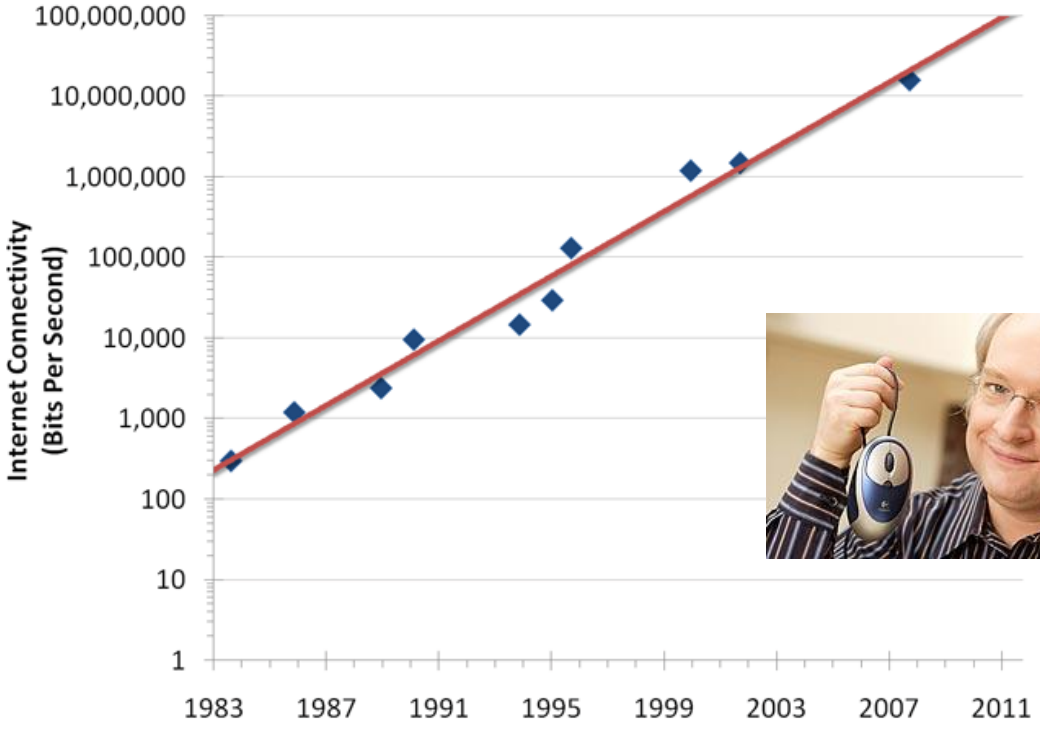


Speed



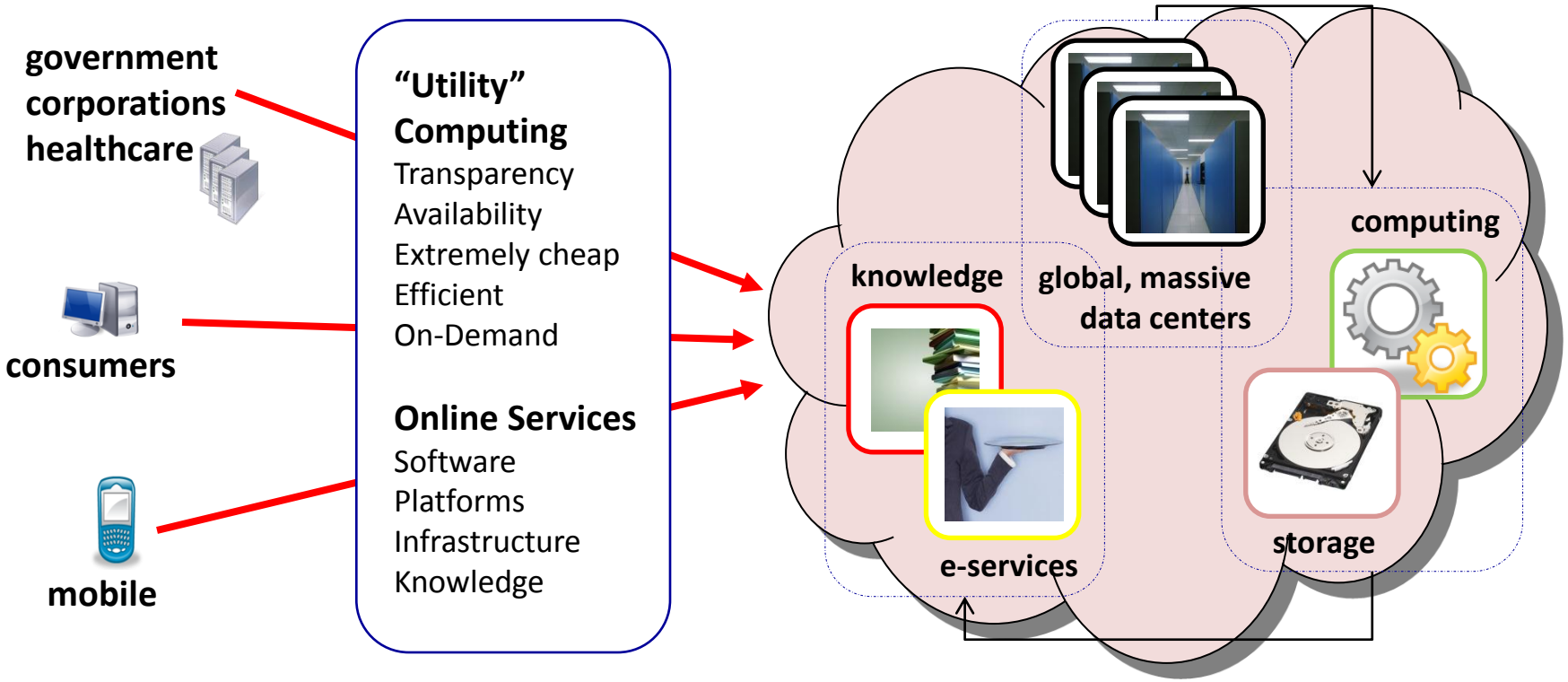
Source: "Gigascale Integration-Challenges and Opportunities", Shekhar Borkar, Director, Microprocessor Technology, Intel

Networks



"high end connection speed grows 50% per year"

The cloud


government
corporations
healthcare
consumers
mobile
"Utility" Computing
Transparency
Availability
Extremely cheap
Efficient
On-Demand
Online Services
Software
Platforms
Infrastructure
Knowledge
knowledge
global, massive data centers
computing
e-services
storage

Clouds v. Grids v. …

+ Control Structure
+ Illusion of “Unlimited”
+ No up-front commitment (“pay as you go”)
+ On-demand
+ (Very) Short-term allocation
+ Close to 100% Transparency
+ Increased Platform Independence
+ It is actually here and happening!

Buzzword Bandwagon

On your marks, get set, GO

Race to results with the powerful Sun Grid Compute environment and our first class catalog of applications!

» Learn More

ON DEMAND BUSINESS™

10g

ORACLE DATABASE

Flavors

Traditional Outsourcing [(Semi)Private Clouds]
ACME Corp. manages servers for XYZ Financials

Clouds
Amazon EC2, Google Apps, MS Azure

Managed servers

Un-managed hardware

Should I buy it?

costs vs. benefits

costs
technology costs
cost of security
etc.

clients

benefits
availability
opportunity
consolidation
etc.

the “cloud”

Core costs of computing

+ Storage ($/MByte/year)
+ Computing ($/CPU Cycles)
+ Networking ($/bit)

Reality is way more mundane

Hardware

servers, disks, **network**, racks, power, cooling

Energy

power, cooling, infrastructure

People/Service

maintenance, development

Space

Size does matter

Home Users (1-10 CPUs)
"no" rent/cooling/administration

Small Enterprises (up to 1k)
no custom hardware, low utilization

Mid-size Enterprises (up to 20k)
better network service, better utilization

Large/Clouds (50k+)

Clouds

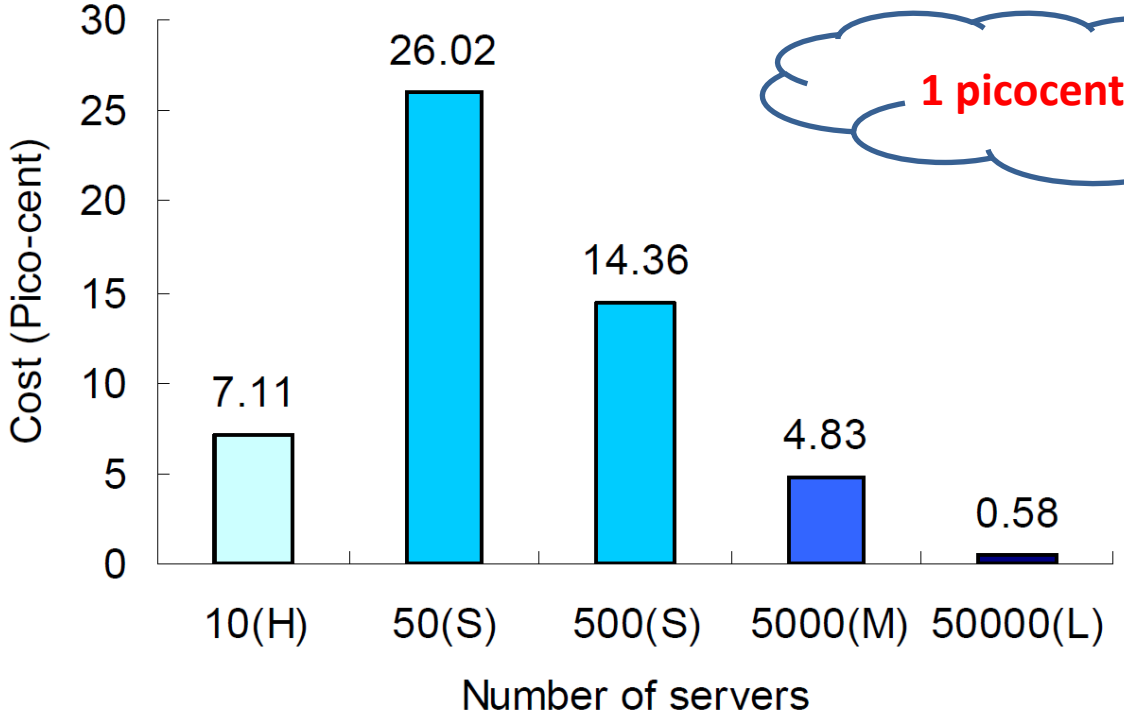
+ Custom hardware
+ Efficient cooling
+ Cross-timezone load shifting
+ High CPU utilization
+ Preferential network deals
+ High Power Usage Efficiency (PUE)

Understand cost of CPU cycle

Parameters	H	S	M	L
CPU utilization	5-8%	10-12%	15-20%	40-56%
server:admin ratio	N.A.	100-140	140-200	800-1000
Space (sqft/month)	N.A.	$0.5	$0.5	$0.25
PUE	N.A.	2-2.5	1.6-2	1.2-1.5

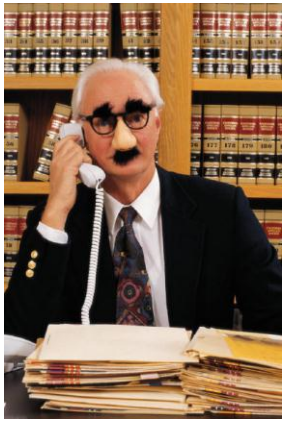
$$\frac{\lambda_s \cdot N_s/\tau_s + (w_p \cdot \mu + w_i \cdot (1-\mu)) \cdot PUE \cdot \lambda_e + \frac{N_s}{\alpha} \cdot \lambda_p + \lambda_w \cdot N_w/\tau_w + \lambda_f \cdot \frac{(w_p \cdot \mu + w_i \cdot (1-\mu)) \cdot PUE}{\beta}}{\mu \cdot \nu \cdot N_s}$$

CPU cycle cost (circa 2009)

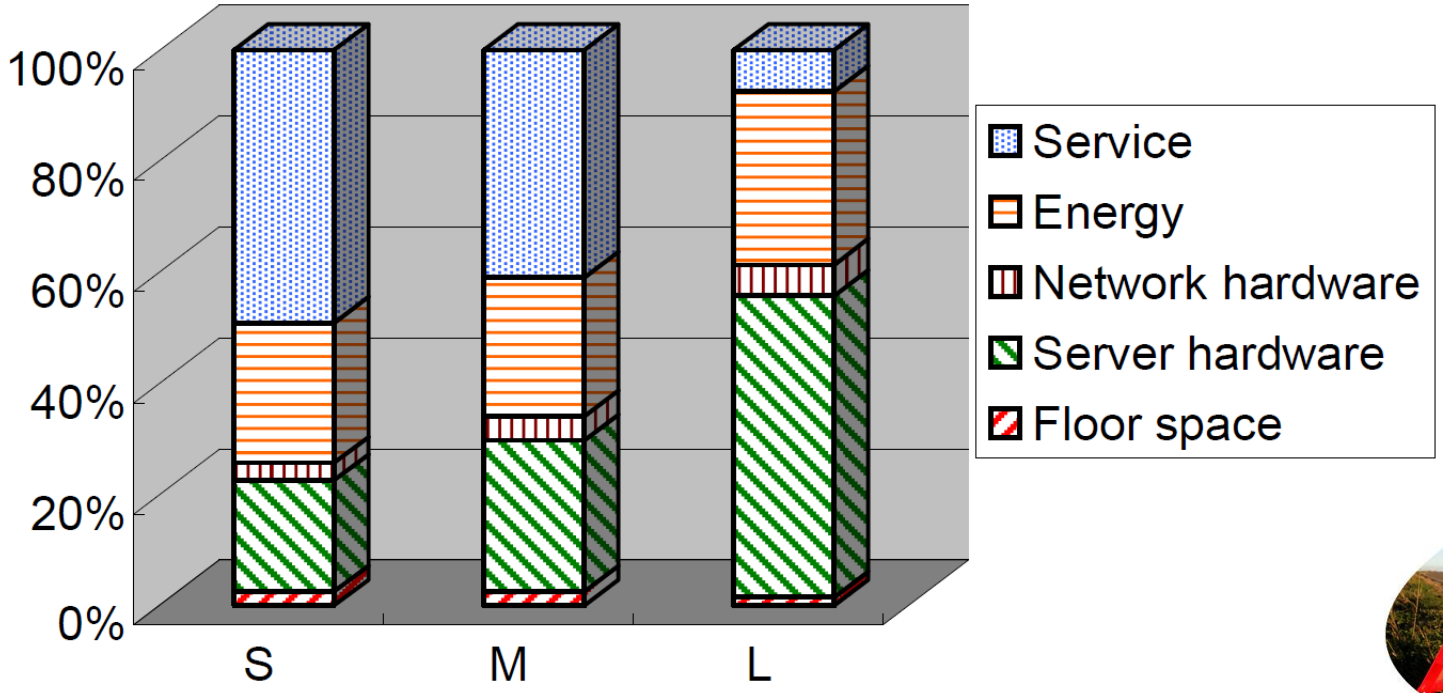


1 picocent = 10^{-14} USD

Consumer clouds today

Provider	Picocents
	0.5 – 2.31
	0.7 – 1.96
	0.93 – 2.36
	0.02 – 2.4

Breakdown


100%
80%
60%
40%
20%
0%
S
M
L
Service
Energy
Network hardware
Server hardware
Floor space

So: is it worth it?

Mostly yes …

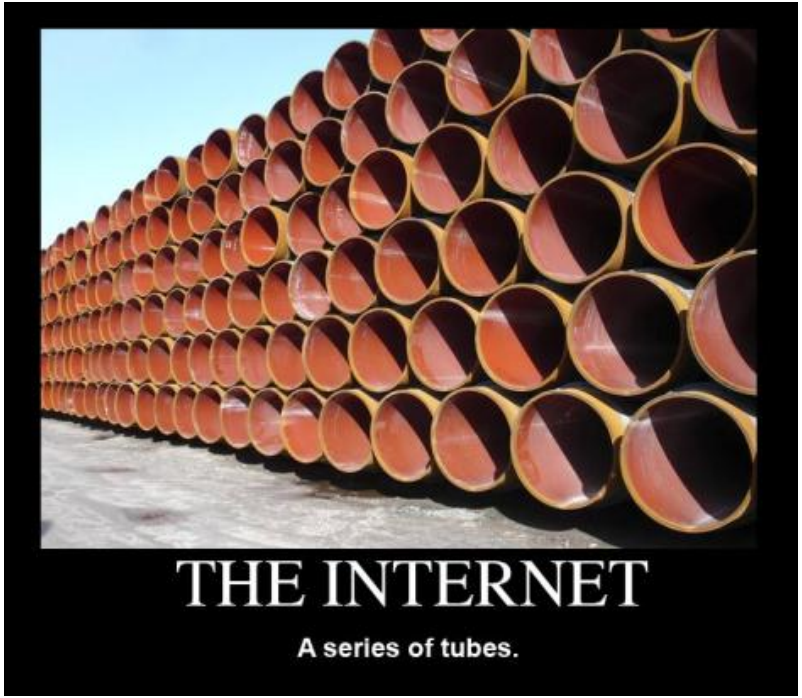
Why ?

1 client cycle
6-27 US picocents

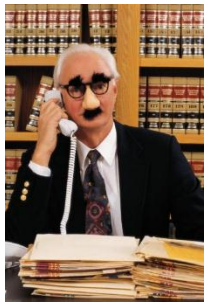
clients

1 cloud cycle
0.58 picocents

What about the tubes?



We are far!

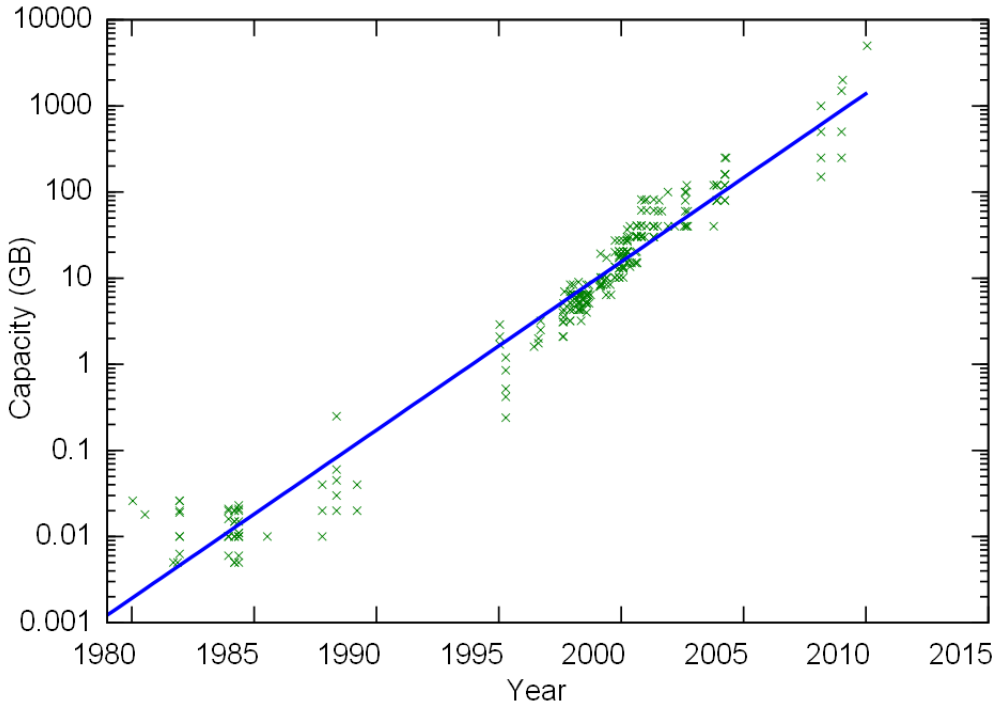
provider	monthly	bandwidth (d/u)	picocent/bit
	$29.95	15 Mbps /5 Mbps	77/231
	$44.9	30 Mbps /5 Mbps	58/346
	>$1000	5-1000 Mbps	5000 (est.)
	$19.99	1 Mbps/384 Kbps	771/2008
	$29.99	3 Mbps/768 Kbps	386/1506
	$42.99	7.1 Mbps/768 Kbps	233/2160
Mid-size	$95 (est.)	1 Mbps (dedicated)	3665 (est.)
Large/cloud	$13 (est.)	1 Mbps (dedicated)	500 (est.)

Additional ammunition?

Disk	cap. (GB)	price (USD)	Adj. MTBF (mil.hrs)	amort. acq. (pcent/bit/yr)	power seek (W)	power2 idle (W)	power3 (W)	power cost (pcent/bit/yr)	total cost (pcent/bit/yr)	acq. %	avg. seek time (ms)	avg. seek4 cost (pcents)	power5 read (W)	read cost (pcent/bit)
Maxtor Diamond Max	500	53	0.35	32.89	13.6	8.10	10.85	237.62	270.50	12.16	9.00	377542	11.16	0.03
Hitachi Deskstar 7k500	500	67	0.29	49.89	15	9.60	12.30	269.37	319.26	15.63	8.50	407953		
Hitachi Ultrastar A7K1000	1024	153	0.35	46.36	14	9.00	11.50	122.97	169.33	27.38	8.20	417631		
WD Caviar GP Low Power	1024	103	0.29	37.45	7.5	4.00	5.75	61.49	98.93	37.85	8.90	271994	7.40	0.02
Seagate Barracuda 7200.10	750	63	0.35	26.06	12.6	9.30	10.95	159.87	185.93	14.02	9.25	369615	13.00	0.06
WD Caviar SE16	500	62	N/A		8.77	8.40	8.59	188.01			9.90		8.77	0.04
Samsung SSD	32	269	0.29	3129.65	1	1.00	1.00	342.19	3471.83	90.14	1.70	47912	0.5	0.0017
Intel SSD X18-M	80	389	0.35	1508.59	0.15	0.06	0.11	14.37	1522.96	99.06			0.15	0.0002
Intel SSD X25-M	160	765	0.35	1483.38	0.15	0.06	0.11	7.19	1490.57	99.52			0.15	0.0002

Up to 350 for 3 year lifetime!

Storage capacity over time



So: should I buy a piece of sky?

… not always.

CPU Cycle
6-27 picocents

1 bit storage/year
6 picocents

clients

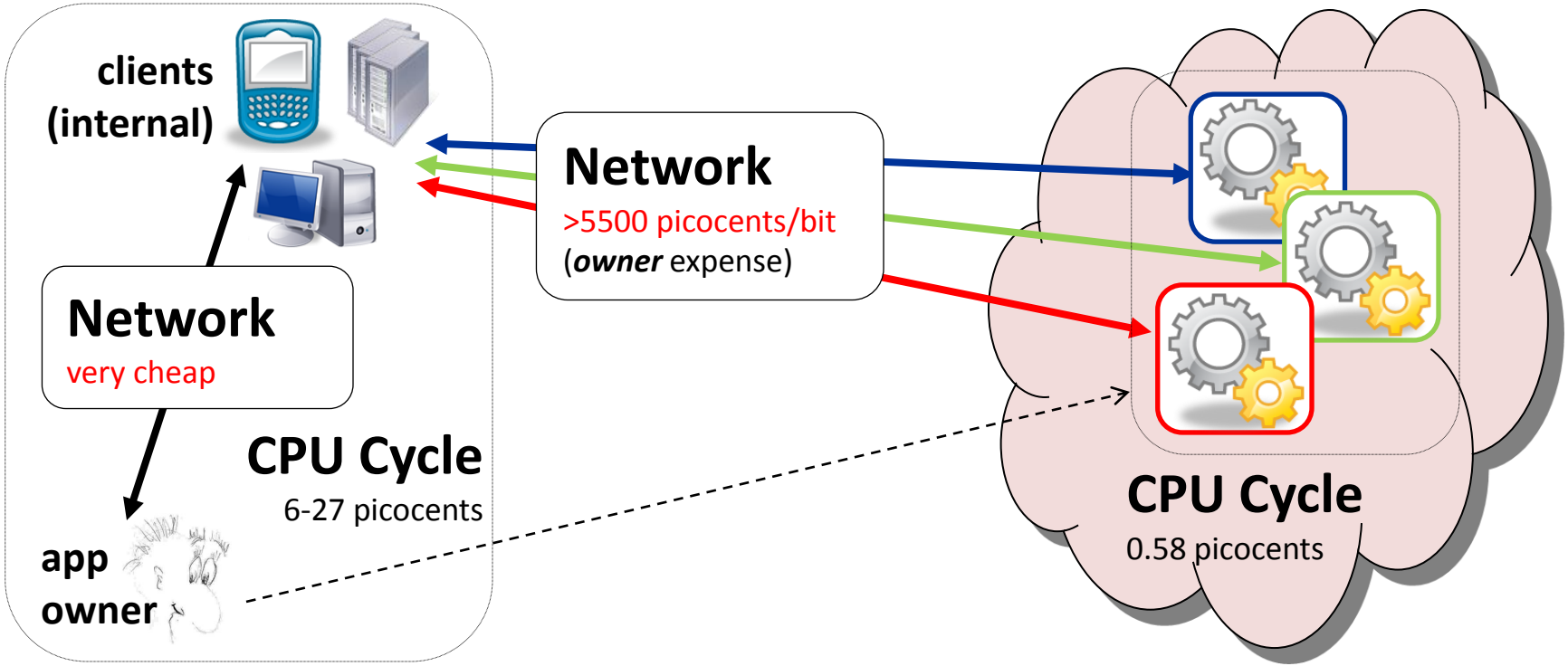
1 bit network transfer
800-6000 picocents

CPU Cycle
0.58 picocents

1 bit storage/year
5.3-6 picocents

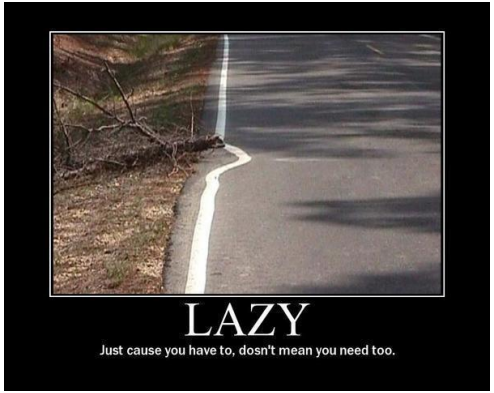

LIARLIAR

App Owner = Sole Client



So when is it clearly worth it?

Q: is the application doing enough computation work (cheaper) to offset the distance cost to the cloud?



First Principle of Cloud Viability

It is not worth outsourcing any task of less than 4000 CPU cycles per transferred 32-bit input.

Why should this hold tomorrow?

Difference of exponentials is exponential ☺

Moore vs. Nielsen

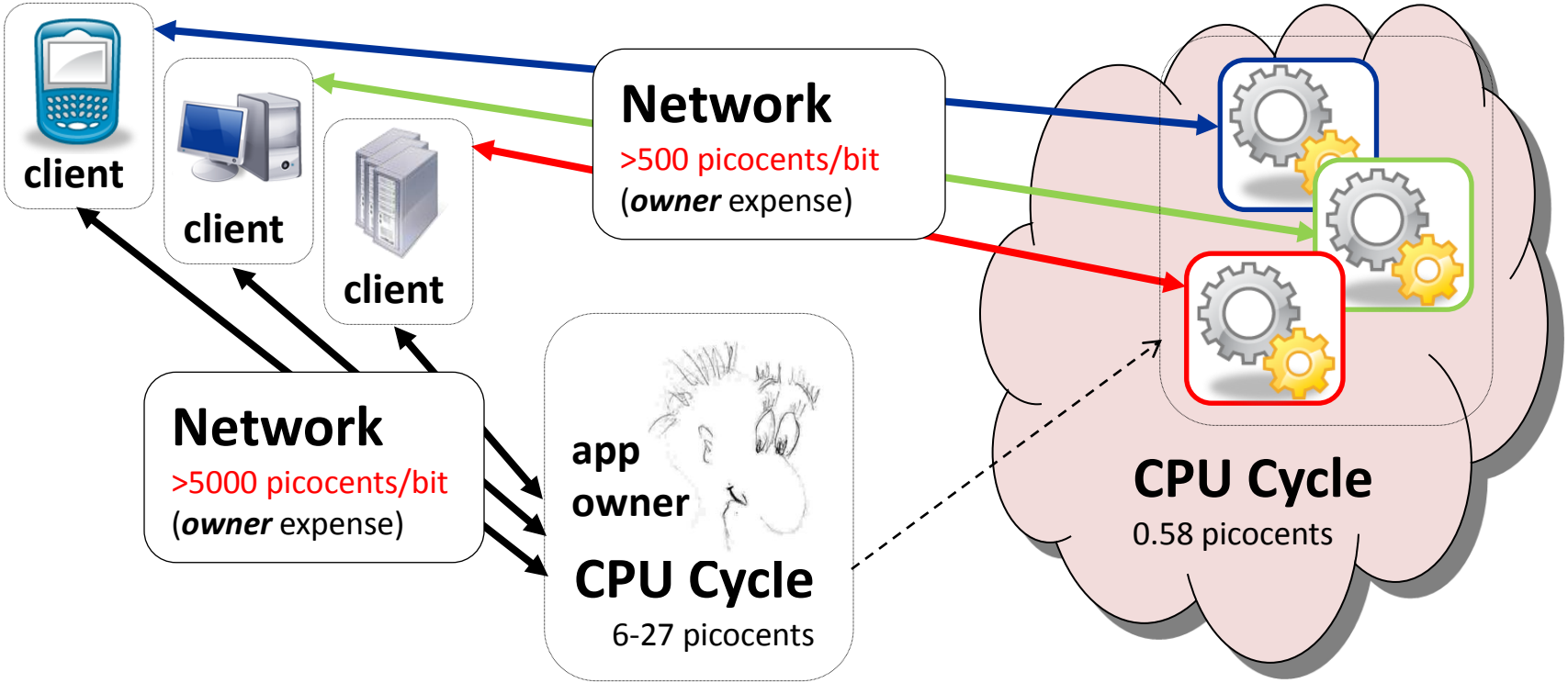

But wait theres more!
ICANHASCHEEZBURGER.COM

We had only partial view

The **actual question** to ask: what is the overall application profile (comp+net+storage)

Second Principle of Cloud Viability (paraphrased)
"It is almost always worth outsourcing"

App Owner != Client(s)



Thus

cloud deployment saves

+ >4500 picocents per client-to-app traffic bit

+ tens of picocents per CPU cycle.

What about other goodies?

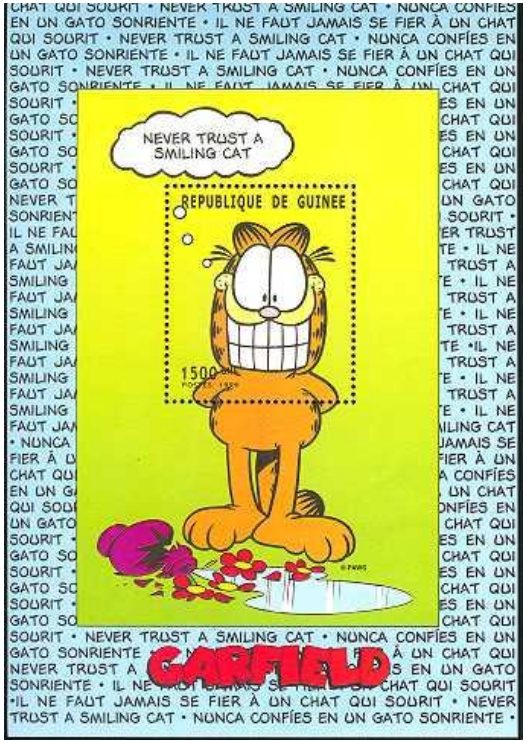
Primitive	Picocents
CPU Cycle	0.58 - 26
Disk Access /bit	0.02 - 0.06
Disk Access+DMA /bit	0.023- 0.11
Disk Seek	**270,000 - 417,000**
Disk Store /bit/hr.	0.011 - 0.036
Disk am. acq. /bit/hr.	0.003 - 0.0057
SDRAM am. acq. /bit/hr.	5.96 - 32.96
SDRAM Access /bit	0.003 - 0.05

Are clouds more or less secure?

+ Yes
+ But what is security?!

Trusting stuff …

"behave in the *expected manner* for the *intended purpose*"



Usually the monkey gets you

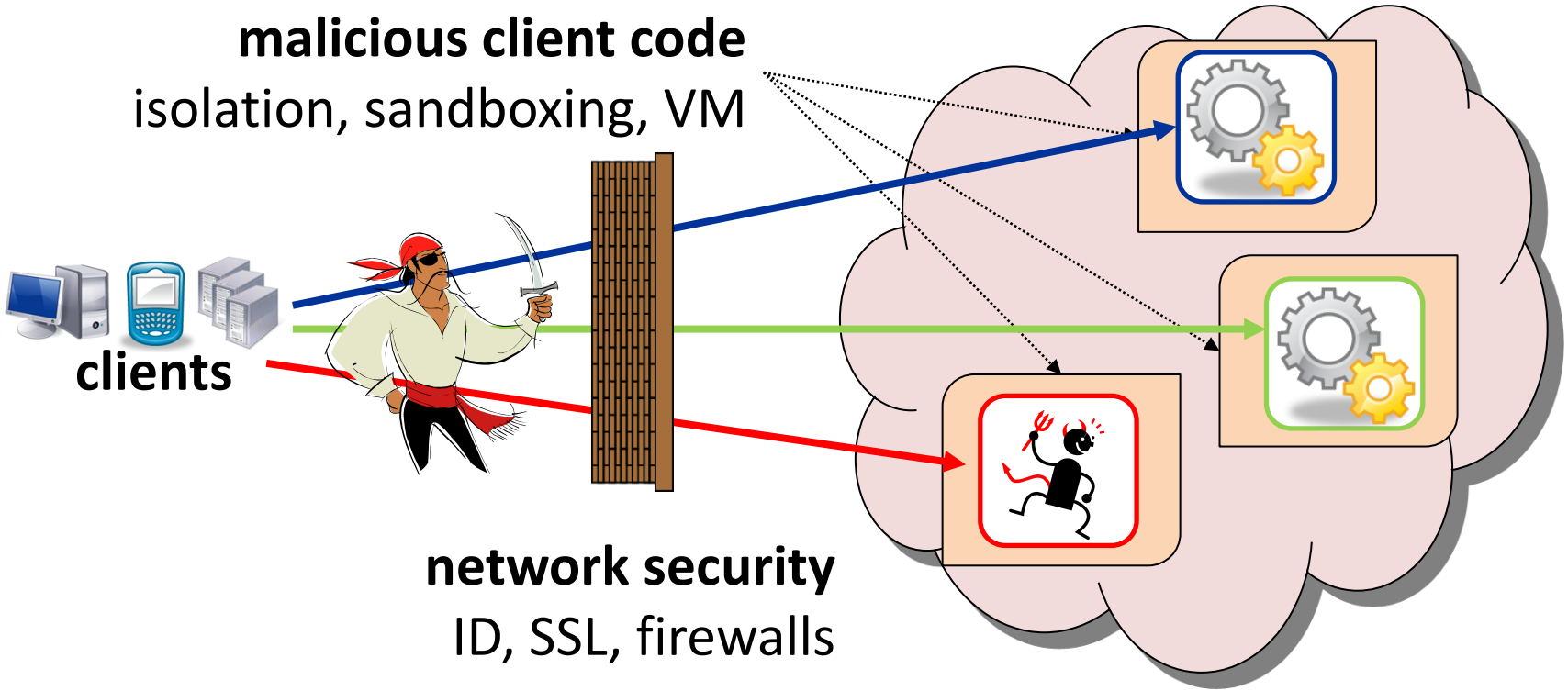
online public picture of ***actual*** key

_____ Voting Machine

Usual suspects

malicious client code

isolation, sandboxing, VM

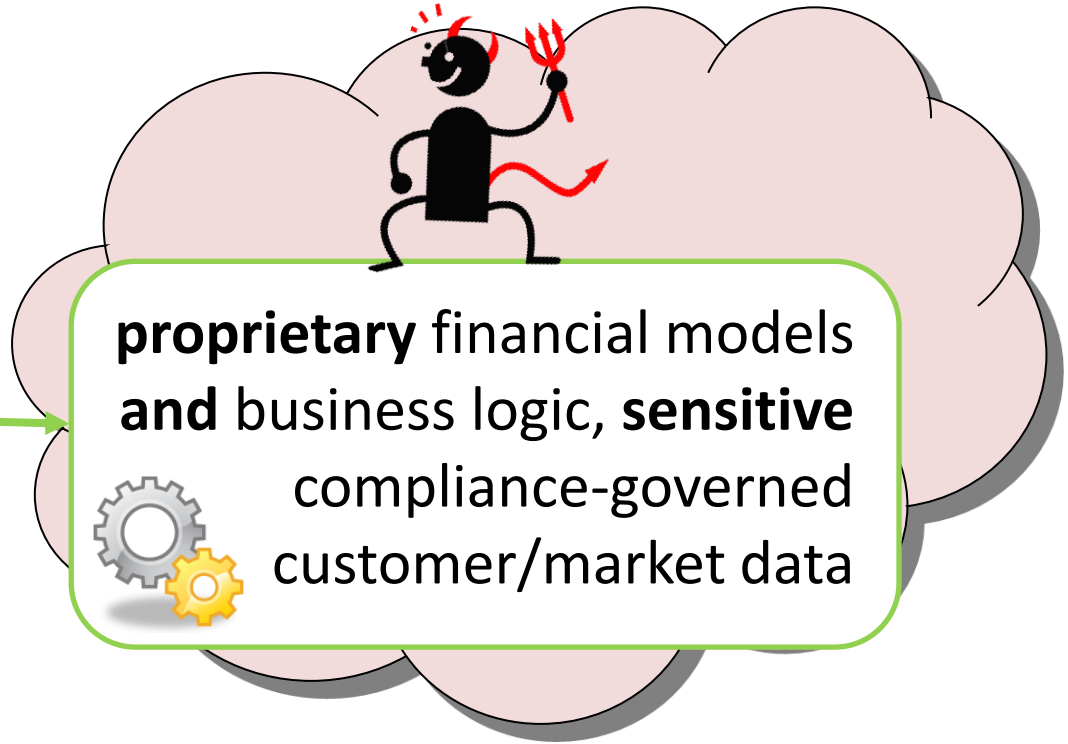


network security

ID, SSL, firewalls

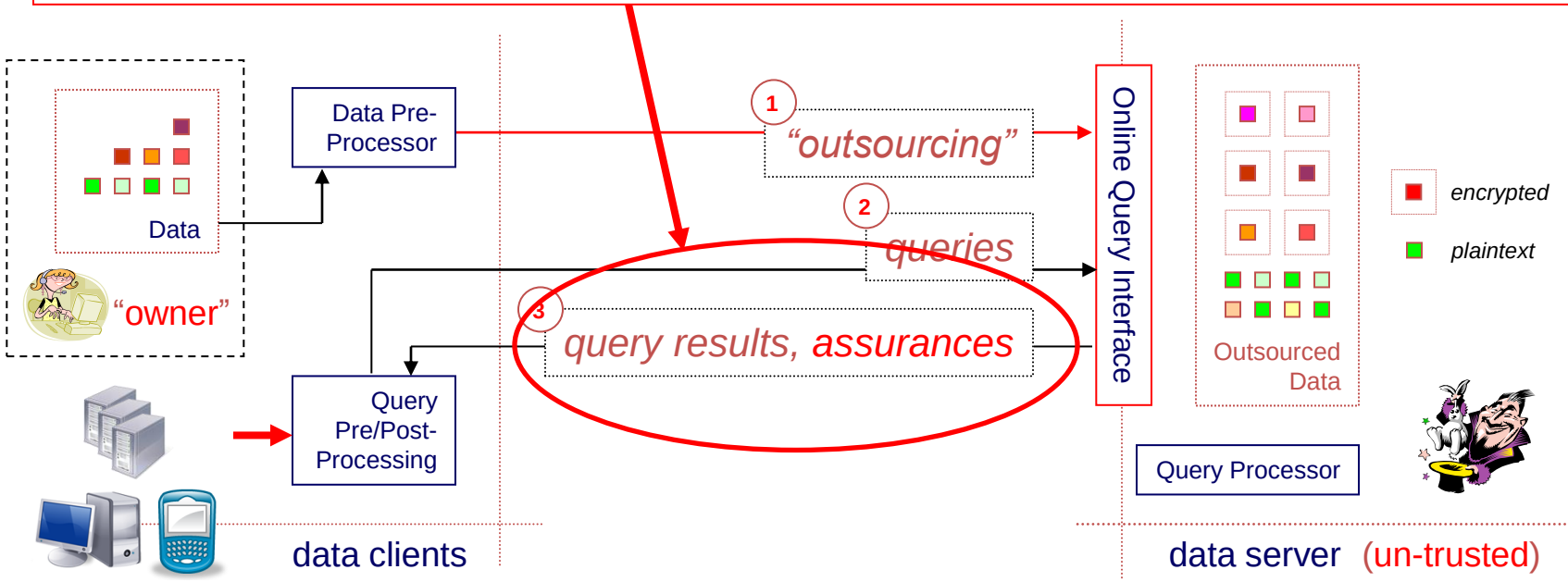
Secure Outsourcing

Finance Inc.



Ideas

assurances ⊆ {query correctness, data confidentiality, access privacy}



Brute-forcing 80 bit key?

Oracle costs ~ 1 picocent/bit.

2^{80} x 80 / 2 = 5 x 2^{83} picocents

~ **$483.5 billion**

for 64 bits … **$5 million** ☺

What can you buy with $1 ?

500,000 2048-bit DSA sigs

(in the comfort of your home)