Internet Architecture

Tuesday 16:50-18:35, 2026

http://hiroshi1.hongo.wide.ad.jp/hiroshi/lecture/IST-internet/

Hiroshi Esaki (江崎 浩)

<hiroshi@wide.ad.jp>

How our class goes ?

1. In April 7, 14, 21, 28) : Presentation by Esaki
   - ✓ Your question or opinion should be submitted via ITC-LMS
2. **Presentation by students from May 12, 2024**
   - ✓ **About 20 min. (plus Q&A 10 min.) per person**
   - ✓ **Check attendees at every class using ITC-LMS/UTOL.**
   - ✓ **Pick some topic related with the Internet (technology, business, policy, governance). How the topic is related with the Internet should be discussed in the presentation.**
3. Reports
   - i. Mini report at April 7th via ITC-LMS (April 14, 7:00AM)
   - ii. Topic, that you presented in the class

Mini-Report on April 7, 2024

submit via ITC-LMS

(deadline; April 14, 7:00AM)

1. Your opinion on the Yuval Noah Harari ‘s contribution to TIME on March 15, 2020, while considering about the roles and architecture of the Internet.
2. Your opinion on the presentation by Prof.Lawrence Lessig at OSCON2002.

(*) When you want to submit by file(s), please send file(s) via email, hiroshi@wide.jp

Objects of this class

- Think about
  - Where the Internet goes ?
  - What are the contributions by digital ?
  - What is the architectural essences of the internet ?
  - Future/new technologies for the Internet ?

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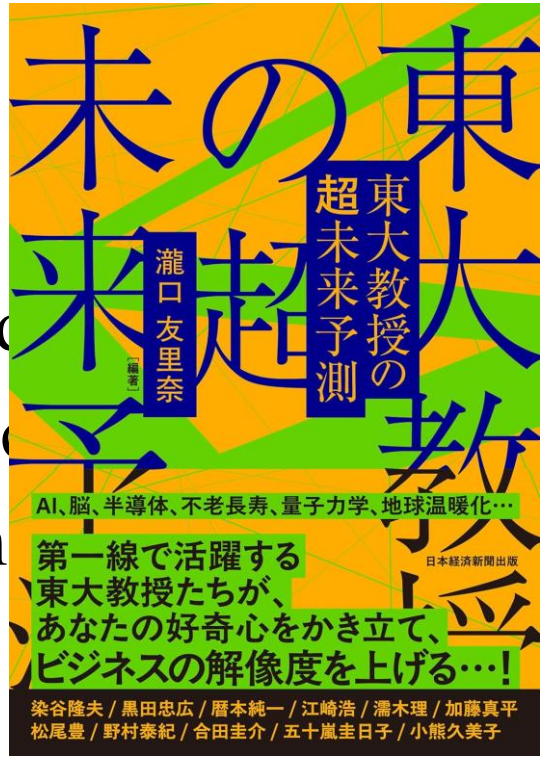


Impact of COVID-19

Impact of COVID-19

1. The Internet has **been working !**

   ➔ **Why the Internet had worked ? Architecture**

2. All of social and industrial activities on the earth will be mutated/changed **toward the system premising "online", i.e., online-first, cyber-first and Internet-first**.

   ✓ Only the organizations, that can transform, can survive.

(1) Facebook | The Internet, designed to survive | 『サピエンス全史』のユヴァル・ノア・ハ

https://www.washingtonpost.com/technology/2020/04/06/your-internet-is-...

Sections | The Washington Post — Democracy Dies in Darkness | Get 1 year for $29 | Sign in

Home | Share | 33

Your Internet is working. Thank these Cold War-era pioneers who designed it to handle almost anything

Coronavirus may have forced people to stay at home, but the Internet these scientists envisioned long ago is keeping the world connected

Internet pioneer Vinton Cerf in May 2015 at Google's offices in Washington, D.C. (Bill O'Leary/The Washington Post)

By **Craig Timberg**

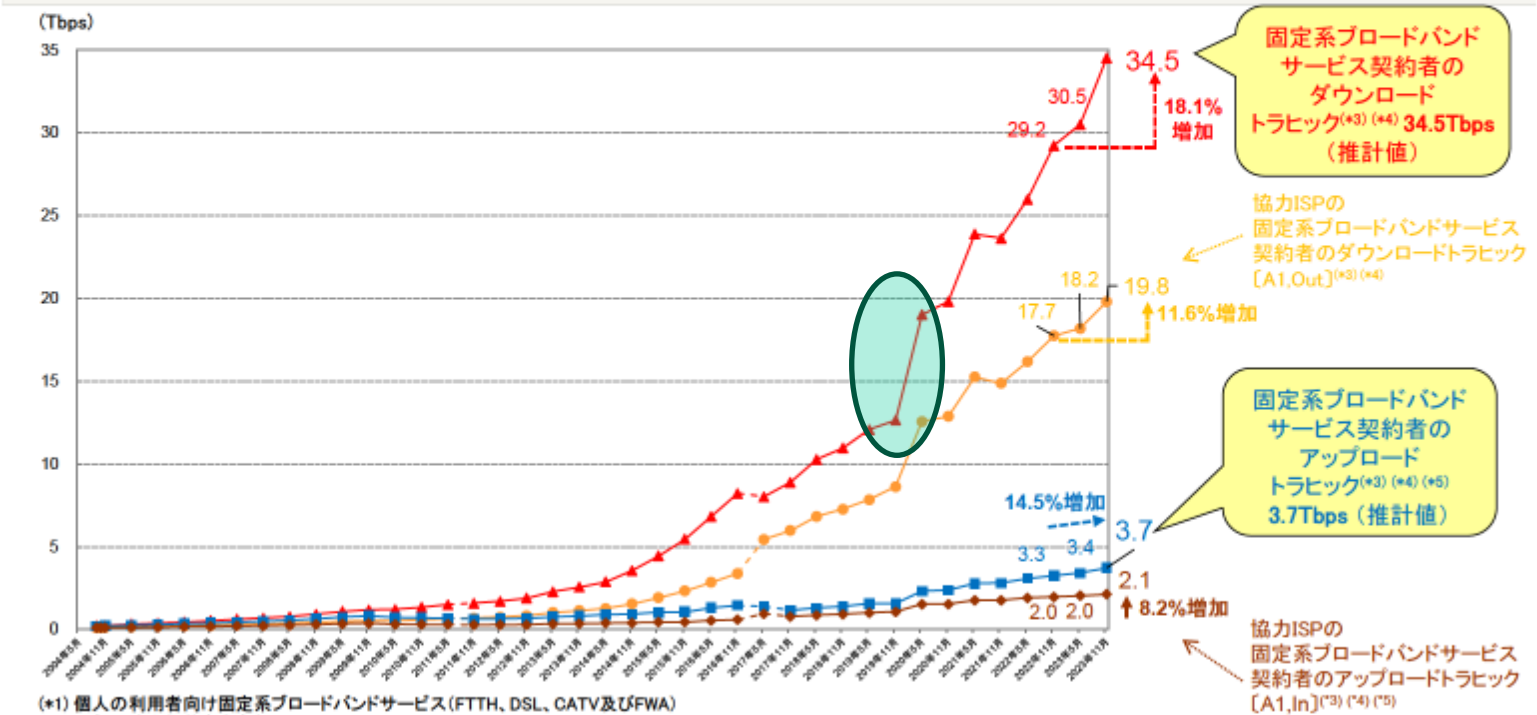
April 7, 2020 at 4:48 a.m. GMT+9

https://www.washingtonpost.com/technology/2020/04/06/your-internet-is-working-thank-these-cold-war-era-pioneers-who-designed-it-handle-almost-anything/?fbclid=IwAR22ddVr18ib_UZDp76a2OMo6c2sS7Mjo_R_PIfj6_tctg04afAGGOosbh4

debilitating."

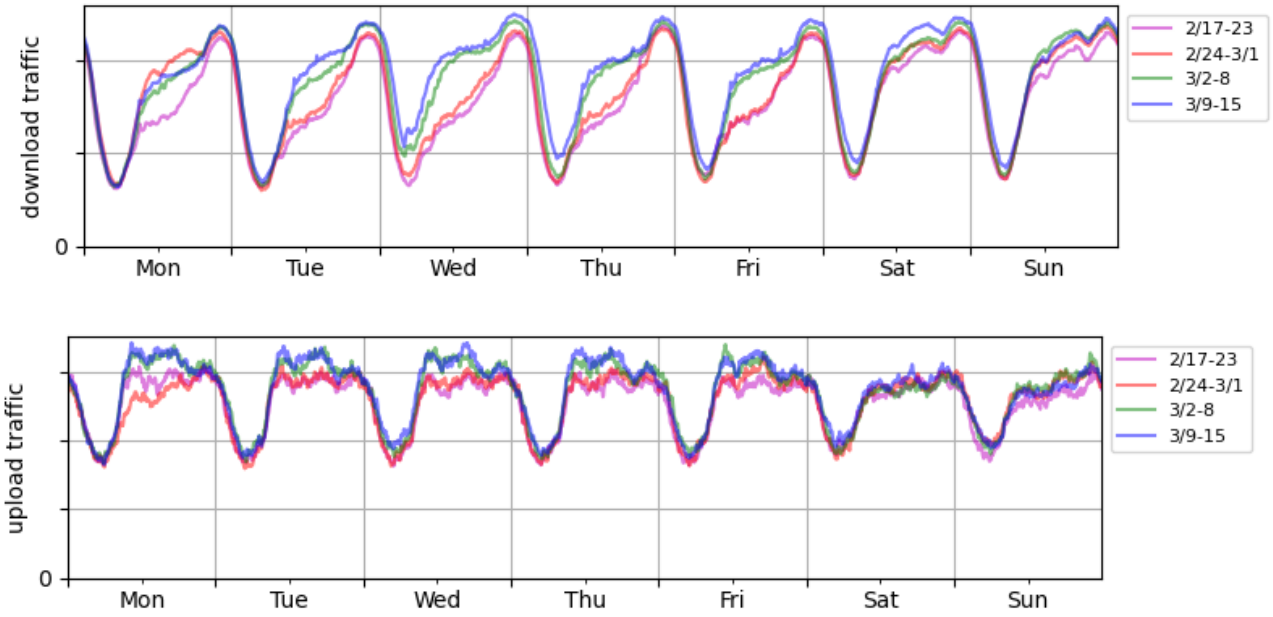
2. 我が国の固定系ブロードバンドサービス契約者のトラヒック（推計値）

○ 2023年11月の我が国の固定系ブロードバンドサービス(*1)契約者(*2)の**ダウンロードトラヒック**([A1,Out]から推計)は、約34.5Tbps（1日あたり約355.6 ペタバイト。前年同月比18.1%増）。
○ また、**アップロードトラヒック**([A1,In]から推計)は、約3.7Tbps（1日あたり38.3ペタバイト。前年同月比14.5%増）。

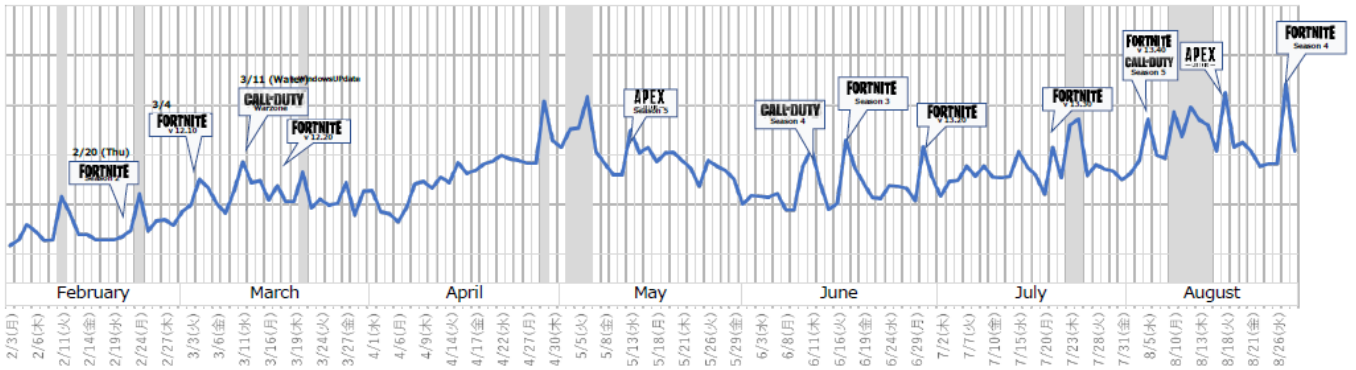


(*1) 個人の利用者向け固定系ブロードバンドサービス（FTTH、DSL、CATV及びFWA）
(*2) 一部の法人契約者を含む
(*3) 2011年5月以前は、一部の協力ISPとブロードバンドサービス契約者との間のトラヒックに携帯電話網との間の移動通信トラヒックの一部が含まれていたが、当該トラヒックを区別することが可能となったため、2011年11月から当該トラヒックを除く形でトラヒックの集計・推計を行うこととした
(*4) 2017年5月から協力ISPが5社から9社に増加し、9社からの情報による集計値及び推計値としたため、不連続が生じている
(*5) 2017年5月から11月までの期間に、協力事業者の一部において計測方法を見直したため、不連続が生じている

https://eng-blog.iij.ad.jp/archives/5536



ゲームのリリースとトラヒックの関連 by NTTCom OCN
（平日昼間帯 9時～17時の最大値）



FORTNITE
▲2020/02/20 Chapter 2, Season 2.
03/03 v 12.10
03/17 v 12.20
03/24 v 12.21
03/31 v 12.30
04/08 v 12.31
04/15 v 12.40
04/21 v 12.41
05/07 v 12.50.2
05/20 v 12.60
05/26 v 12.61
▲2020/06/17 Chapter Two, Season Three.
06/30 v 13.20
07/21 v 13.30
08/5 v 13.40
▲2020/08/27 Chapter 2 Season 4
v 14.00

CALL OF DUTY
▲3/11 (Wed) Call of Duty: Warzone
+ Windows Update
▲6/11 15: 00 ~ Season 4
▲8/5 Season 5

APEX LEGENDS
▲5/13 Apex Legend Season 5
▲8/18 Season 6

ゲーム配信時のトラフィック混雑状況を把握・解消するために、事前の配信情報入手や必要に応じて経路制御等を実施し各社対応している

Where the Internet goes ?

COVID-19 has accelerated and shall continue to accelerate the mutation of Cyber-First, Code-First, and Online-First.

Impact of COVID-19

1. The Internet has **been working**
2. All of social and industrial activities on the earth will be mutated/changed **toward the system premising "online", i.e., online-first, cyber-first and Internet-first**.
   ✓ Only the organizations, that can transform, can survive.

3. Social governance

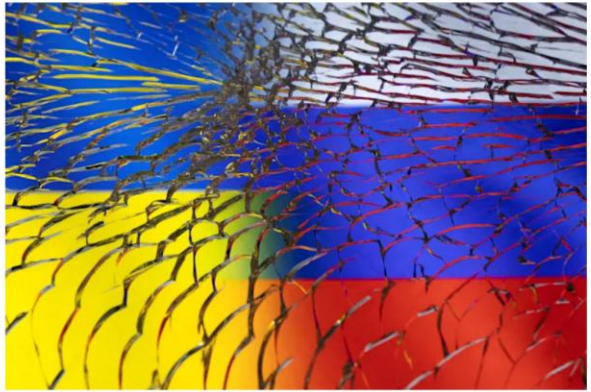
Also, by Ukraine war

ICANN says it won't kick Russia off the internet

Ukraine had petitioned the non-profit in response to the invasion.

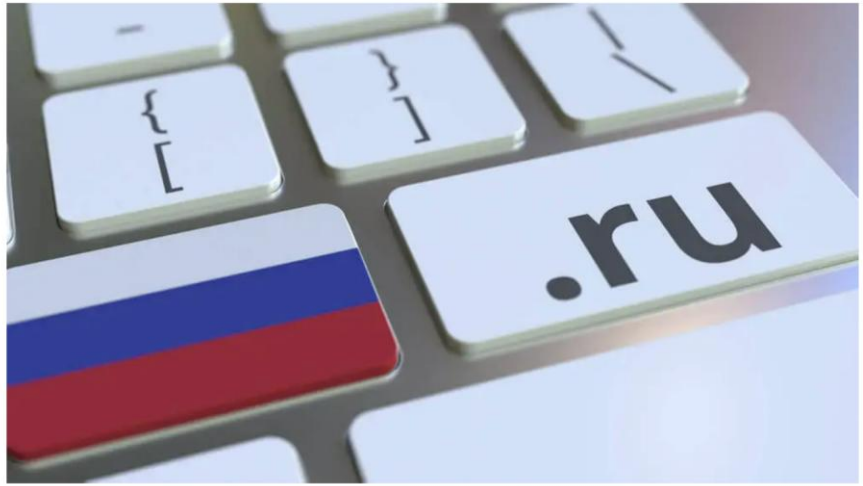
A. Tarantola
@terrortola
March 3rd, 2022

In this article: DNS, news, gear, ICANN, IP address, internet, Andrii Nabok, ukraine, russia



Dado Ruvic / reuters

Even as governments and corporations around the globe squeeze the Russian economy through increasingly stringent financial sanctions for the country's invasion of its neighbor, Ukraine, some within the aggrieved nation have sought to punish Russia further, by kicking it off the internet entirely.



ウクライナ、ICANNにロシアの全ウェブサイトとDNSの接続解除を要請

Data Center Dynamics 2022-03-03 239 views

Today's Mini-Report

ユヴァル・ノア・ハラリ

単行本 - 人文書

『サピエンス全史』のユヴァル・ノア・ハラリ氏、“新型コロナウィルス”についてＴＩＭＥ誌に緊急寄稿！

ユヴァル・ノア・ハラリ

2020.03.24

- Eng.,
  - ✓ https://time.com/5803225/yuval-noah-harari-coronavirus-humanity-leadership/
  - ✓ http://hiroshi1.hongo.wide.ad.jp/hiroshi/lecture/IST-internet/TIME_Harari_March2020.pdf
- Jpn.,
  - ✓ http://web.kawade.co.jp/bungei/3455/
  - ✓ http://hiroshi1.hongo.wide.ad.jp/hiroshi/lecture/IST-internet/TIME_Harari_March2020_JPN.pdf

History of Human-being

「銃・病原菌・鉄」(*Guns, Germs, and Steel)*by Jared Diamond
「第3の波」(The Third Wave) by Alvin Toffler

1. **Livestock, Agriculture**

   Change: Hunting ➔ Cultivation, Rearing

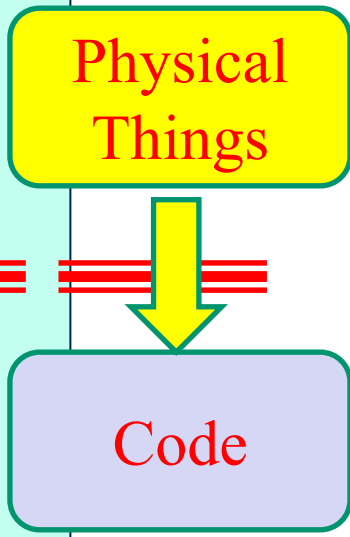
2. **Logistics, Factory by "Renaissance"**

   Change: Confident, Inherit ➔ Sharing, Create

3. **Internet, Computer, Information**

   Change: Nation, physical object

   ➔ Global & Code (Program/Rule)



What is the role of the Internet ?

- Internet in 20th Century
  - "IP for **Everyone**" : Connecting "human"

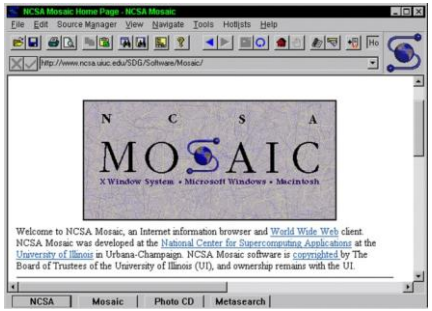
- Internet in 21st Century
  - Internet of **Things** (i.e., Io**T**)
    - Connecting "things" and "human"
  - Internet of **Functions** (i.e., Io**F**)
    - **Connecting "functions" in things and human**

On-going around us !
"update"

3rd wave of the Internet

- 1st wave: Web ···P2P

  connecting & online



- 2nd wave: Search engine …CS

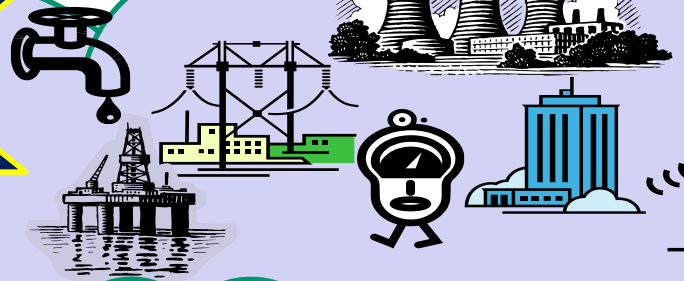
YAHOO! Google

- 3rd wave: IoT with Cloud AI

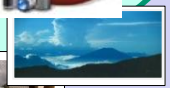
  ··· CS ➔ P2P

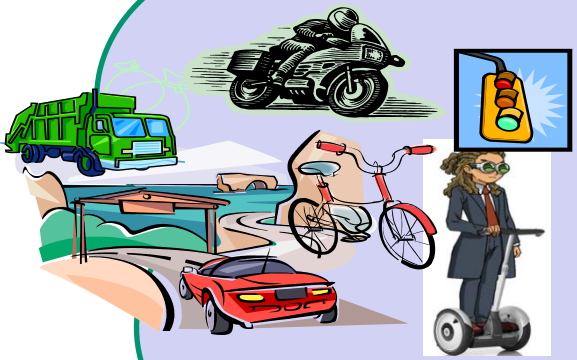
IP for Everyone

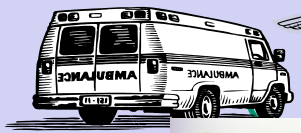
IoT (Internet of Things)
IP for Everything

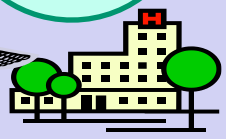


IP for Everyone









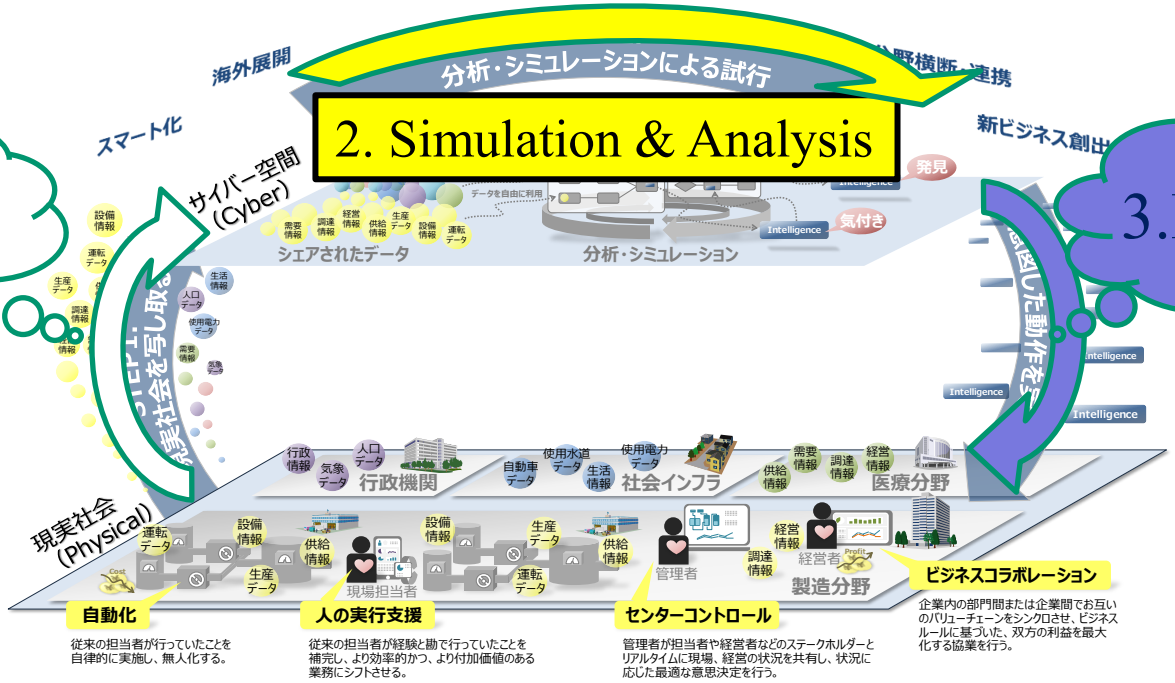
- **Past: Physical First**
  - **Digital Technology was supporter to improve efficiency**

- **Now: Digital Copy in Cyber**
  - **CPS: Cyber Physical System**
  - **Emulation/Simulation of Physical Space**

Before Cyber-First aka., “Physical-First”

“COPY-First”, “Code-Second”

1. Digital Copy!



3.Print out !

- **Past**: **Physical First**
  - **Digital Technology w**
- **Now**: **Digital**
  - **CPS: Cyber Physi**
  - **Emulation/Simula**
- **Future**: **Cyber Fir**
  - **Programing(設計) in Cyber Space**
  - **Print-out (印刷/実装) to Physical Space**

SDI;
Software Defined
(code-based)
Infrastructure

“Cyber-First”

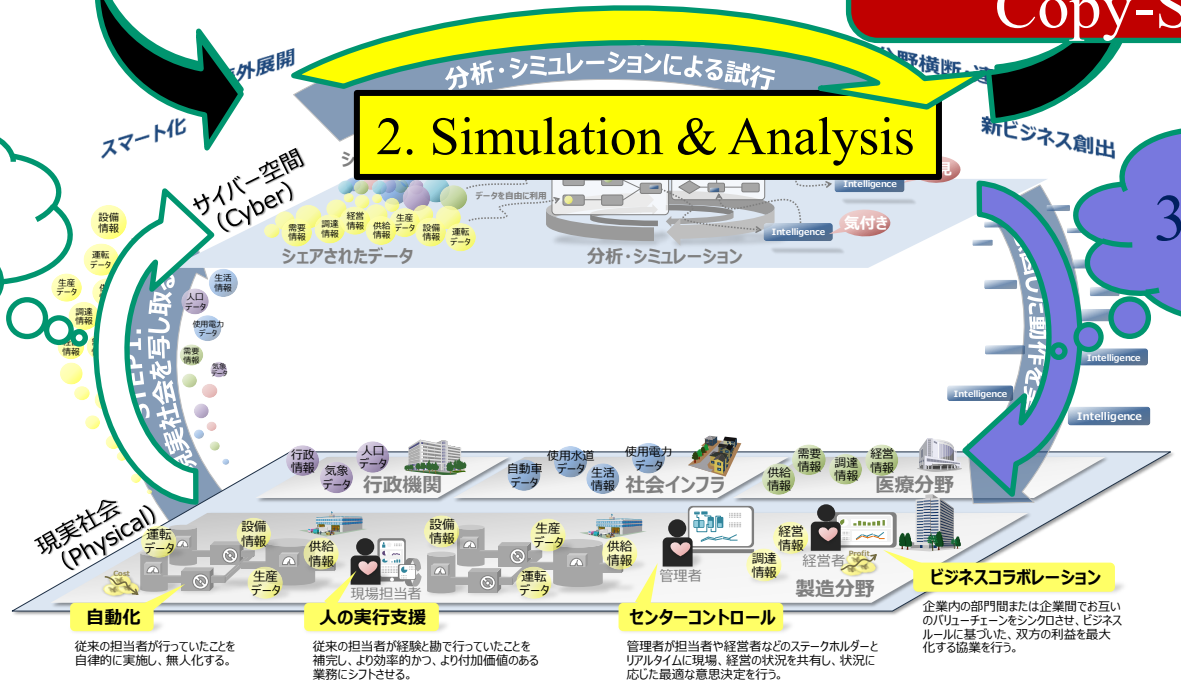
1. Digital-Native Design in Cloud DC

“CODE-First”, “Copy-Second”

2. Simulation & Analysis

4. Digital Copy!

3.Print out !



Simulator

Real World

Source: Prof./Dr Shinpei Kato (加藤真平), Tier IV Founder/CIO

LG SVL SIMULATOR

Further changes by “digital”

Digital-by-Design is going to “Unwire”-ing

i. “*Cyber First*” from Digital Twin

ii. “***Native***” **digital from “*Bogus*” digital**

iii. Internet of “*Functions*” (IoF), from IoT

ii. "Native" digital from "Bogus" digital

1. Analogue Native media
   - "bit-map" data
   - Ex. CD/DVD/BluRay, MP3/4, **4K/8K…**

   ➔ **"expensive"** contents, called as **"rich"** contents…

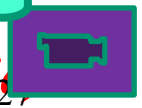
2. **Digital Native** media
   - "object-oriented" data
   - Ex., text, MIDI, VRML, Game

   ➔ "cheap" contents !!!!!!

   ➔ **D.I.Y** (Do It Yourself), e.g., ***SDM(Software Defined Media)***

"Bogus" digital
The 1st Wave

"Native" digital
The 2nd Wave



Think about money/currency…..

◆Currency represents value by digital number, i.e., abstraction

◆Used be, currency has “real” value, by Gold/Silver/Bronze

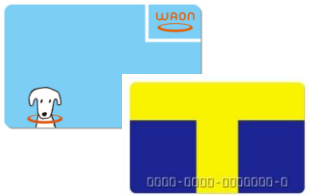
- ✓ total amount of currency is far less than CF in the market

◆Once upon a time,  currency becomes real digital.

◆Currency without doodle  vs. infinite doodling on cyber cash

◆In old days, transaction data does not have value….

Now : Transaction data delivers new value !!!!



➔ How you use money ?

1. BS, PL, CF == Credit information
2. Where you invest ? == Purchase

ii. “ … “Bogus” digital

1. A
   •
   • E … 0/4 … 4K/8K….

➔ **“expensive”** … nts, called as **“rich”** c … ents…

Number is printed out by “bit-map”

“Bogus” digital
The 1st Wave

2. D
   •

Number is invisible and can doodle their meanings/semantics !!

“Native” digital
The 2nd Wave

➔ …), e.g., ***SDM(Software Defined Medi…***

Further changes by “digital”

Digital-by-Design is going to “Unwire”-ing

i. “*Cyber First*” from Digital Twin

ii. “*Native*” digital from “*Bogus*” digital

iii. **Internet of “*Functions*” (IoF), from IoT**

Computer getting smart and small

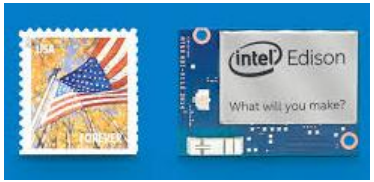
	1960s MF	1970s OC	1980s WS	1990s PC	2000s Note	2010s Smart Phone
CPU (MIPS)	0.1	1	10	100	1k	10k
Memory (GB)	0.01	0.1	1	10	100	1k (1T)
Weight (Kg)	10k	1k	100	10	1	0.1
Mobility	10^{-15}	10^{-12}	10^{-9}	10^{-6}	10^{-3}	1

Mobility ＝MIPS x GB / g

（improved 10^3 per decade）

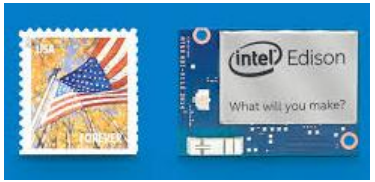
Computer getting smart and small

	1960s MF	1970s OC	1980s WS	1990s PC	2000s Note	2010s Smart Phone	2020s Stamp ?
CPU (MIPS)	0.1	1	10	100	1k	10k	100k
Memory (GB)	0.01	0.1	1	10		1k (1T)	10k (10T)
Weight (Kg)	10k	1k	100	10		0.1	0.01
Mobility	10^{-15}	10^{-12}	10^{-9}	10^{-6}	10^{-3}	1	10^{3}



Mobility = MIPS x GB / g
(improved 10^3 per decade)

Now,
AI
inside the chip !



CPU (MI							
Memory (GB)	0.01	0				T)	1 (10T)
Weight (Kg)	10k	1k	100	10		0.1	0.01
Mobility	10^{-15}	10^{-12}	10^{-9}	10^{-6}	10^{-3}	1	10^{3}

Mobility ＝MIPS x GB / g
（improved 10^3 per decade）

Now, **in 2024**
cloud architecture in the **back-end**
at Data Center
is expanding
into IoT space, **“fog”** or **“edge-heavy”**
computing, in the **front-end**

This means.....

Internet of Things (IoT)

Physical First with Digital Twin

Internet of Functions (IoF)

Cyber First with Digital Twin

Case study: smart key

…Key has 4,000 yeas history

Since key was “physical” object, we start to recognize a lot of inconvenience for sharing economy

貸宿、空きスペース市場

5,429億円

電子錠市場

496億円

不動産仲介市場

2,328億円

店舗の防犯
勤怠管理市場

1,263億円

高齢者
見守りサービス市場

132億円

ホテルフロント業務市場！

876億円

What you must do is only attaching a module !!
Your smart-phone be
with awesome "ne
Legacy function

【Physical key】
1. Insert key
   a. Open
   b. Close
   nove key

【Key as function=code】
1. begin & authenticate
   a. open (e.g.,turn right)
   b. close (e.g.,turn left)
2. end

Important point;
"digital" key can obtain
infinite doodling capability
for new value !!!
Physical key is an obstacle
for digital innovation !!!

Well,…… what we've realized is;

- **Physical Key and money(currency) are just of temporal appearance, as a physical instance, when we do realize Cyber-First.**

1. **Software module, with micro-service, has mobility with virtualization(= abstraction = digitization)**
2. **Some functions(=code) are printed out to physical object, called as "thing", from cyber space.**

Then,

Internet of Things (IoT)

→ Internet of Functions (IoF)

Observe **IoT**, from the view point of **coding**

【Old】connect things via cyber space

【New】put/write functions(= code),
in things so as to execute the codes.

➔ Unbundling of Function and Thing
Functions(コト) ＝＝ Gene(遺伝子)
Things(モノ) ＝＝ Survival machines/vehicles(生存機械)

「利己的な遺伝子(The Seflish Gene)」 by **Clinton Richard Dawkins**

1976年

- 言葉・文字はATGCの核酸塩基(=Character)、**文章・プログラムそして文化は遺伝子に同じ。**
- 生存機械(実存個体)の存在なしに、個体の意思(＝ルール)を永遠に残そうと努力(＝利己的)する。
- **交叉を繰り返し、進化(変化・誤複製)するし、淘汰もされる。**
  発現しなくても、残っていれば、『発現する可能性』がある。
- 遺伝子は、『歴史を記憶・記録』している。
- 遺伝子が遺伝子のプール内で繁殖するに際して、精子や卵子を担体として個体から個体へと飛びまるのと同様に、**ミーム<mimine>がミームプール内で繁殖する際には、広い意味で模倣と呼びうる過程を媒介として、脳から脳へと渡り歩く**のである。

Informatization invented by human-being

1. **Language(言語) ： information sharing**
2. **Character (文字)：store information**
3. **Money (お金)：intermediator among things &human**
4. Paper (紙) ：improvement of mobility **not digital**
5. Printing (印刷)：copy of characters **not digital**
6. Digital copy：no quality degradation
7. **Digital transmission：media independency**
8. **Program (code)：“Software Defined”**

Informatization invented by human-being

Essene of Software Defined;

Unbundling of logical functions (=software/code)
from physical things(=hardware)
This means;

1. Functions can be upgraded and added.
2. Break the spell of hardware, free to move around
3. Store every transactions and logs

7. **Digital transmission : media [illegible] key**
8. **Program (code) : "Software Defined"**

Well,.....

When you think about keys and currency by Cyber/Digital First, the current physical instance is just a temporary appearance. This is unbundling.

Well,.....

When you thi

currency by C

the current p sic e is

just a temporary appearance.

This is unbundling.

You can select an available physical object, whichever you want, from alternatives.

【e.g., key system】

・Metal key + cylinder

➔ Iris/Finger-Print + Sensor

・Open/close ➔ Voice recognit.

Let’s think about impact of Digital to infrastructure

Great revolution in“logistics”

Before 19th century
= exclusive logistics

Middle of 20th century
(1) Physical Sharing Economy

Container
Palette
(1956)

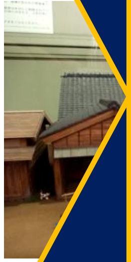
Late 20th century
(2) Sharing Economy
in Cyber space

Digital parcel
(=IP Packet)

2020s =Cyber-First Sharing Economy

3D printer

lution in "logistics"



[Media Independency]

1. **Carrier & Carried object**
   ➔ **Un-bundling , Mobility & Interoperability**
2. **End-to-End**
   a. **Simple and shared/common infrastructure**
      ➔ Toward Sharing Economy
   b. Buffer-less (inventory house-less)
      ➔ Goal of Industry 4.0
3. **Physical is a exit point of Cyber-space**
   a. Digital Native (Cyber-First) ➔ Different "rule"
   b. **Software Defined** ➔ "Agility"

ace

- **{デジタル化された＝アンバンドル}企業は地球のどこでも移動できる**ようになり、自分たちに有利な労働法のある場所で最低賃金で労働者を雇えるようになった。**かつては引く手あまただった手に職のある熟練労働者も、今では使い捨て可能になった。資本と労働力のマルクス的な闘いはもう終ろうとしている。**
- 現金がなくなるにつれ、**8,000を超える通貨乱立**の時代が戻ってきている。現金の死は決済方式が自然に進化した結果ではない。銀行や政府によるお金の支配を、テクノロジー企業(GAFA+M, BAT)の手にその支配権を渡す計画の結果なのである。 ➔『信用』できるかが鍵
- **新しい通貨は、人間 と データ**
  - **1860年代までには、アメリカだけで 8,000 を超える通貨があった。さまざまな銀行や鉄道会社や小売店が独自の通貨を持っていた。債権も交換制度も信用の形態も無数にあった。**
  - **1863年 国法銀行法は、この混乱状況に終止符を打ち、ドルという単一通貨でまとめた。**

2010年、中国企業は閉鎖工場の再建など米国製造業へ投資を増加させた。
中国の企業がアメリカの廃工場を復活させ、歓喜が戻ったアメリカ中西部。
本作はその代表的な例として挙げられる中国の巨大企業 福耀(フーヤオ)のアメリカ進出の裏側を追ったドキュメンタリー。

① デジタル化された工場は、地面からの拘束から解放される。
② 既存の{独自技術を用いた}設備の Up Grade は、とても大変。
③ Clean Slateな オープン技術を用いたSmart Factoryは、Up Grade と引っ越しの障壁が小さい。

Great[illegible]olution i[illegible]

Before 19th ce[illegible]
= exclusive

Sharing Economy

Object transfer/mobility cost over sharing platform !!

1. Physical object
2. Digital object
3. 廃棄物の大幅削減!!

Cost of object transfer/mobility?
Physical >> Digital

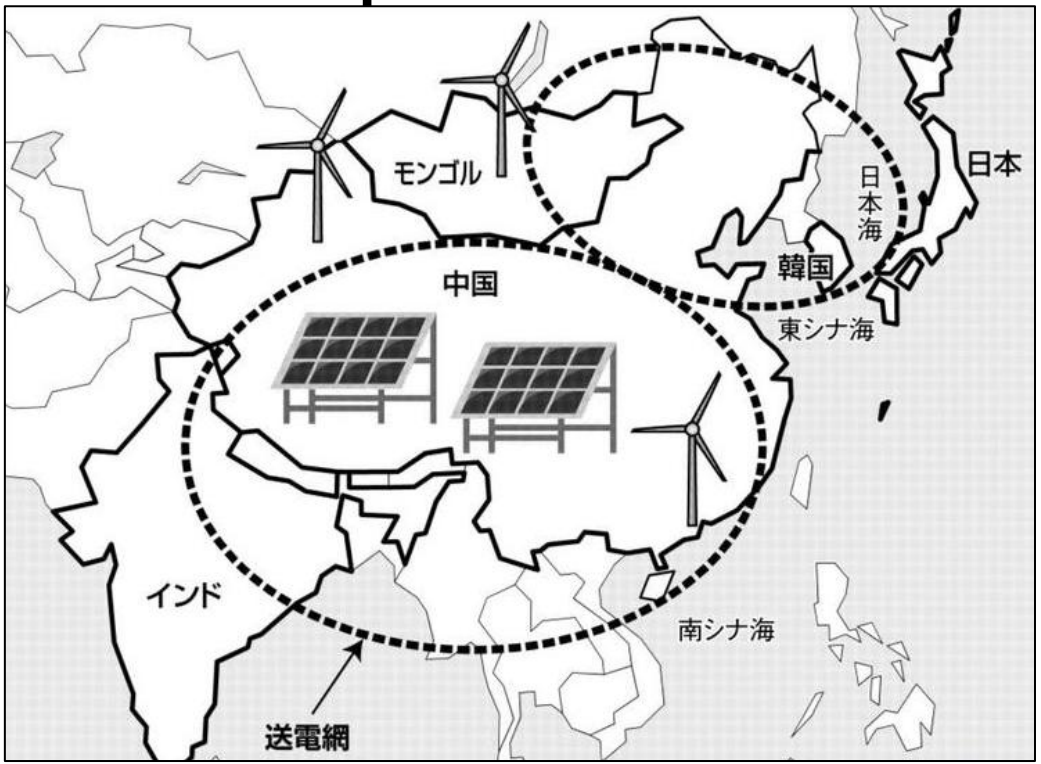
Huge EP(Energy Productivity) improvement !!!

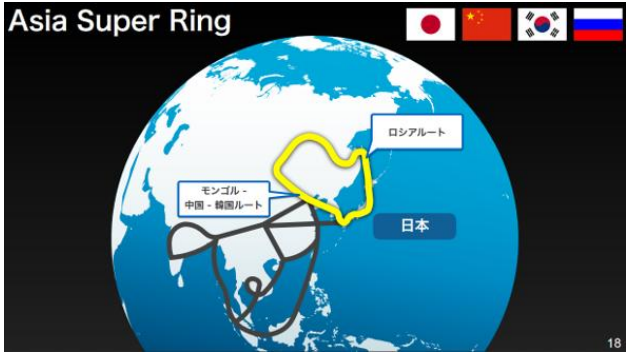
Container Palette (1956)

移動に必要なエネルギー=Energy Productivity

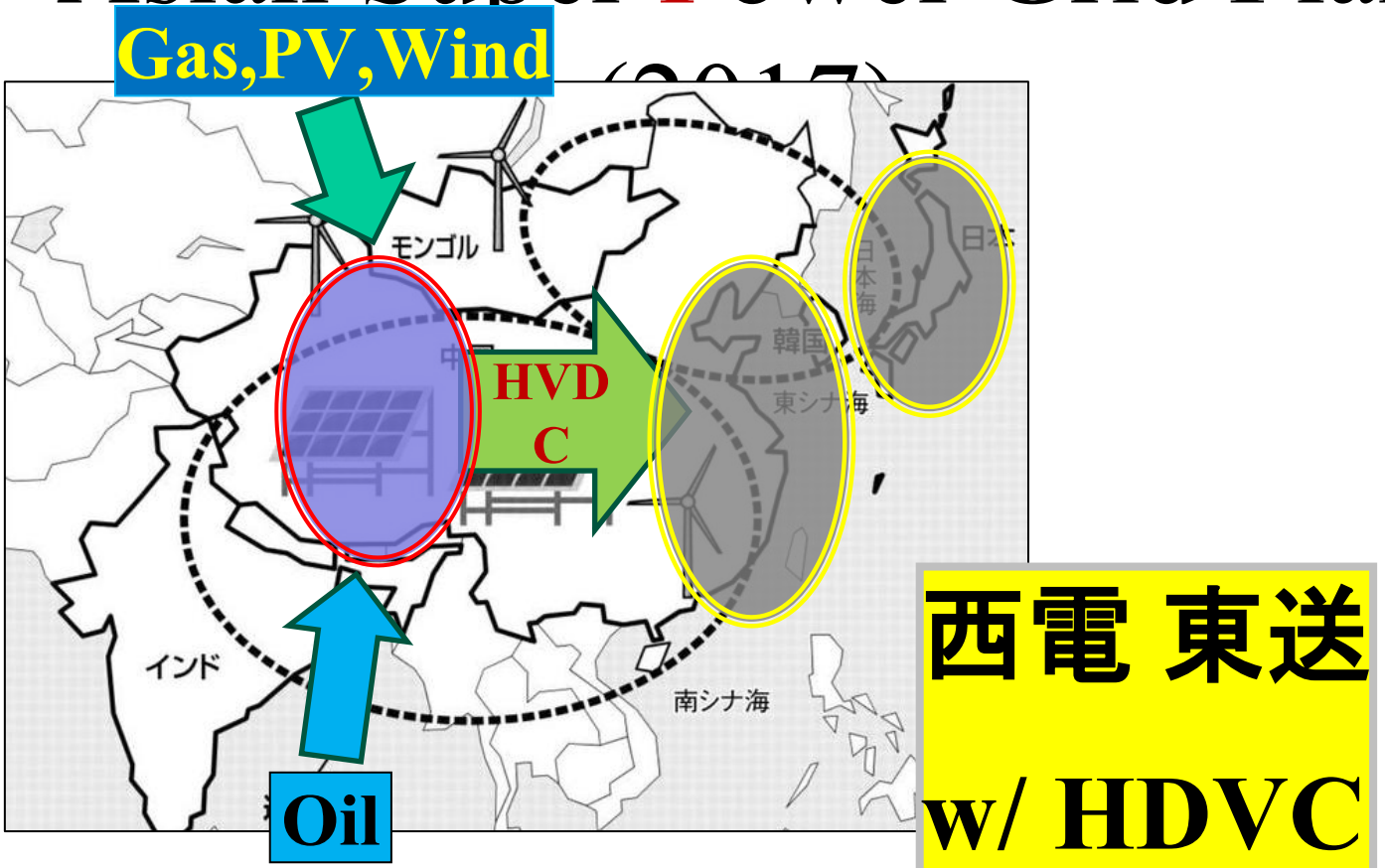
x0000 : x00 : 1

Asian Super Power Grid Plan (2017)



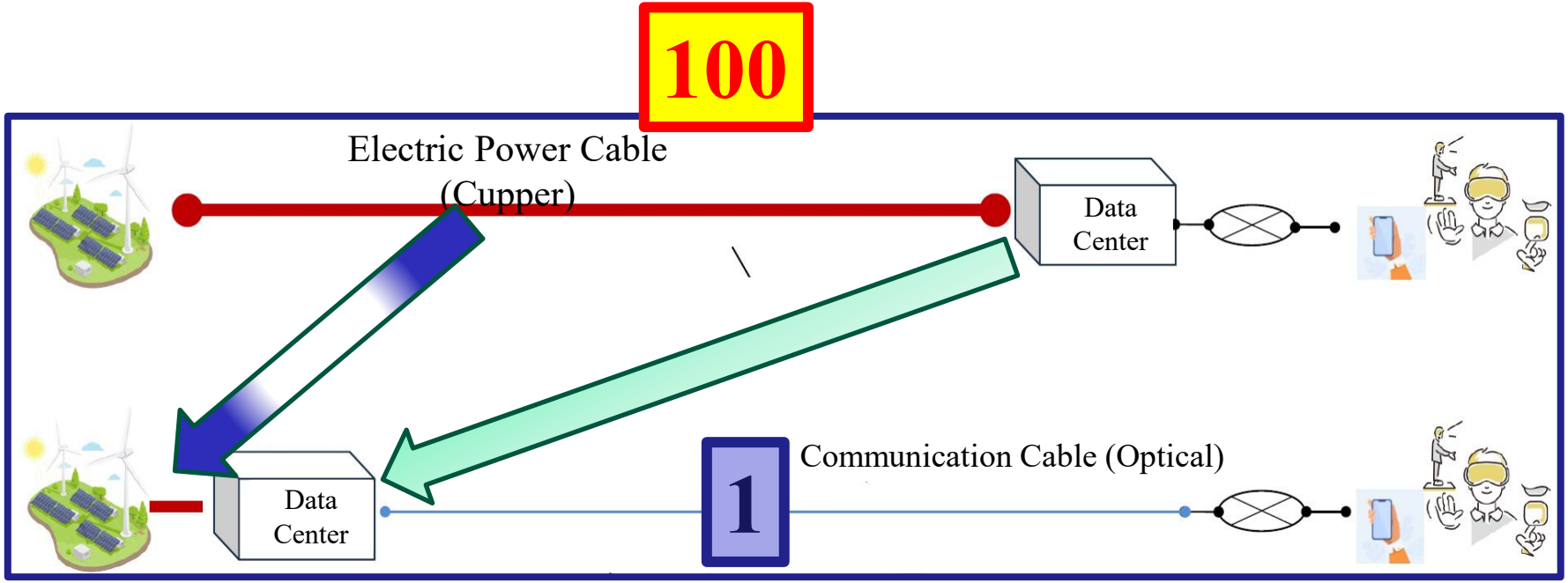


Asian Super Power Grid Plan



移動に必要なエネルギー=Energy Productivity

x0000 : x00 : 1


100
Electric Power Cable
(Cupper)
Data
Center
Data
Center
1
Communication Cable (Optical)

東数 西算(2021 第13期全人代)

Business case

BMW in Germany

Before

Germany

100%

of IT Load

Tier III

5 MW

200万ユーロ

200万ユーロ

After

Germany

20%

of IT Load

Tier III

1MW

Iceland

50%

of IT Load

New standard

2.5 MW

Sweden

30%

of IT Load

New standard

1.5 MW

Small latency
&
Critical data
at {dark-side}DC

Allowing large latency
&
Non-Critical data
at cheap and green DC

Transfer DCs to energy clean sites (Iceland & Sweden)

✓ 100% Renewal Energy (Hydro & Geothermal)

1. Gentle & contribute to Earth
   - ✓ by use of renewal energy (RE-100)
   - ✓ by use of cool air (EP-100)

2. Cost 👇 & Productivity 👆 (EP-x000)

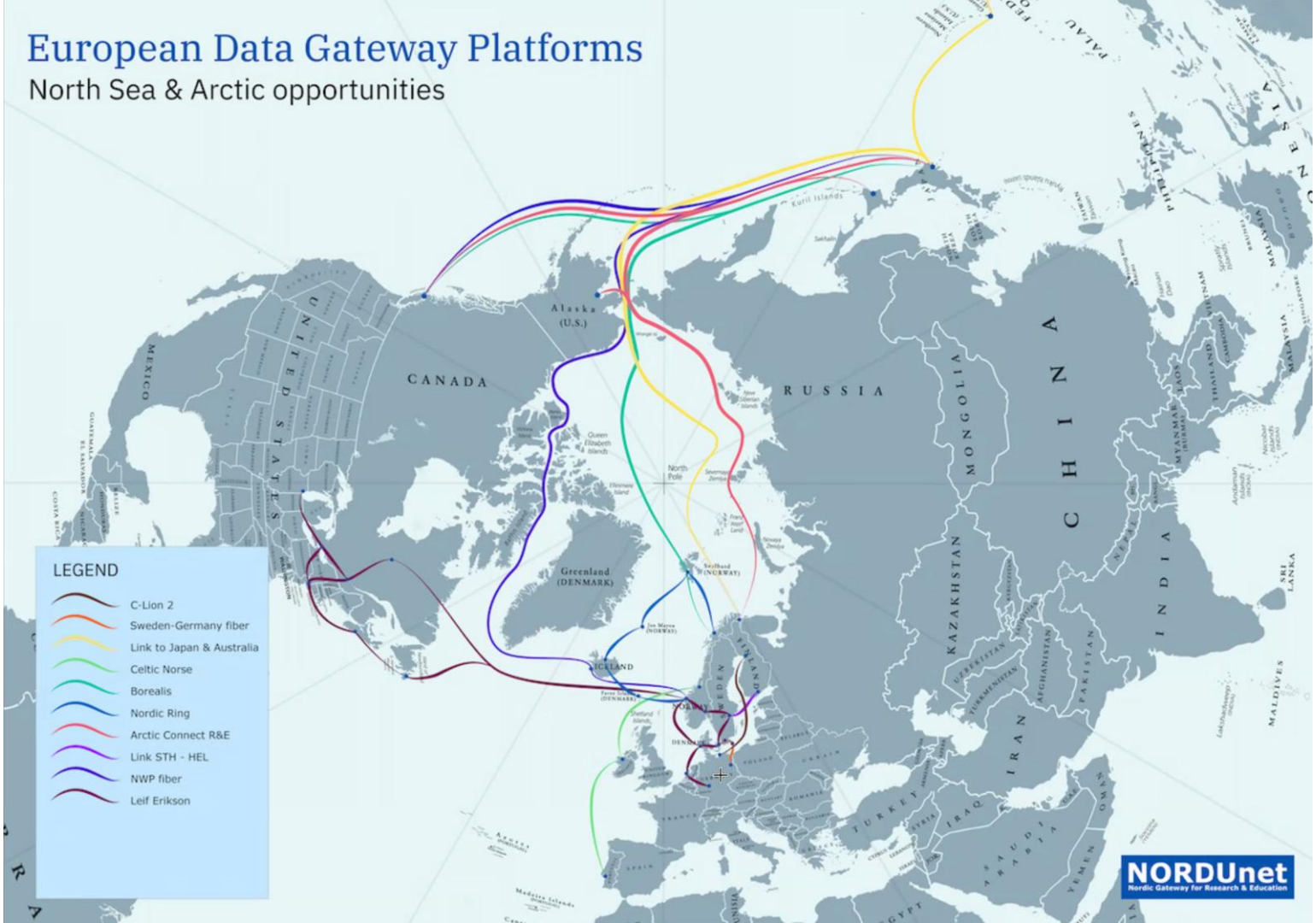
Replacing power cable (copper)

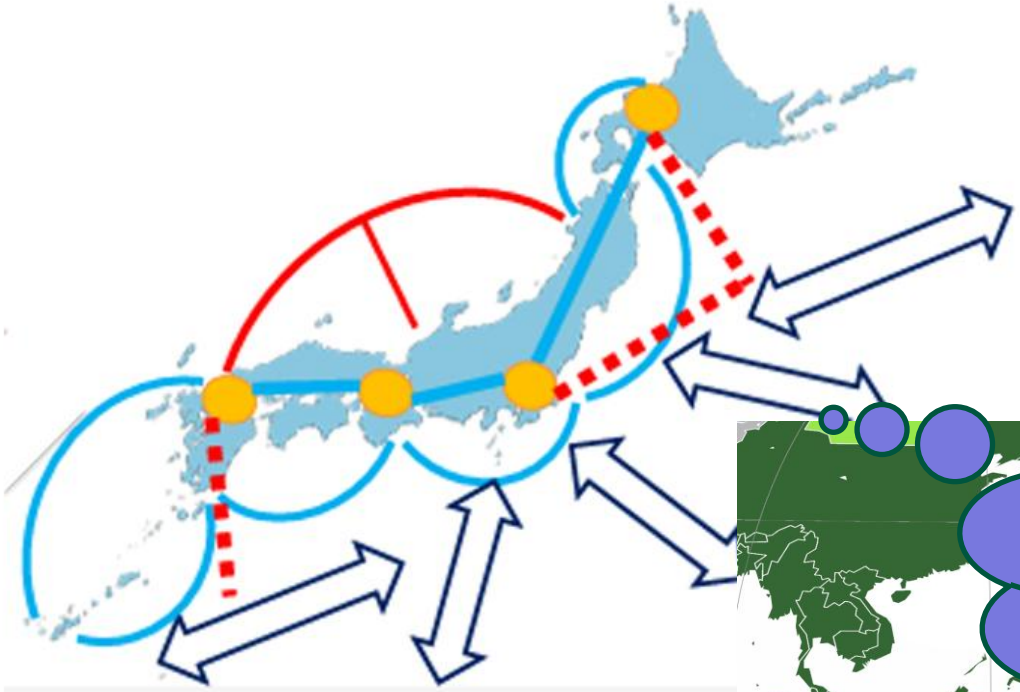
to

tele-communication cable (glass)

European Data Gateway Platforms

North Sea & Arctic opportunities



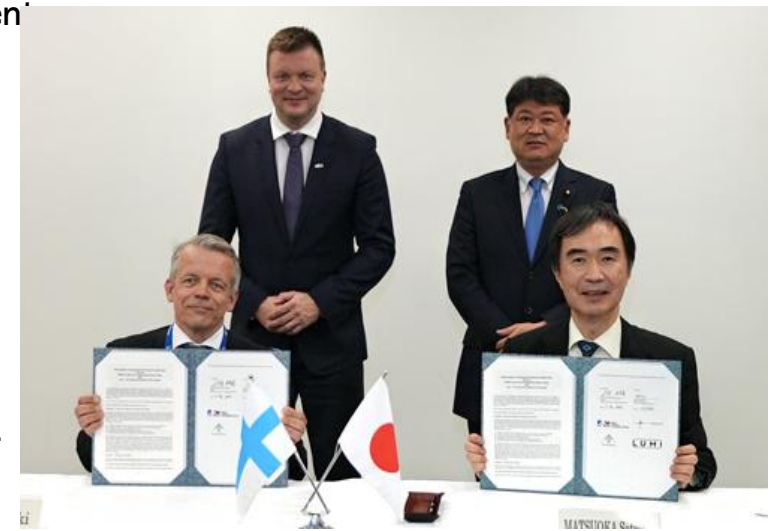


We need “Global” collaboration and cooperation

Strengthening Japanese-Finnish partnership in high-performance computing

May 18, 2022

On May 11, a Memorandum of Cooperation (MoC) was signed by the RIKEN Center for Computational Science and the CSC – Center for Science Information Technology, a Finnish center of expertise in information technology, to strengthen collaboration in the area of high-performance computing, making use of two world-leading supercomputers—the Fugaku supercomputer managed by RIKEN and LUMI, Europe's most efficient pre-exascale supercomputer, which is hosted by CSC. The goal is to promote international cutting-edge research by enabling Finnish and Japanese researchers to utilize ever more efficient computational tools for their collaborative efforts.



The agreement was signed in Tokyo by Kimmo Koski, Managing Director of CSC and Satoshi Matsuoka, Director of RIKEN R-CCS. From the two respective governments, words of support were given by Ville Skinnari, Finnish Minister for Development Cooperation and Foreign Trade, and Hideyuki Tanaka, Vice-Minister of the MEXT. In his remarks, Center Director Matsuoka said, “As the two machines are architecturally very different while providing similar computing capabilities, comparisons of the platforms as well as development of software that can run across the machines efficiently will pave the way for significant advances of the supercomputing field.”

https://www.riken.jp/en/news_pubs/news/2022/20220518_1/index.html

Memorandum of Cooperation, May 12, 2022.

EU Japan digital partnership on submarine cables for secure, resilient and sustainable global connectivity between the Ministry of Internal Affairs and Communications of Japan and the European Commission on behalf of the European Union

MATSUMOTO Takeaki
Minister for Internal Affairs and Communications of Japan

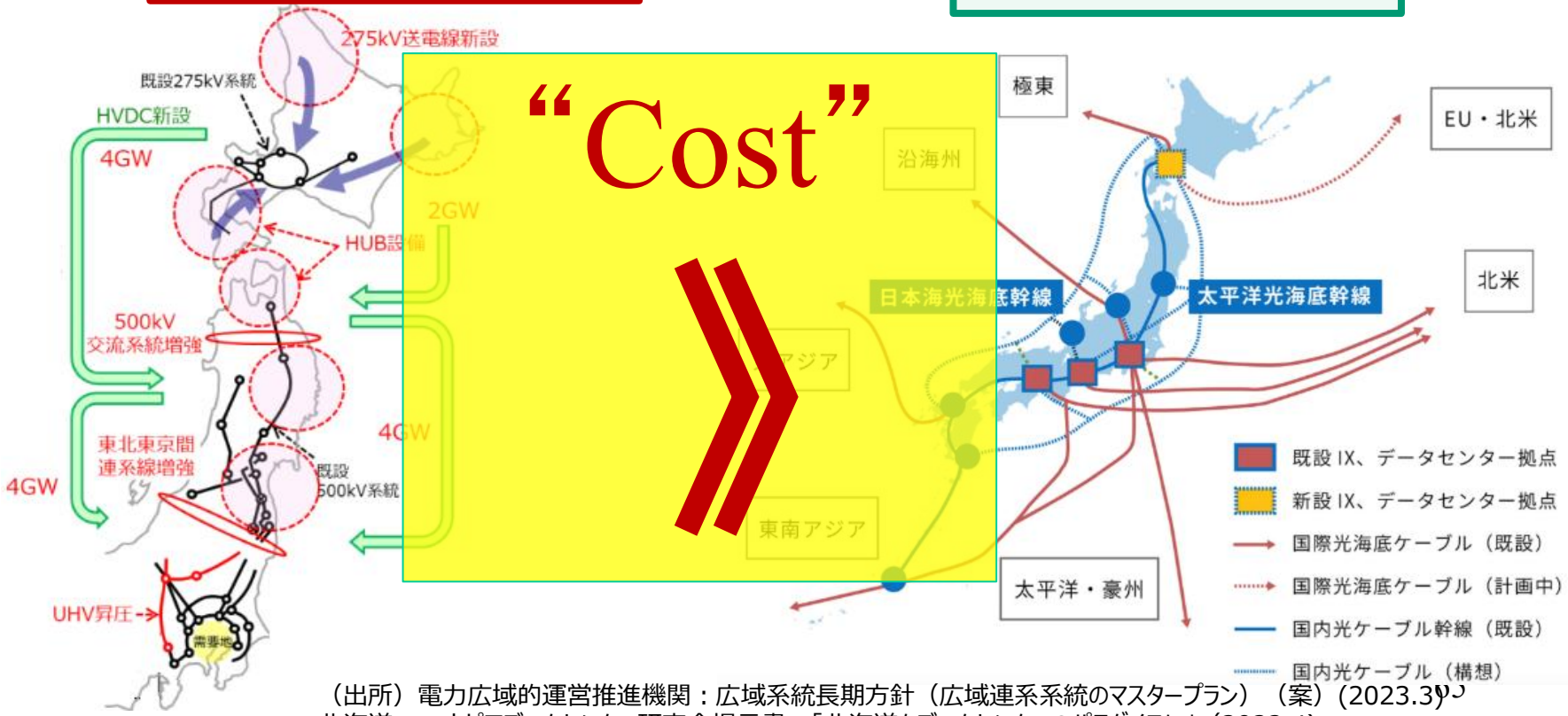
Thierry BRETON
Commissioner for Internal Market
European Commission
on behalf of the European Union

https://www.soumu.go.jp/menu_news/s-news/01tsushin08_02000155.html

As a デジタル田園都市国家構想(Digital Garden City Initiative)

Electric Power

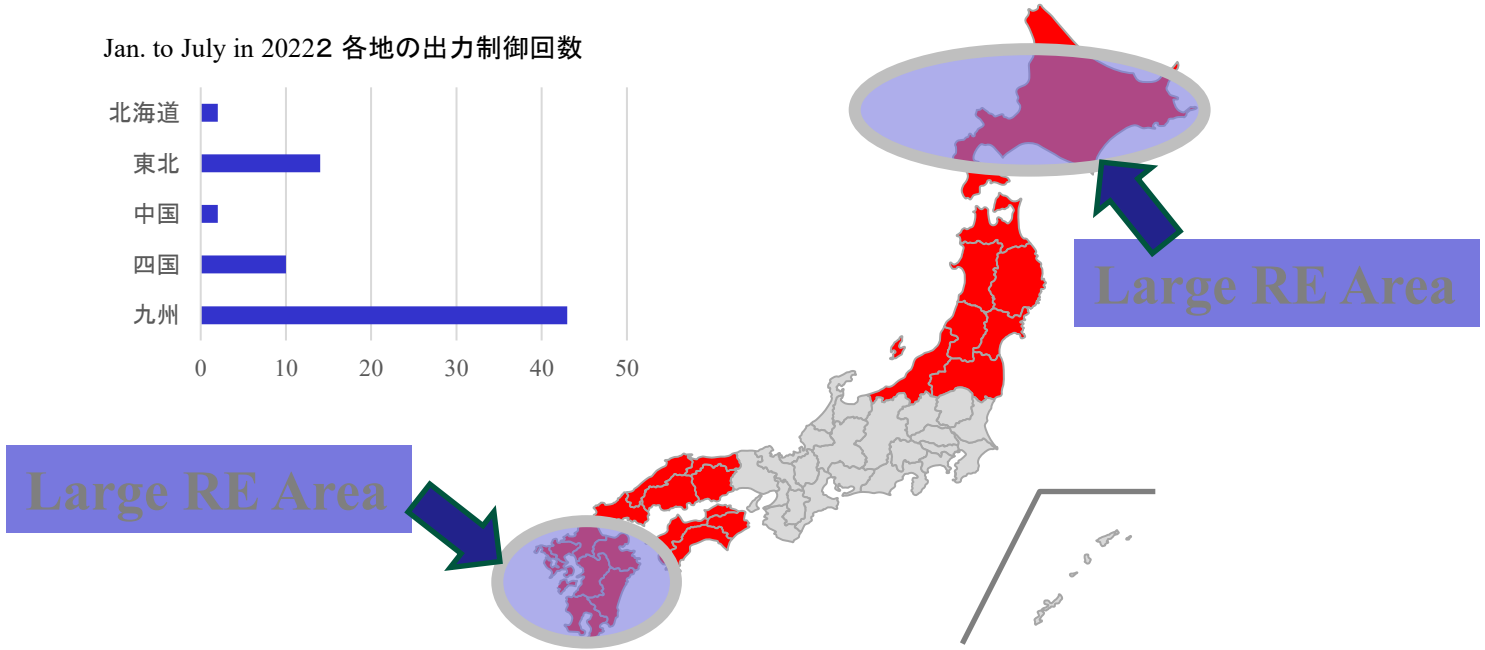
Information



（出所）電力広域的運営推進機関：広域系統長期方針（広域連系系統のマスタープラン）（案）(2023.3)
北海道ニュートピアデータセンター研究会提言書：「北海道をデータセンターのパラダイスに」(2022.4)

Electrical Power shortage in spring and winter in Japan

- 2022年再エネ出力制御は四国・中国・東北・北海道電力管内に拡大



【資料】 ビットメディア 代表取締役社長 高野 雅晴 氏
第４回イベント（2022年9月28日）
「データセンターの地域エネルギー貢献」

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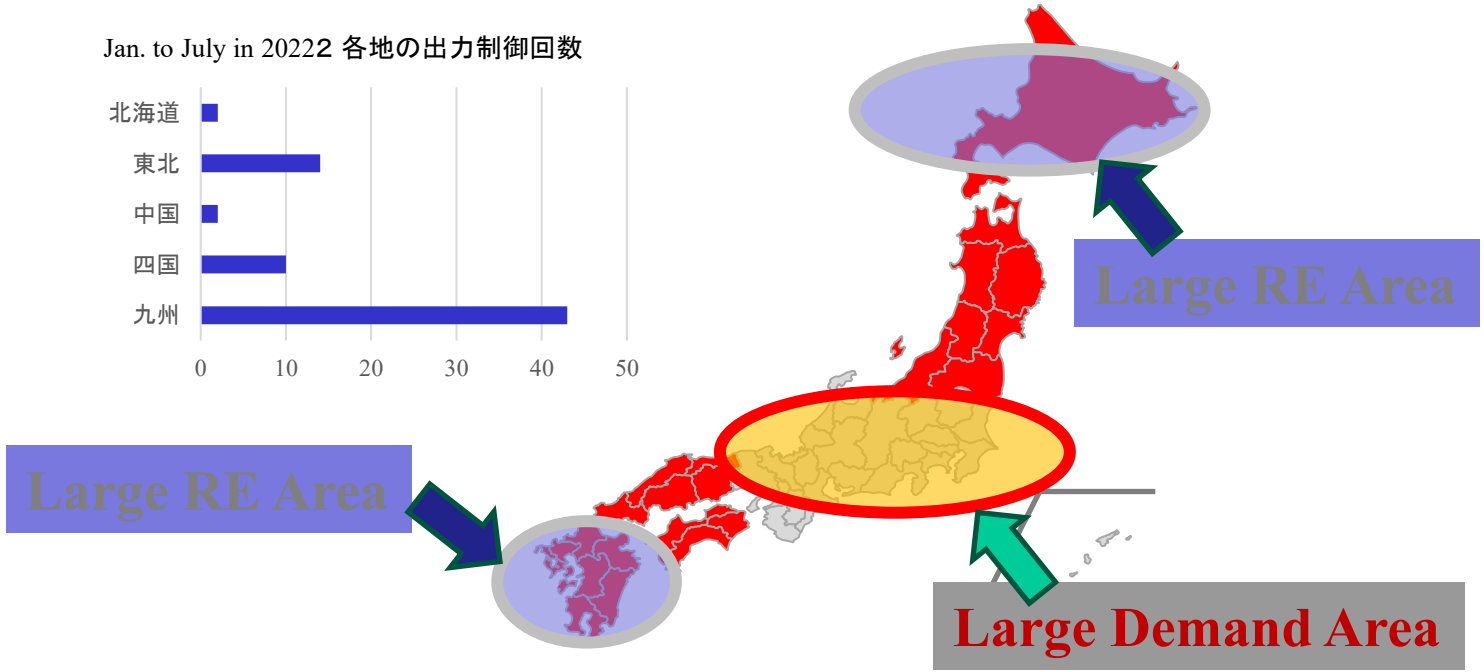

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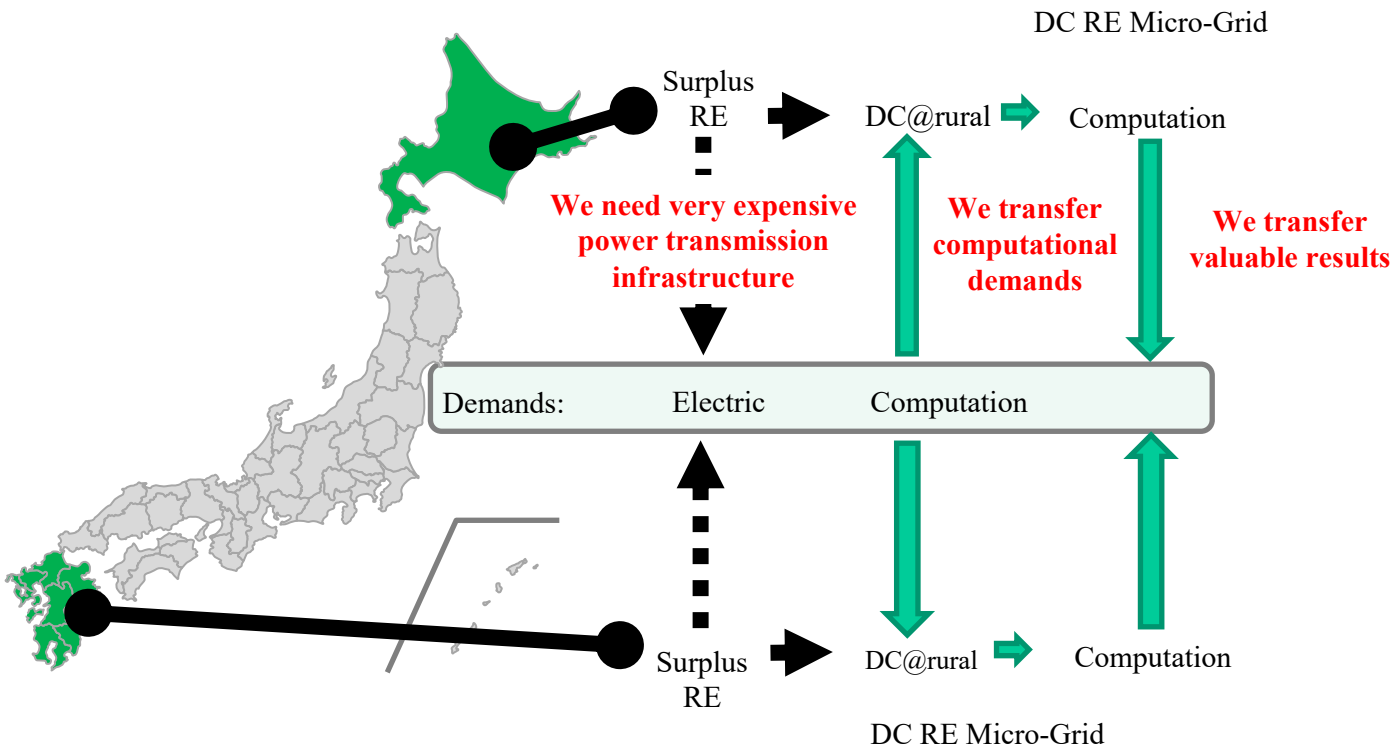
Data Center in rural area can help !!!



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Cyber/digital-First is coming…..

But,…..

There’re some rules, which can’t be broken down by us

Cyber/digital-First is coming….. But,…..

There're some rules, which can't be broken down

1. Signal is fast, but **slower than light !!**
   ➔ We need **edge-heavy computing**, since we are on the earth with unavoidable **{not small} latency**
2. Computers must eat {huge} **energy**....
   (a) Strategic cooperation with energy infrastructure
   (b) High **energy and heat density**
   (c) **White-box** implementation
3. We need **"link"** to connect to each other
   ➔ policy and regulation

FA&ROBOT&ROBOMACHINE
FANUC
×
Preferred Networks

5G ?

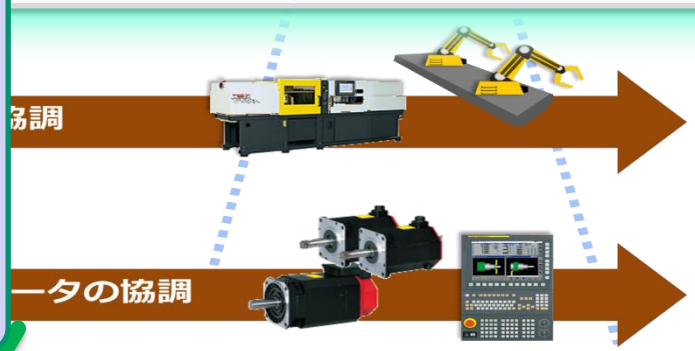
well…

Beyond Industry 4.0

Industry 4.0

New Requirements

- ✓Latency {by M2M/P2P}
- ✓Privacy & Security
- ✓Resiliency{against disconnect}
- ✓Massive (IoT)



Beyond Industry 4.0

Challenges in Edge-Computing Platform

1. **Event Driven End-to-End Architecture**
   - ✓ P2P, such as pub-sub, without storage(e.g., DB) for scalability
   - ✓ Stateless system operation, e.g., pub-sub
2. **Scalability**
   - ✓ Efficient program development environment/platform
   - ✓ System monitoring
   - ✓ Cyber security
3. **Platform-Free (Interoperability, Mobility, Transparency)**
   - ✓ We must avoid locking-on to particular platform
   - ✓ We want to connect/accommodate “new” modules

Some risks of 3rd wave Internet

Risks of 3rd wave Internet

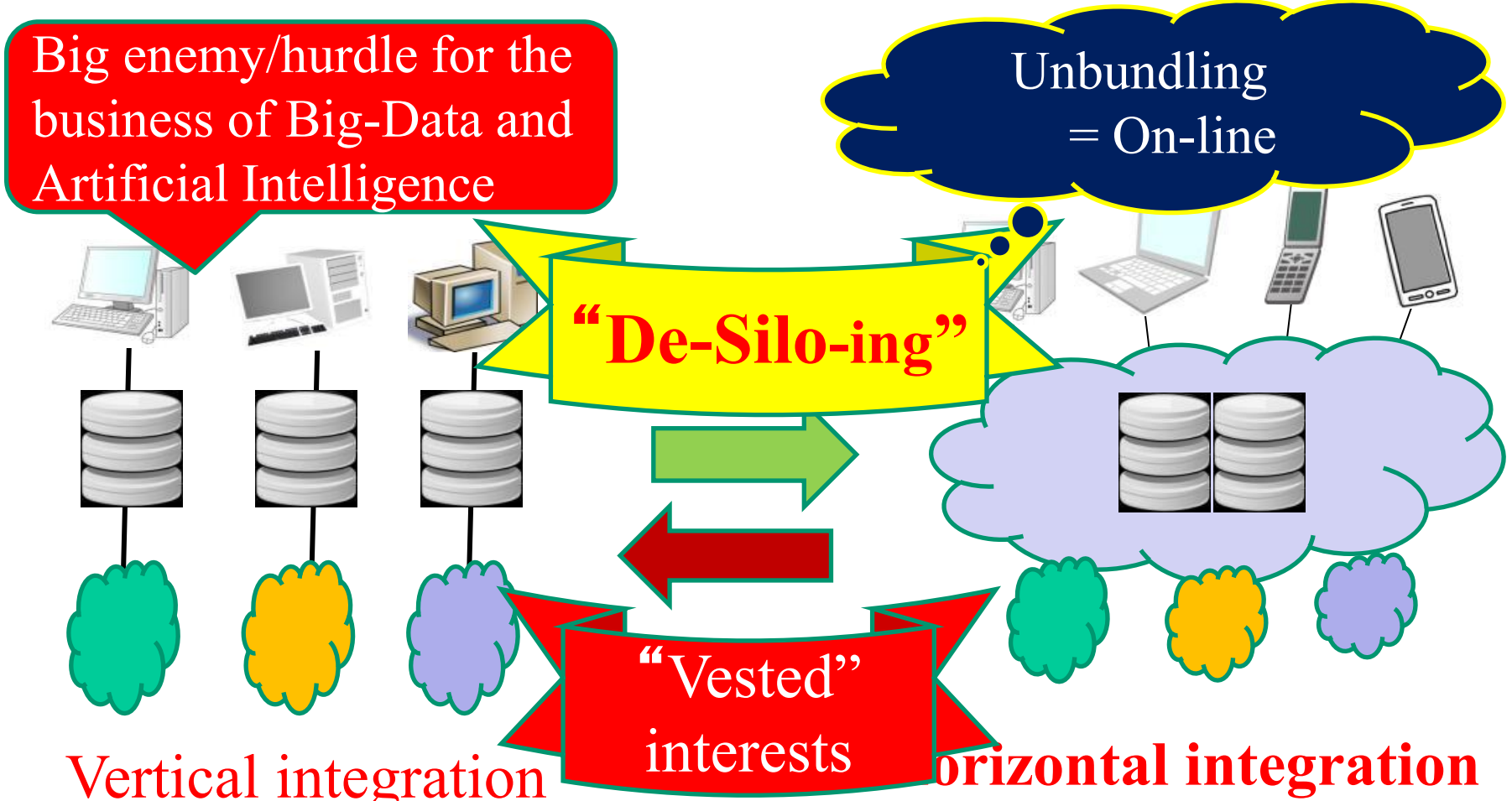
1. **"Fragmentation" of the Internet by IoT**
   - ✓ They love to develop own {private} silo……
2. **"Trust", such as Cyber Security**
   - ✓ IoT without security by own {private} silo
     - ➔ Need **"Security-by-Design"**
3. **Cloud platform**
   - ✓ "Closed" open source forum
     - ➔ Need **"Interoperability"**

Risks of IoT (Internet of Things) systems;

IoT people loves "own private silo"

1) Not **"the I"** (Internet),
   but **"an i"** (internet), i.e., closed
2) Poor security measures…..
   Never be connected to the net !!!
3) Closed open source cloud forums
   Lack of **Interoperability with silo's**

IoT(Internet of Things) people may tend to **skip** or to **ignore** the implementation of **enough** security measure for their IoT System.
Of course, I share that the implementation of cyber security function in their system is **large overhead** for **time** and for **money**.
However, we will and **shall** go to the **globally interconnected large scale eco-system,** rather than **isolated small scale silo** eco-system for each industry segments.
Therefore, the **"Collaborative Security"** is critical and mandatory from the beginning of IoT development, which is the **new stage** of our global digital economy.
And, we must encourage and try to use the common technologies, while assuming that all the sectors shall be **inter-connected** to the global unique digital platform


Big enemy/hurdle for the business of Big-Data and Artificial Intelligence
Unbundling
= On-line
"De-Silo-ing"
"Vested" interests
Vertical integration
(closed system)
orizontal integration
(co-operative platform)

Big enemy/hurdle for the business of Big-Data and Artificial Intelligence

Unbundling
= On-line

Challenge of corporate governance for corporate value and BCP, as auditor or external board member

Security measures is mandatory

d"

interests

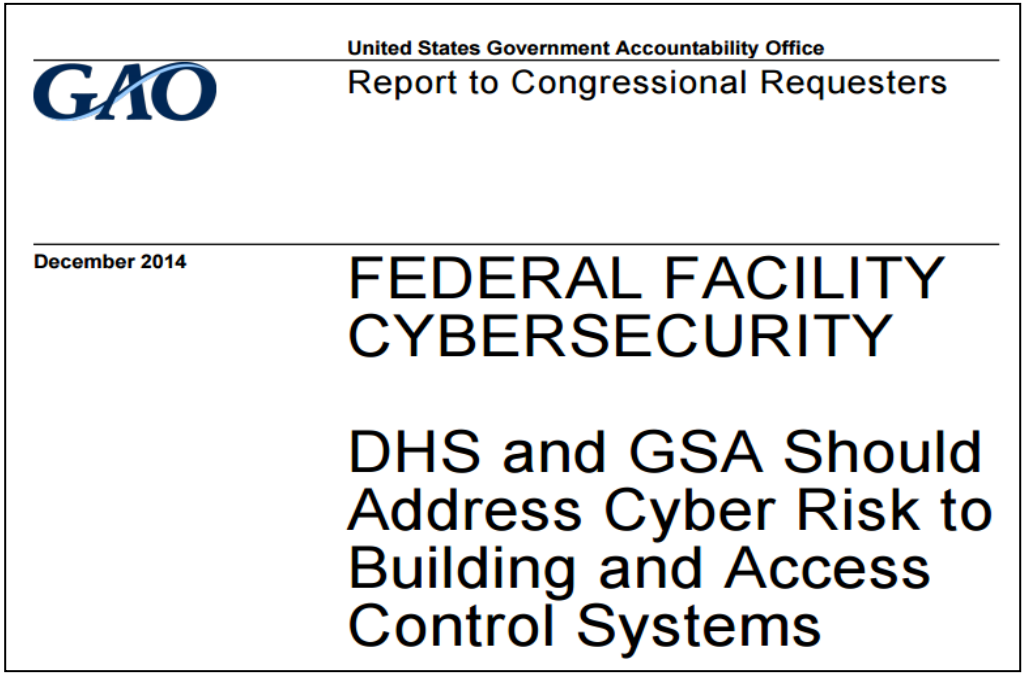
Vertical integration
(closed system)

orizontal integration
(co-operative platform)

Report by GAO

(United States Government Accountability Office)

- http://www.gao.gov/assets/670/667512.pdf



United States Government Accountability Office

GAO

Report to Congressional Requesters

December 2014

FEDERAL FACILITY CYBERSECURITY

DHS and GSA Should Address Cyber Risk to Building and Access Control Systems

(*) DHS: Department of Homeland Security

Procurement process and structute of US Federal Government

- GAO (Government Accounting Office, 会計検査院)
  - ⇔ OMB(Office of Management and Budget, 行政管理予算局)
- GSA (General Services Administration, 連邦調達庁)
  - Specification and auditing of procurement processes and documents
- NIST (Institute of Standards and Technology, 標準技術研究所)
  - Specification of technologies

Practical US government acts

1. Cyber security is mandatory requirement in procurement as national security

   (*) Ex. Smart Grid Interoperability Panel

   ➔ Every technology must be approved by cyber security WG

2. Entering cloud infrastructure

   - Out-sourcing of risk management of cyber security of IT/ICT platform

FedRAMP from FISMA

- **Fed**eral **R**isk and **A**uthorization **M**anagement **P**rogram
  - 連邦政府共通のクラウドサービス調達のためのセキュリティ基準。クラウドサービスプロバイダーが、このプログラムの認証を受けて登録されると、省庁ごとに新たな調達評価の手続きを経ることなく、提供／調達することが可能な仕組。
  - 「連邦情報セキュリティマネジメント法」

    FISMA＝Federal Information Security Modernization Act.(2002年12月)

    ✓ **NISTに連邦政府がFISMAに準拠するための支援をすることを義務付けている**。国土安全保障省（DHS）配下の情報セキュリティ対策組織である「US-CERT」設置の根拠法令。

Digital Transformation of Industrial Structure

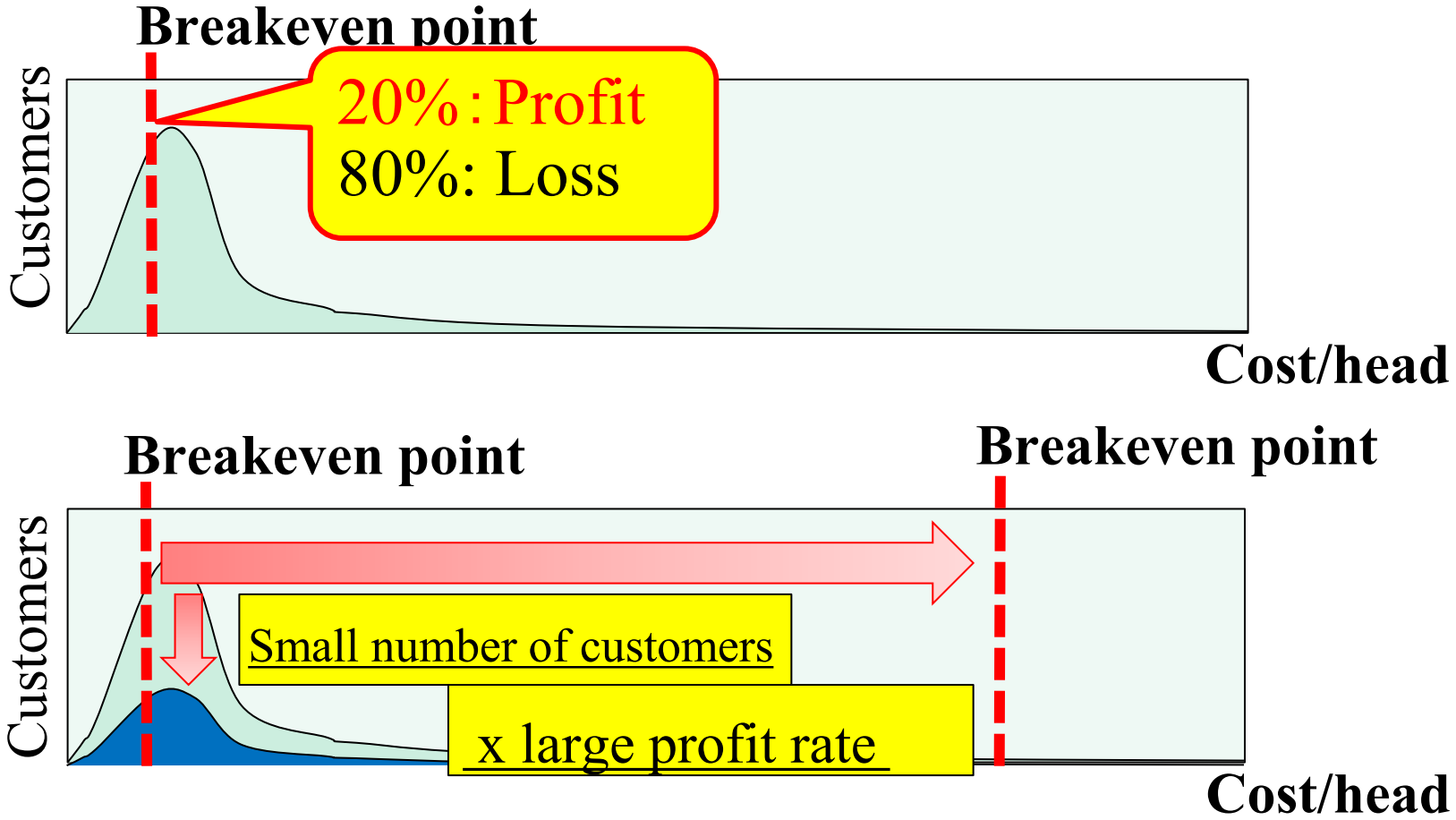
Supply Chain
➔ Demand Chain

Digital Transformation

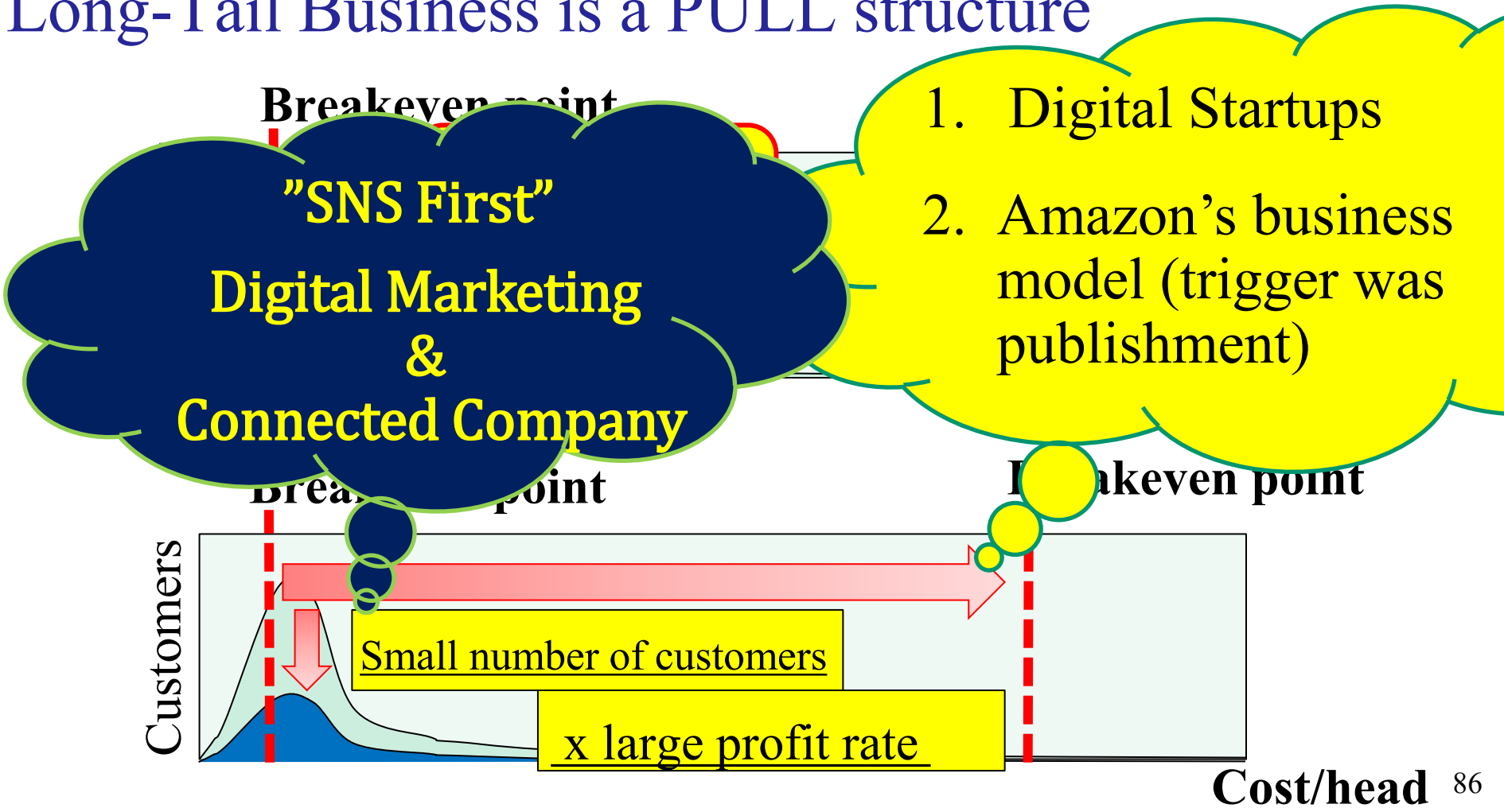
from PUSH to "PULL",
we need "De-Siloing"

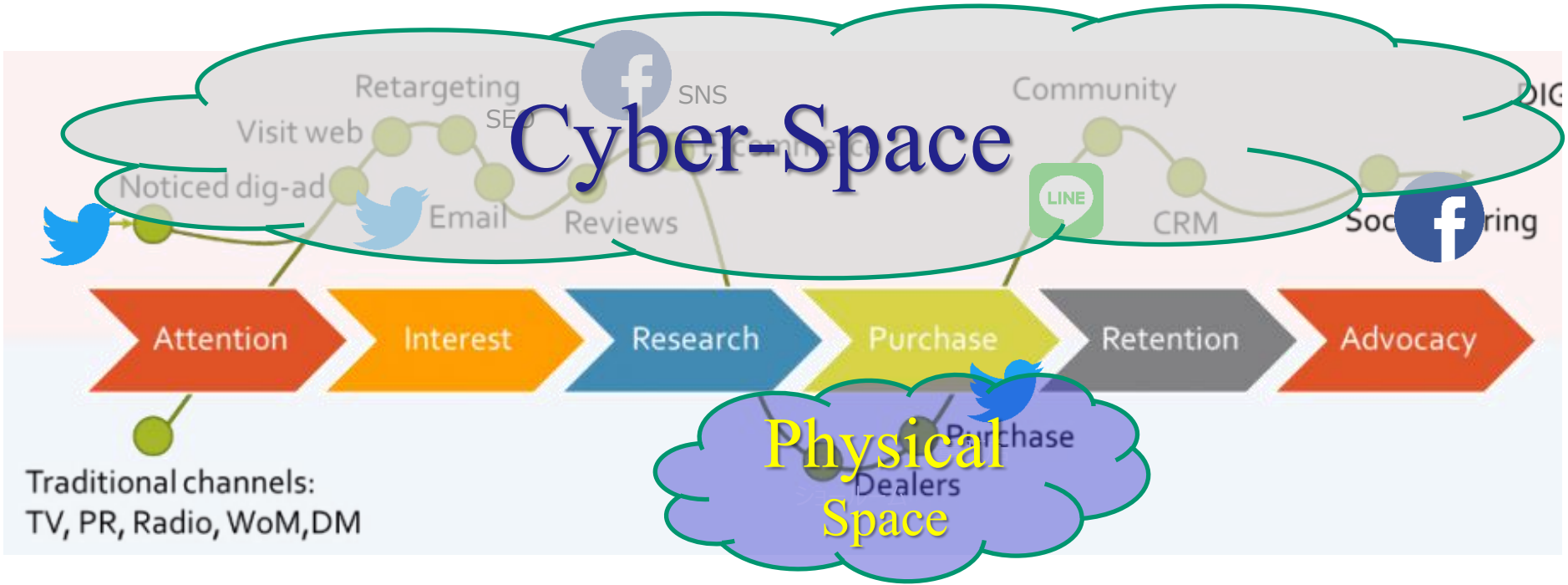
Customer Lock-on
➔ Open Platform

Long-Tail Business is a PULL structure



Long-Tail Business is a PULL structure



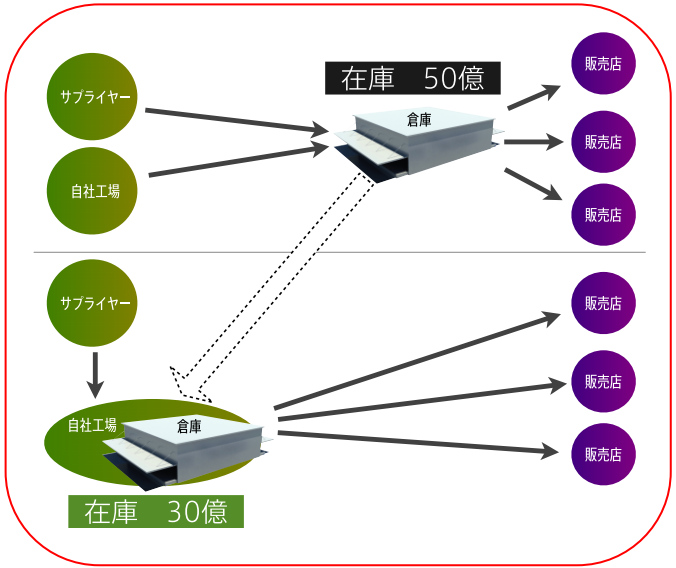


Going into "Connected-Company":
Cyber space is majority and
interface (read/write) with physical space

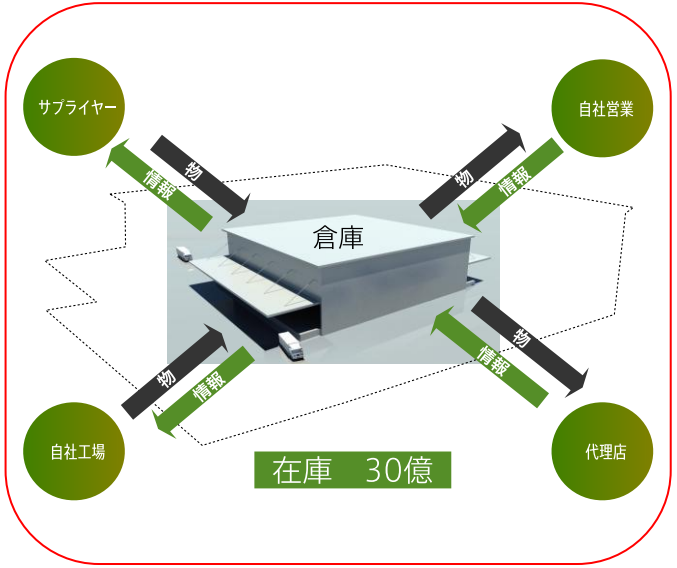
Cost Reduction of Construction cost by the Reducing amount of Inventory

Order of client　Inventory house for 50 M $ goods

自社工場近辺に倉庫を建設
在庫を30億に減らして建設コストを40%削減



ITの活用による物流の改善で
欠品率を上げない小さな倉庫はできる



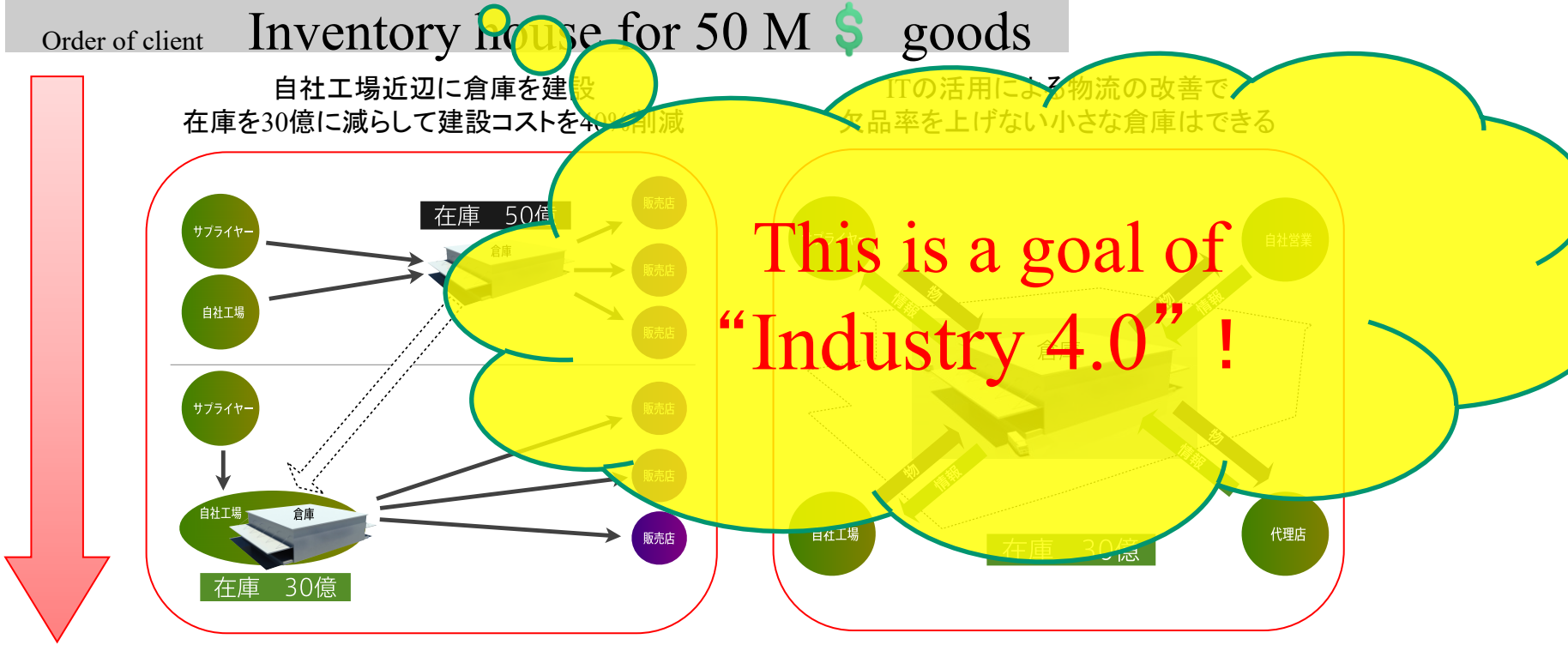
↓30 M $ goods in inventory house with Supply-Chain using ICT

Source: Plantec Associates

Cost Reduction of Construction cost by the Reducing amount of Inventory

Order of client

Inventory house for 50 M $ goods



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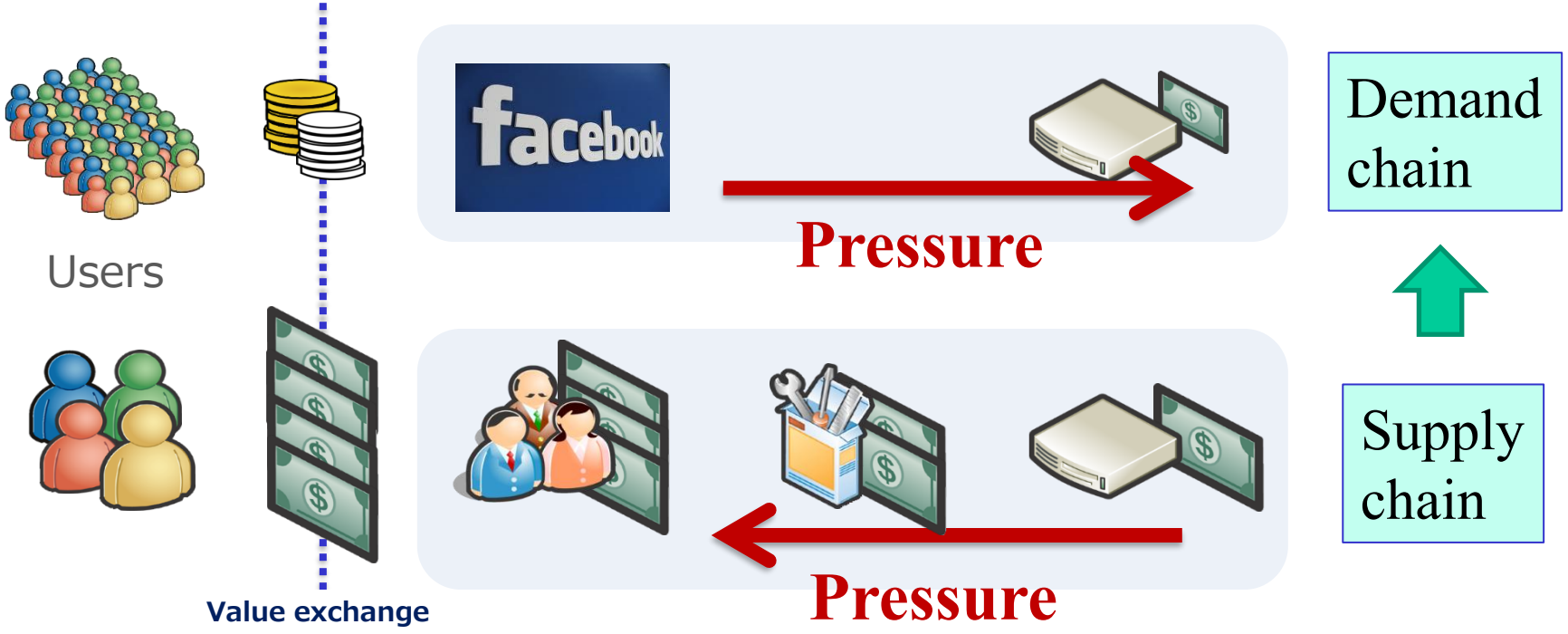
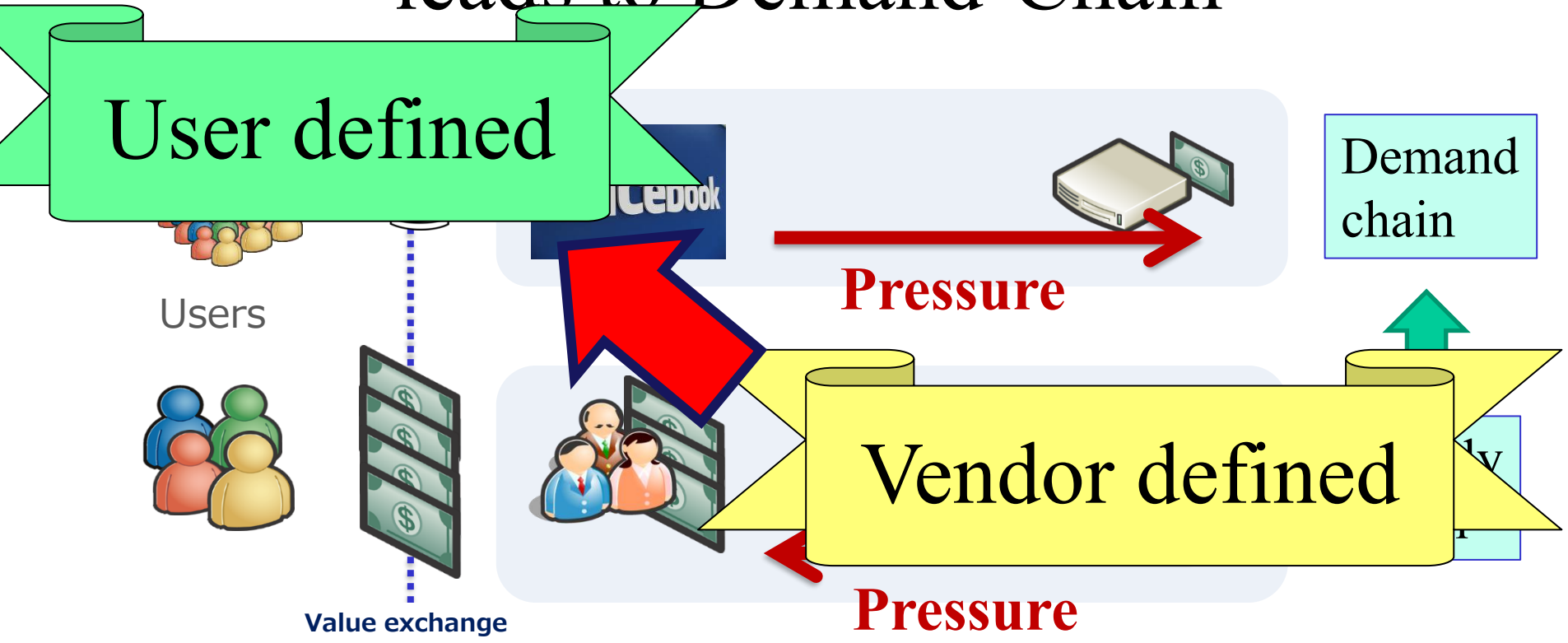
Dev-Ops by GAFA+M/BAT leads to Demand-Chain



Dev-Ops by GAFA+M/BAT leads to Demand-Chain



Some thoughts on **A.I.** **in 2020**

Wide variety of business

I. Why banks use mainframe computer ?

- ✓ No calculation error !!! By IBM CPU (POWER)

II. Google/FaceBook vs, Amazon/Yahoo!

- ✓ A/Y; No error because of Online-Shopping
  (*) However, it is far relaxed than banks !
- ✓ G/F; None could criticize their results……

(*) Now, how about the date for decision making in professional organizations ?

Wide variety of business

I. Why

✓

II. Go

✓

✓

(*)

There are calculations;
(1) any bit error can not be allowed, and
(2) some bit errors can be allowed !!!

However,

Especially decision making for high profit rate or high risk business may need only few significant figures, but large amount of data to deliver the figures.

Two ty Intelligence

Computer delivers directions by itself !!!

- "Adults"
  - Language context analyses
  - Discover/deliver algorithm

Computing capacity changes paradigm !!

- "Children"
  - Deep-Learning
  - Pattern matching

{computing power} * {amount of data} is competiveness !!!

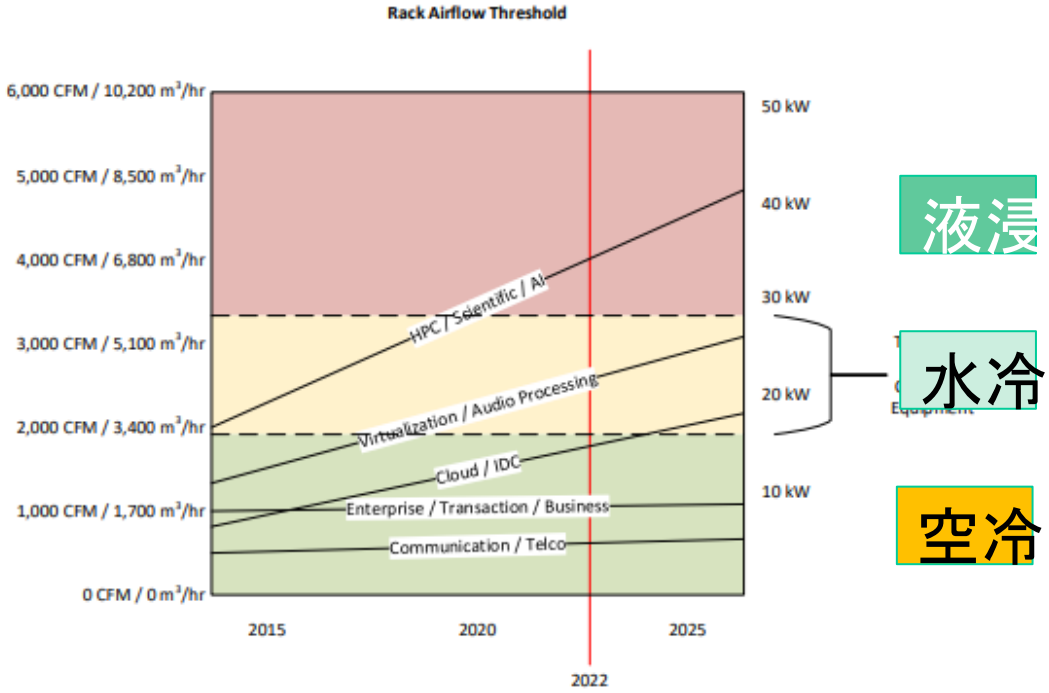
つまり、、、

『自力で』、音も物 も
『自由に』操作できる
ようになる !!
さらに、実空間では、聴け
ない&観れない ものが
聴けちゃう&観れちゃう !!

ある意味、
『超能力』!!

What happened in Data Center and Servers ❓

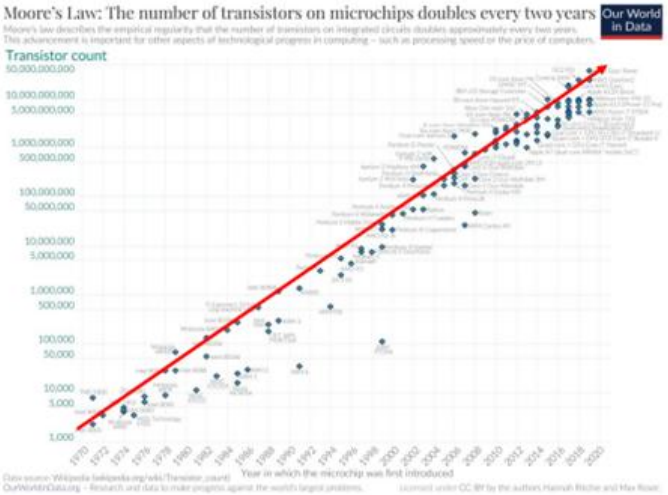
1. Implosion(=high density heat & power)
2. IoF, Internet of Function = VM/GPU moves on the net.
3. Optical technologies(electron ➔ photon)
4. Growth of demands (Digital Twin ➔ HW/SW robots & AI)
5. Massive scale & energy saving
6. Networking DCs with fat pipes (power and com.)
7. WhiteBox (customization with common tech.s)
   - ✓ Including modulization and pre-fabric construction
8. Migrate DCs beside Renewal Energy sources
9. Open system (not only IT, but also OT)
10. Hybrid and diverse of DC profiles

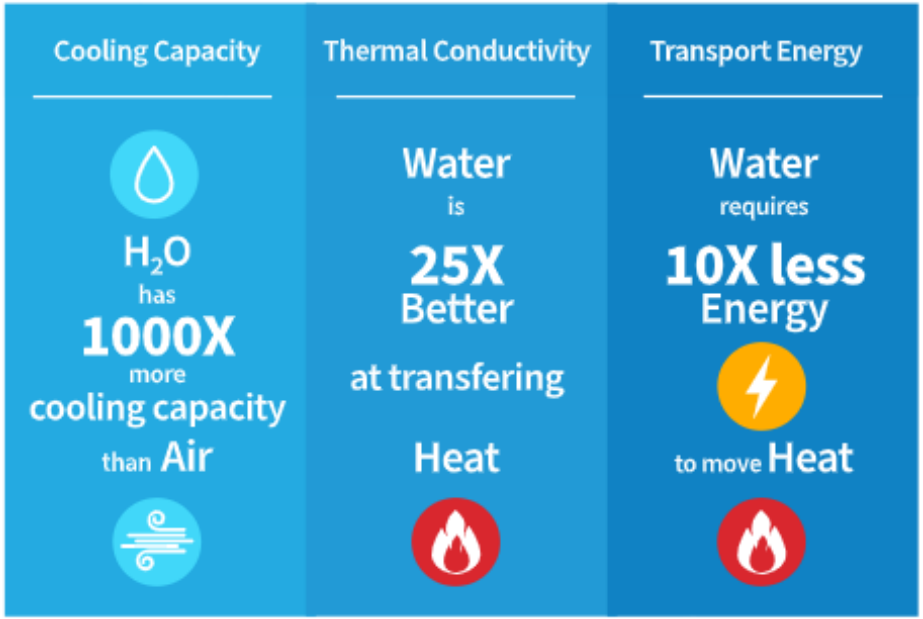

Rack Airflow Threshold
6,000 CFM / 10,200 m³/hr
5,000 CFM / 8,500 m³/hr
4,000 CFM / 6,800 m³/hr
3,000 CFM / 5,100 m³/hr
2,000 CFM / 3,400 m³/hr
1,000 CFM / 1,700 m³/hr
0 CFM / 0 m³/hr
50 kW
40 kW
30 kW
20 kW
10 kW
HPC / Scientific / AI
Virtualization / Audio Processing
Cloud / IDC
Enterprise / Transaction / Business
Communication / Telco
2015
2020
2025
2022

液浸

水冷

空冷

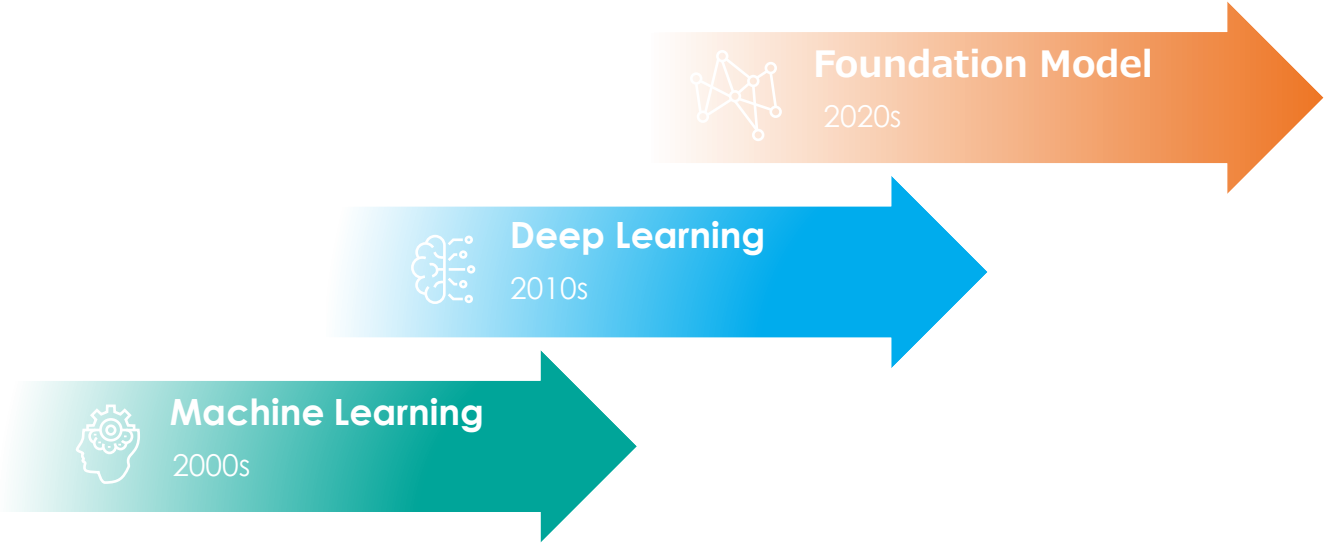

Moore's Law: The number of transistors on microchips doubles every two years
Our World in Data
Transistor count
Year in which the microchip was first introduced



https://www.supermicro.com/ja/solutions/liquid-cooling より引用

New challenges

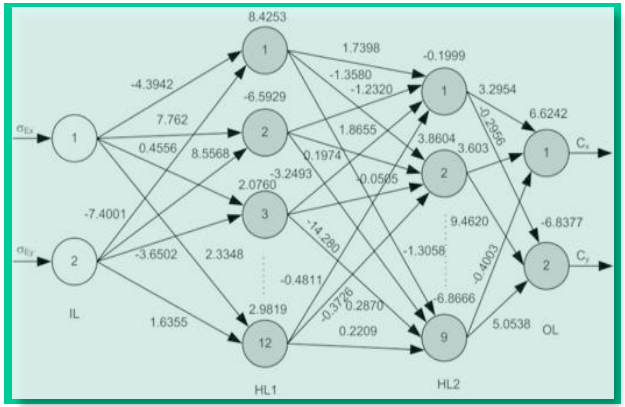
1. WUE(Water Usage Effectiveness)
2. Storage: Semiconductor, Disk, Tape
   ➔ Optical, Quantum
3. Computation:
   i. GPU for AI : Dense matrix ➔ Sparse matrix
      (image/video bitmap) (semantic data, e.g.,LLM)
   ii. Quantum as accelerator
4. Embodied carbon (Scope 3 supply chain)



Source：SambaNova
https://sambanova.ai/

Latest AI calculation is of Data-Flow

```cpp
#include <iostream>
using namespace std;

int _tmain (int argc, _TCHAR* argv[])
{

    int iVal1 = 0, iVal2 = 0, iVal3 = 0;

     printf("Enter three numbers:");
     scanf("%d %d %d", &iVal1, &iVal2, &iVal3);

    if (iVal1 >= iVal2)
     {
         if(iVal1 >= iVal3)
           printf("Largest number = %.2d", iVal1);
         else
           printf("Largest number = %.2d", iVal3);
     }
     else
     {
         if(iVal2 >= iVal3)
           printf("Largest number = %.2d", iVal2);
         else
           printf("Largest number = %.2d", iVal3);
     }

 getchar ();
 return 0;
}
```



Software 1.0

- Algorithm is written by code (e.g., C++, ...)
- Programmer, called as domain expert needs domain specific experty, knowledge and experiences

AI is Data Flow（Software2.0）

- Data, not code, delivers and trains model.
- Deep Neural Networks
- Weight of works define/deliver parameters

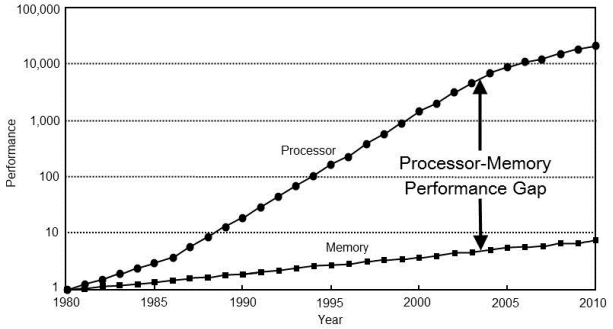
Source：SambaNova
https://sambanova.ai/

Semiconductors for AI processing

Recent AI computing, such as LLM, requires sparse matrix computation and huge electric power by CPU and GPU

- Big gap between processors and memories, is exponentially growing
  - Hierarchal memory structure conceals data transmission latency
  - Depending on cache hit ratio/character
  - Optimized for Dense GEMM
  - Poor performance for Sparce GEMM
- Data transmission and copying computation consumes far larger electric power than data calculation/processing data does.
  - **Performance of computation depends on how close the data stored so sa to let short/small for data transmission from memory/storage location to ALU location.**

Most of {start up} companies propose legacy semiconductor design for {dense matrix computing based} AI solution.



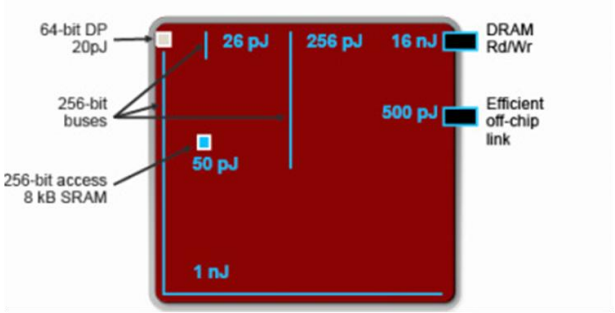


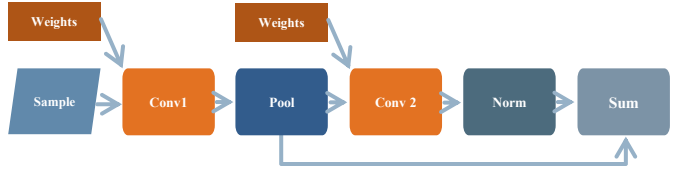
Figure: Computation cost is significantly lower than communication cost in 28nm NVIDIA chips
(Source: Bill Dally)

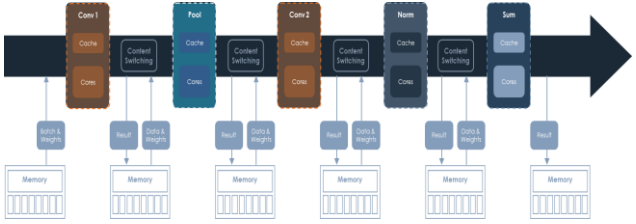
Source: SambaNova
https://sambanova.ai/

Innovation of data-flow data processing architecture

Flow of data and processing is defined by locality and parallelism

CONVOLUTION GRAPH





Since memory access is required for each calculation kernel, it is necessary to place high-speed memory near the computing unit.

➔ **High-Speed memory has a small capacity**

External memory access can be minimized, to eliminate the need of high-speed memory

→ we can have larger capacity for memory

Calculation is triggered only by data migration

→ good for sparce matrix

Source: SambaNova https://sambanova.ai/

What happened in Data Center and Servers

Missing piece……

➔ Energy productivity of Software(code)

(*) challenging with USP Mongolia

- Bad code
  - ① A lot of wasted operations
  - ② Less flexibility
- Good code
  - ① Small wasted operation
  - ② Good flexibility

Reduction of

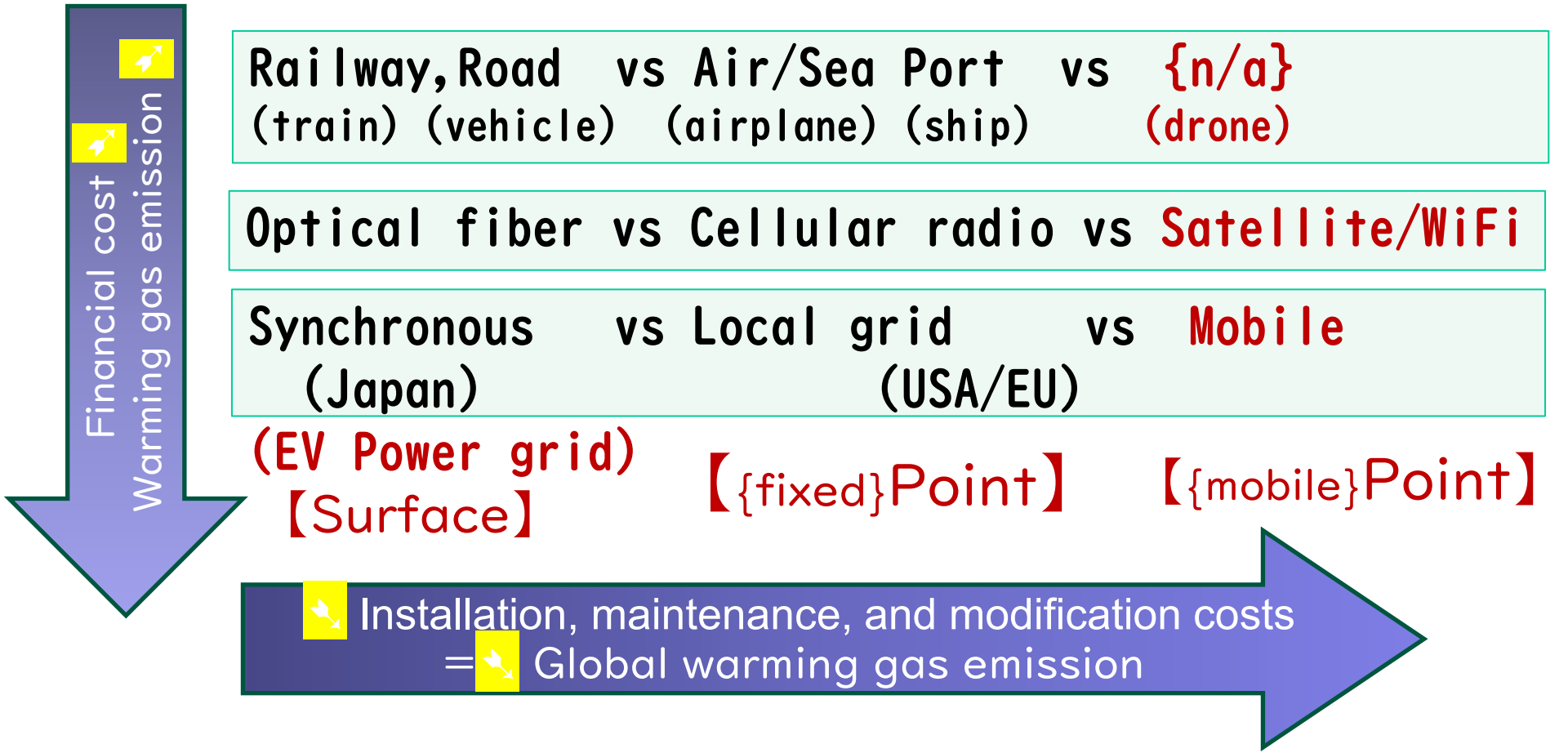
① Operational Power

② Total System Resource, i.e., embodied carbon

Hybrid and diverse of DC profiles

AI; New & interesting & scary phenomenon

- ✓ Experts (= “Takumi(匠)" = "adult" ≒ person) are bound by "wisdom" and "knowledge" based on the accumulation of their past experience.
- ✓ Computers may be a "children", so they come up with ideas that "adults" can't think of (without restrictions).
- ✓ However, because it follows the taught / given data, it makes a straightforward and **biased judgment due to the biased data**.
- ✓ In addition, recent computers have become able to "evaluate" this "adult" by simulating "ideas that cannot be thought of" in cyberspace.
- ✓ It is becoming possible to actually develop ideas that seem to work {but seemed unlikely to work for "adults"}.


Financial cost
Warming gas emission
Railway,Road (train) (vehicle) vs Air/Sea Port (airplane) (ship) vs {n/a} (drone)
Optical fiber vs Cellular radio vs Satellite/WiFi
Synchronous (Japan) vs Local grid (USA/EU) vs Mobile
(EV Power grid)
【Surface】
【{fixed}Point】
【{mobile}Point】
Installation, maintenance, and modification costs
= Global warming gas emission

Energy x Digital

EV as new component

【Operating rate】

- Private : 4~5%
- Commercial : 24%

1. Battery
2. Computation
3. Mobility

体積当たりのエネルギー密度

400V & 12V DC System

100 KW in Peak
30 KW for continuous
↓
30 Houses
by 50cm x 50 cm x 50cm

原子力発電	旧式	300～500 MW
	現在	1.0 ～ 1.5 GW
火力発電 (黒部ダム)		335 MW
水力発電		500MW ～ 1.0 GW
日産リーフ	常時	225 MW
	ピーク	750 MW

HONDA FCV
30 kW (持続)
100 kW (ピーク)

マクロ

駐車場

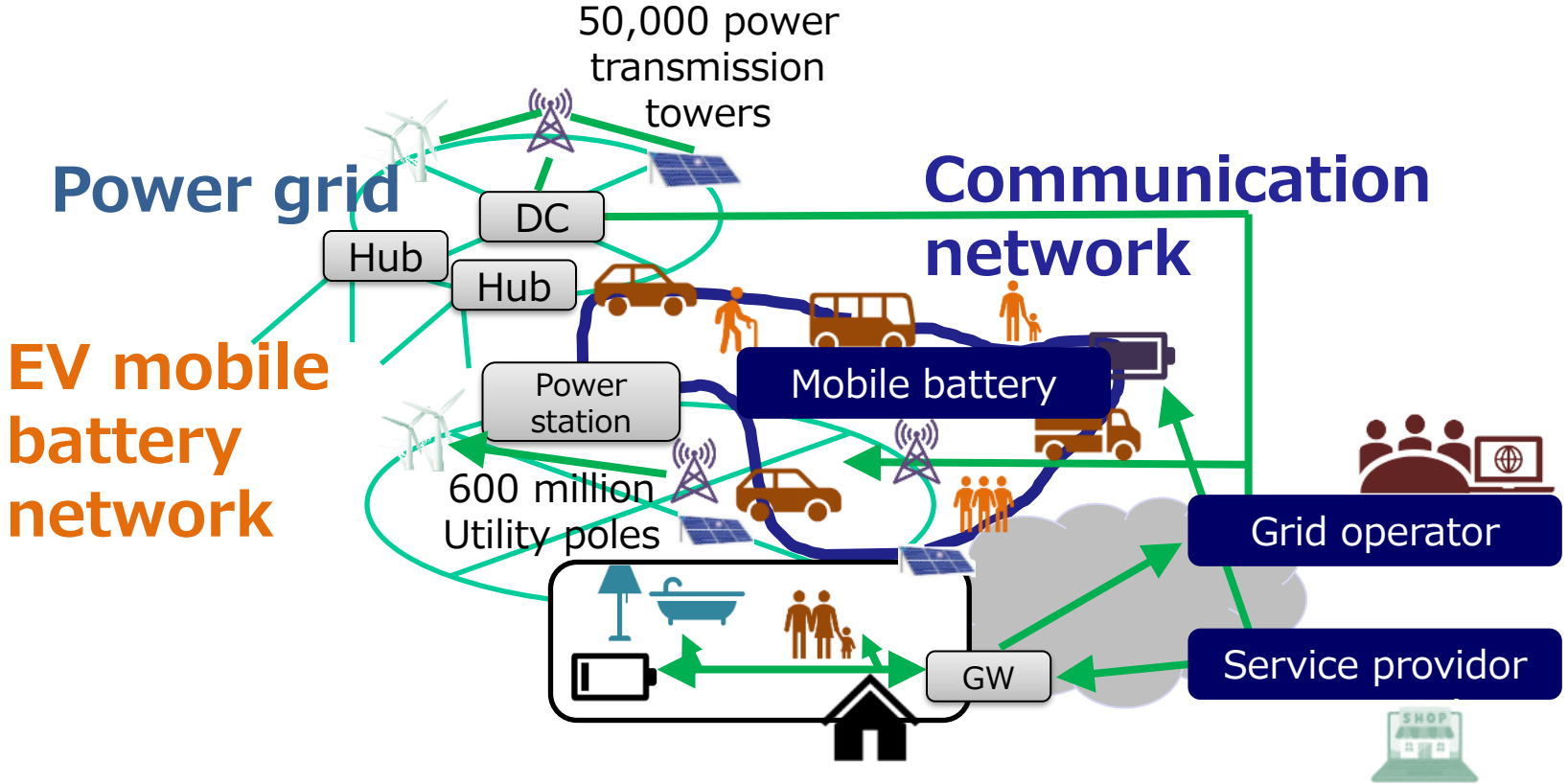
日産リーフ: 常時 30 KWh / 台
累計販売台数: 35万台(Worldwide)
75,000 台(国内)
(*) as of Sept 2016

テスラ家庭向け蓄電装置
13.5KWh
来年約70万円で発売予定

日産リーフ (100台)	常時	3 MW
	ピーク	10 MW

High capacity mobile battery packages

①Battery x ②Computation x ③Mobility



（出所）岡本(2021)「GRIDで理解する電力システム」、電気新聞出版

①Battery x ②Computation x ③Mobility

50,000 power

◆ Nissan EV：30kW(Ave.), {100kW(Peak)}, 100kWh

👇

1. 10^6(1 millions)：30GW(Ave.), 100 GWh(Peak)
   - Pumped storage power in TEPCO (=9GWh) **x 10**
   - 黒部ダム(=335MW) **x 10**

2. 100 EVs ： 3MW(Ave.), {30MW(Peak}
   - Eng.No.2 Bldg (12F)： 700kW (≒35 EVs)
   - Hongo Campus(No.2 in Tokyo)：30MW (≒1 k EVs)

（出所）岡本(2021)「GRIDで理解する電力システム」、電気新聞出版

①Battery x ②Computation x ③Mobility

50,000 power

- Tesla(by AMD@CES2023)： **10 TFLOPS (10^{13})**
  https://car.watch.impress.co.jp/docs/news/1469629.html

- 富岳(No.3 Super Computer)： **1,000 PFLOPS (10^{18})**
  - **3 TFLOPS/node**
  - 158,976 nodes (1.5×10^5)

  https://www.fujitsu.com/jp/about/businesspolicy/tech/fugaku/specifications/

👇

100k(=10^5) Tesla ≒ 富岳(No.3 Super Computer)

（出所）岡本(2021)「GRIDで理解する電力システム」、電気新聞出版