Computer Systems for AI-inspired Cloud: Theory & Lab.

Fall 2018

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School of Electrical Engineering and Computer Science, GIST

- 기존 국문제목: 클라우드, AI기반 소프트웨어 중심의 정보통신

- 수정 영문제목:

Computer Systems for AI-inspired Cloud: Theory & Lab.

- 수정 영문제목:

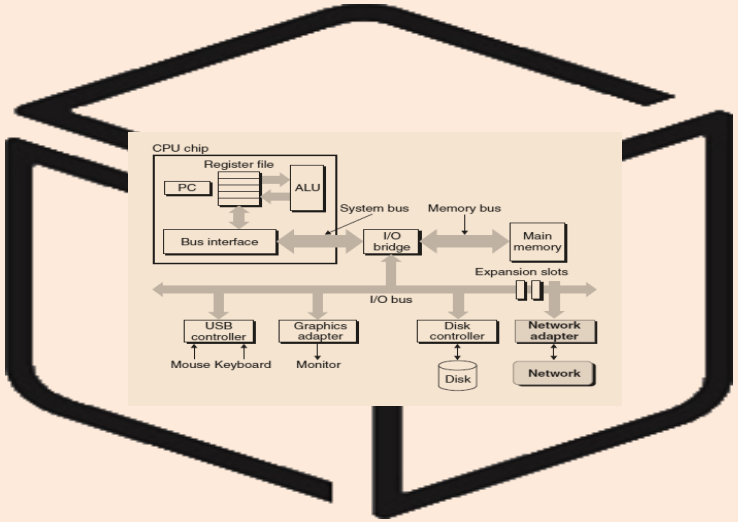
AI 기반 클라우드를 위한 컴퓨터 시스템: 이론 및 실습

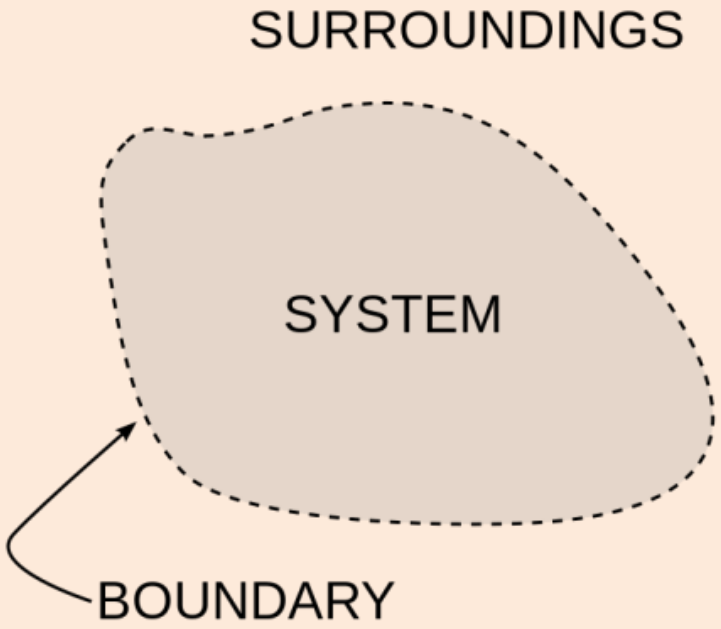
Contents: Theory

Contents: Labs

- Lab #0: **Overview** Lab
- Lab #1: **Box** Lab
- Lab #2: **Inter-Connect** Lab
- Lab #3: **Tower** Lab
- Lab #4: **IoT** Lab
- Lab #5: **Cluster** Lab
- Lab #6: **Analytics** Lab

Chapter 1: What is Computer System?



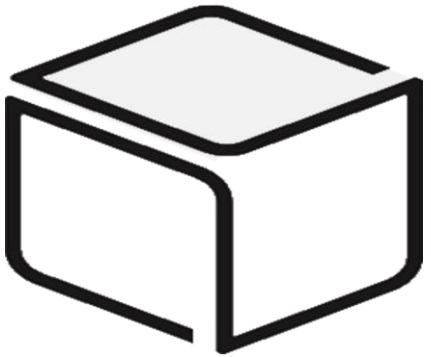


Chapter Keywords

Storage

Compute

Box

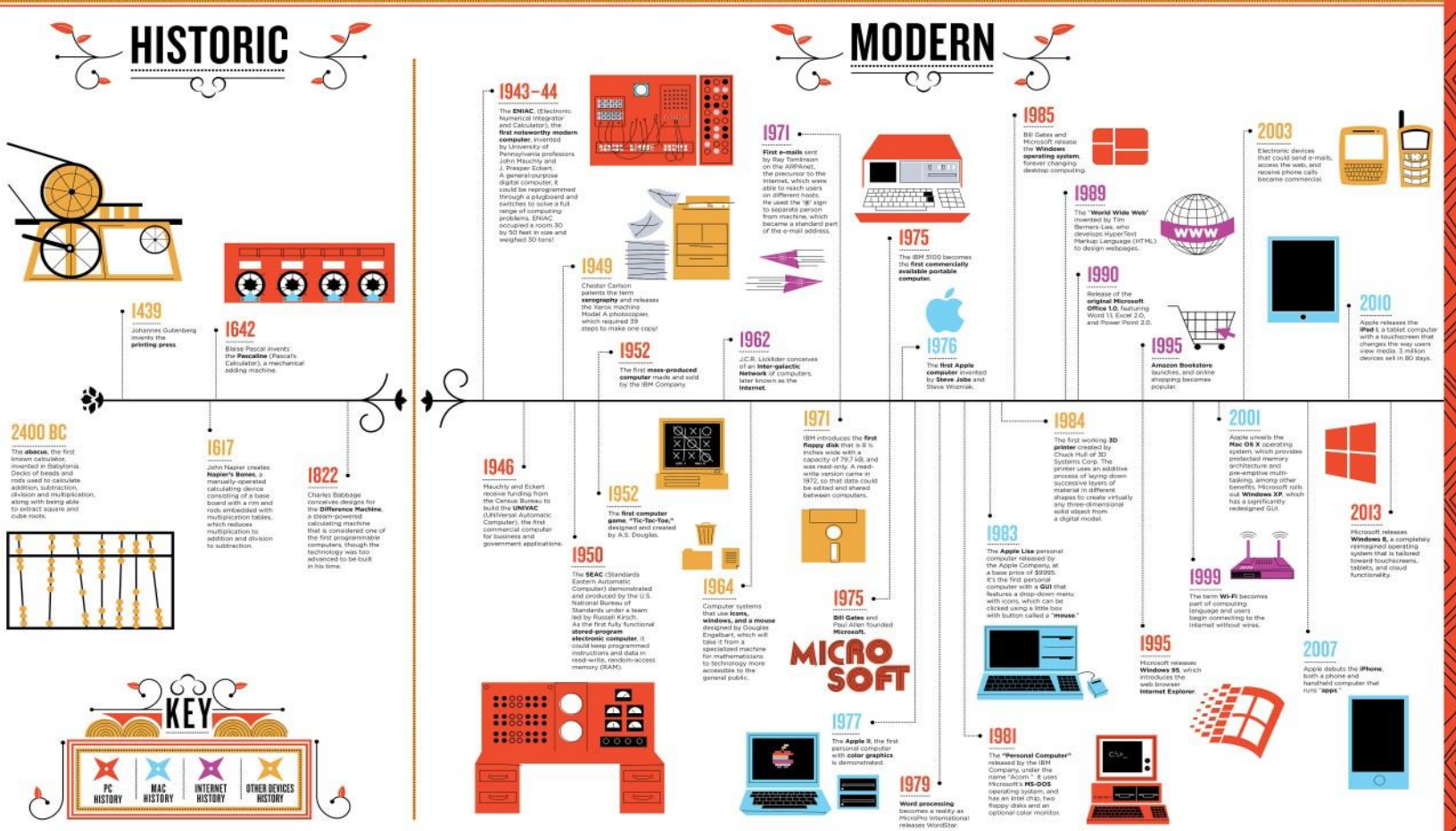


Networking

Check https://www.livescience.com/20718-computer-history.html

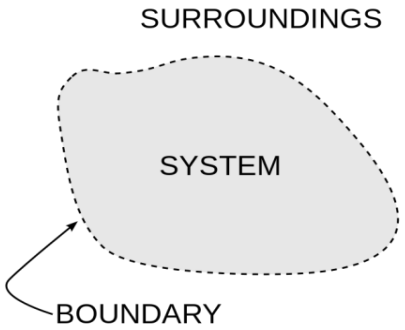
THE EVOLUTION OF COMPUTERS

PC NINJA TRAVELS THROUGH TIME, revealing the history of how computers became our sidekicks. From sliding pebbles on a simple machine to swiping your fingers across a touchscreen, technology has transformed radically!



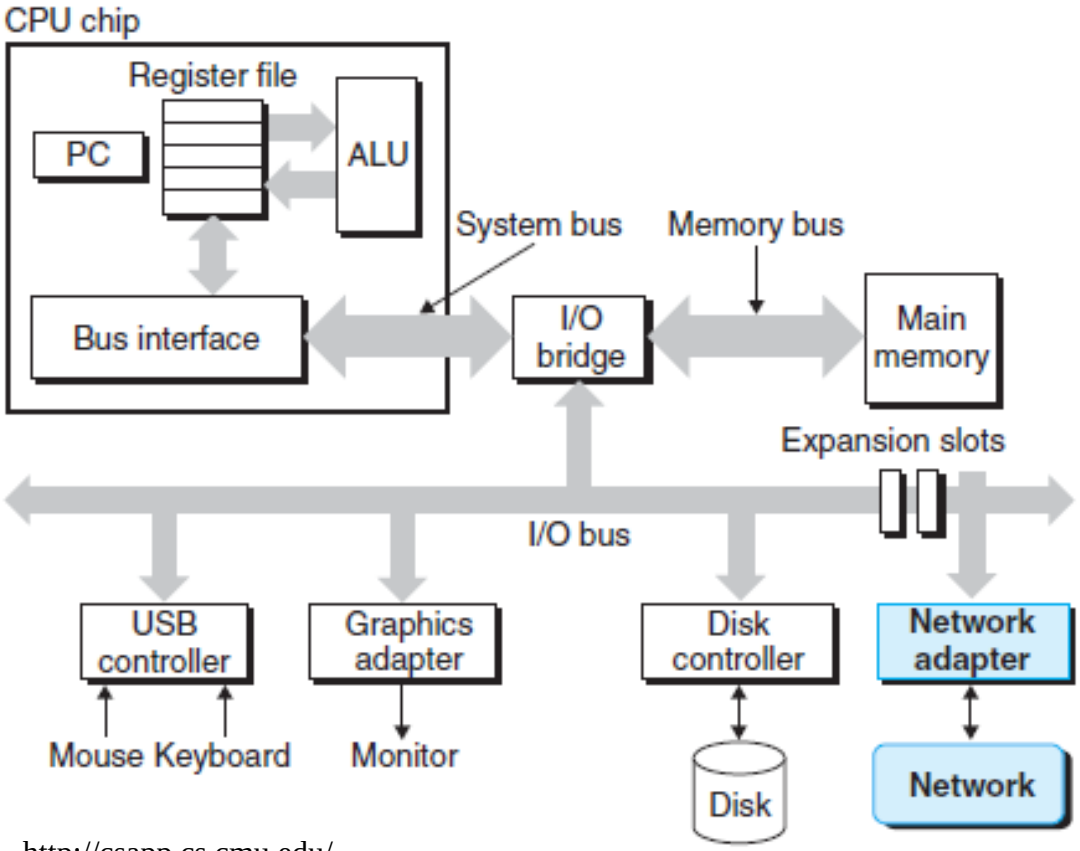
https://visual.ly/community/infographic/computers/evolution-computers

Computer System: Definition

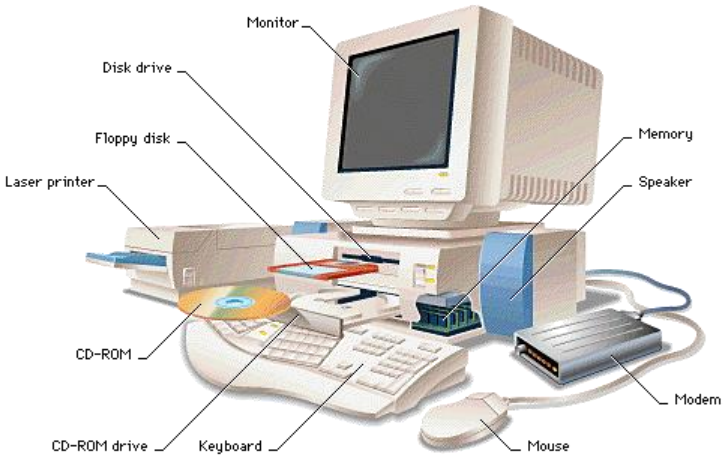


Computer: an electronic device for storing and processing data, typically in binary form, according to instructions given to it in a variable program.

System: a set of interacting or interdependent components forming an integrated whole

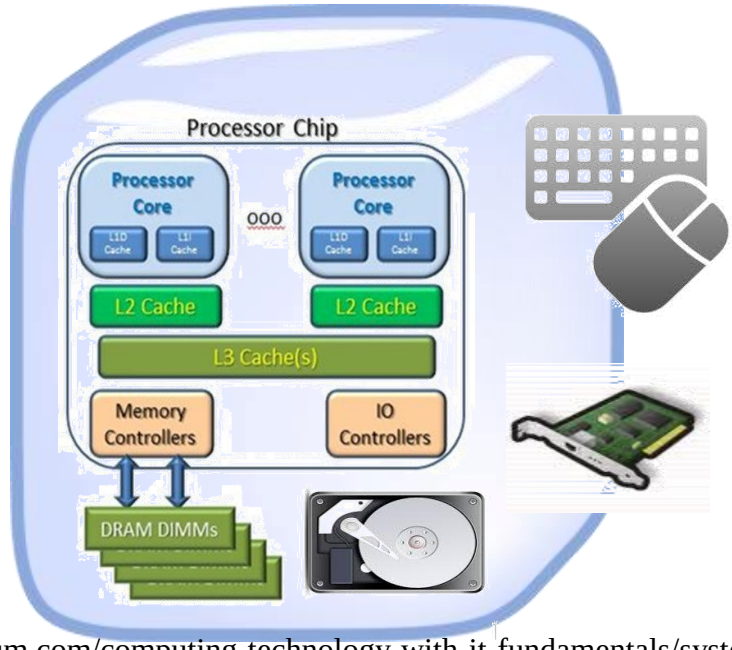


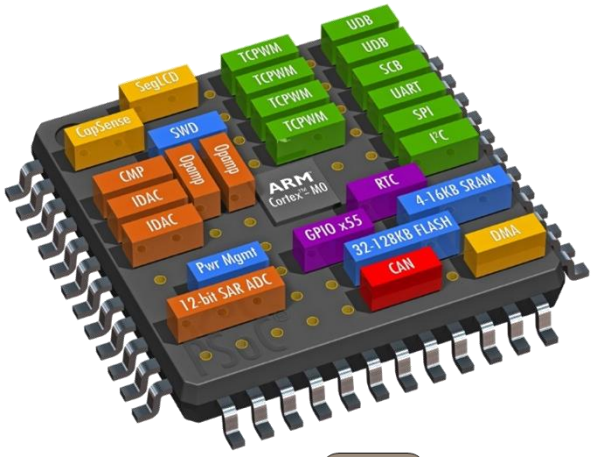
http://csapp.cs.cmu.edu/



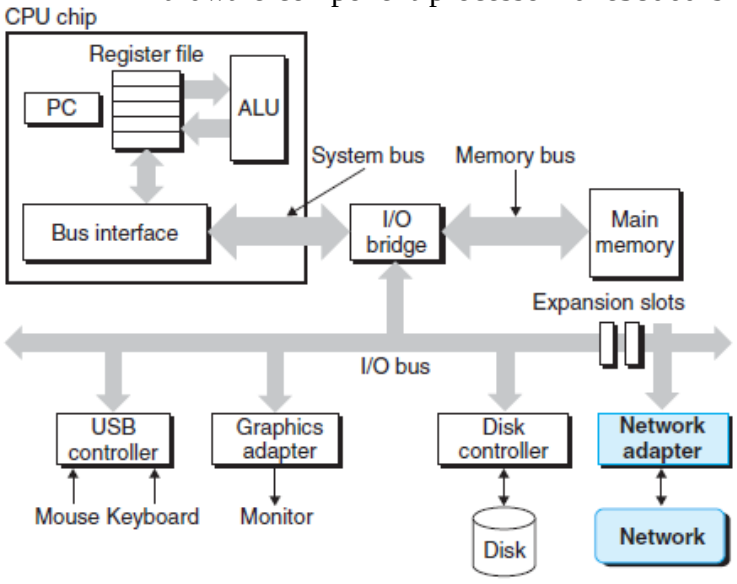
https://slideplayer.com/slide/8830994/

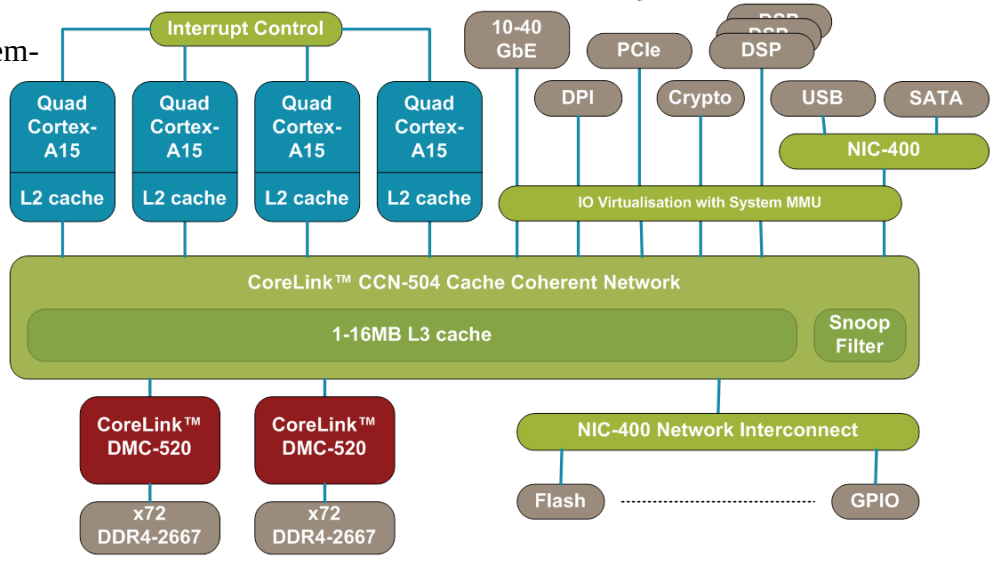
Evolution of Computer System (Chip)





https://medium.com/computing-technology-with-it-fundamentals/system-hardware-component-processor-fd1e58d6dfb2

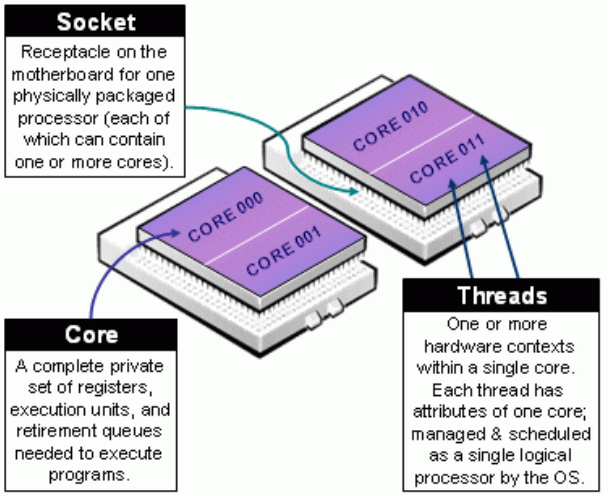




SOC Chip (ARM Cortex + Corelink)

https://community.arm.com/processors/b/blog/posts/coherent-interconnect-technology-supports-exponential-data-flow-growth

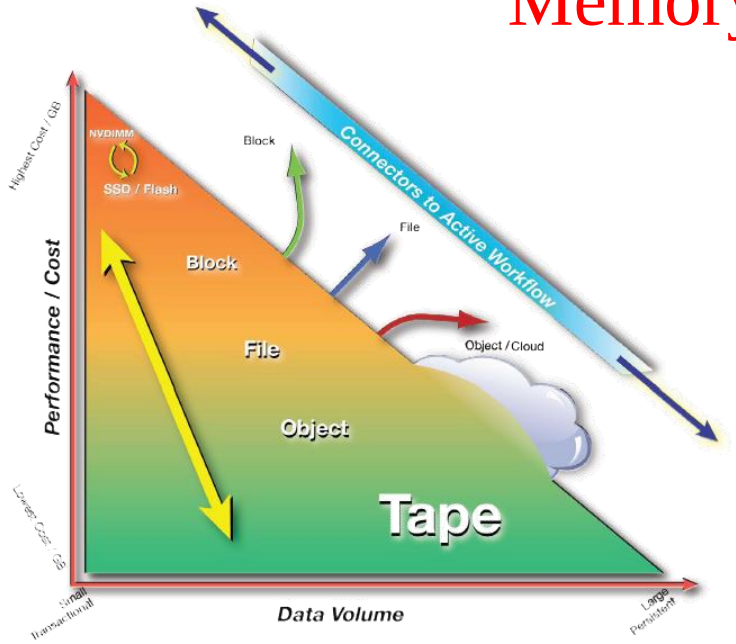
Major Components of Computer Systems



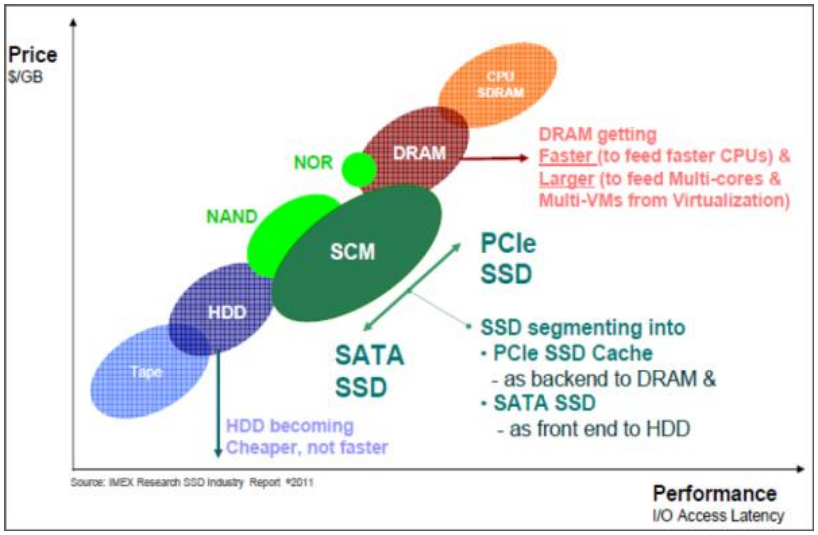
https://slurm.schedmd.com/mc_support.html

- Compute
  - CPU & Memory
- Storage
- Network

Memory/Storage Hierarchy

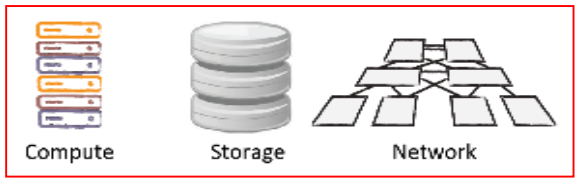


추적 불가

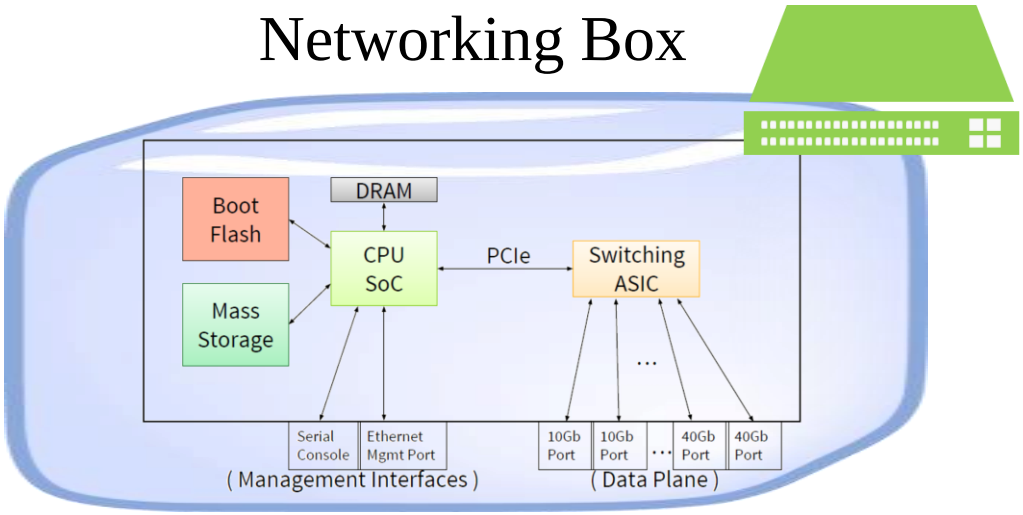


https://www.semanticscholar.org/paper/Optimizations-of-Management-Algorithms-for-Memory-Oren/2799edf40be793a6c7b86b391270014442191cd7

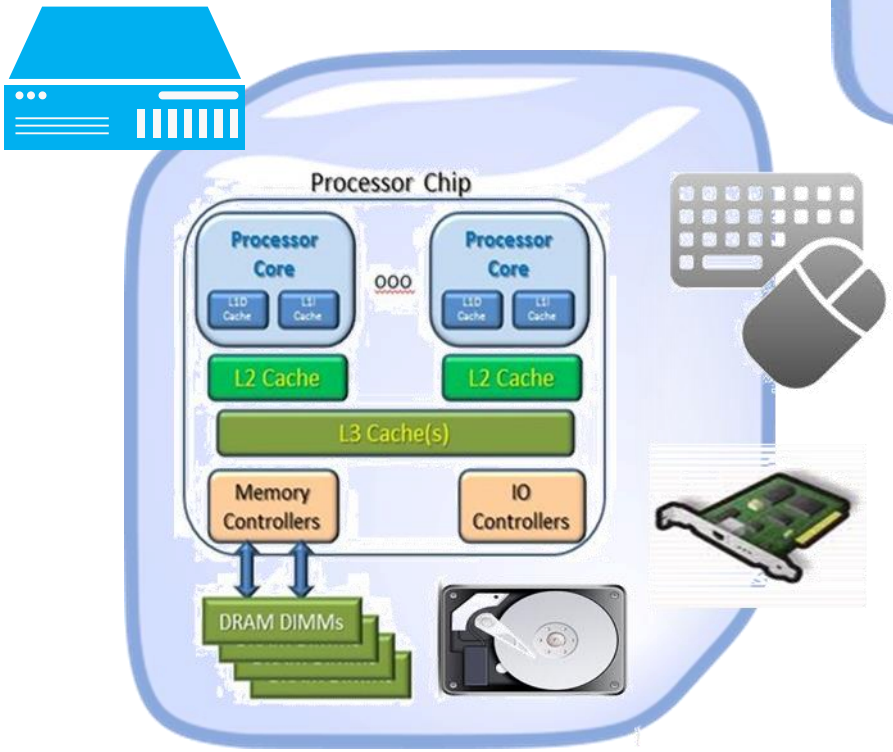
Diversity of Computer Systems ➔➔ Box



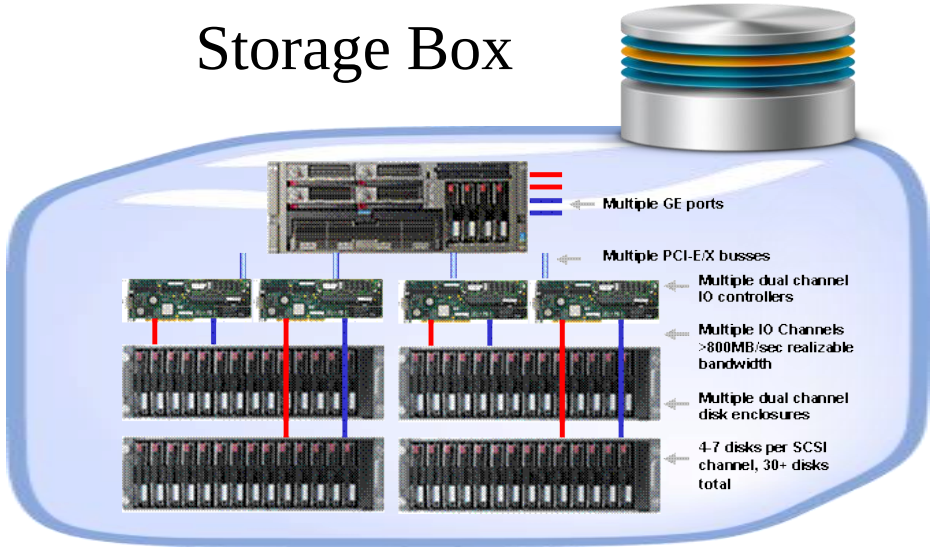
Networking Box



Compute Box



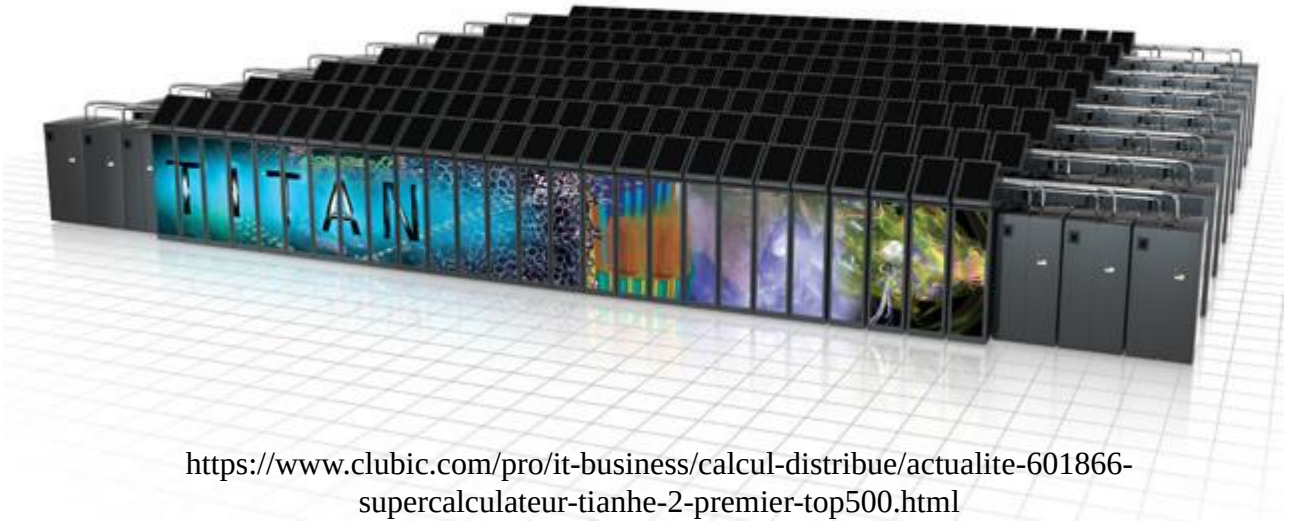
Storage Box



http://www.sql-server-performance.com/2006/system-storage-configuration/

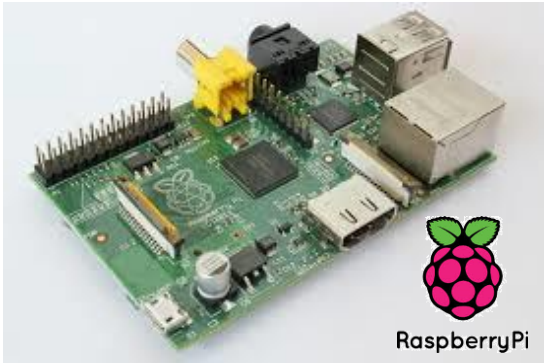
Compute Box: Computers & Computer (Server) Clusters

https://www.engadget.com/2014/03/31/intel-sd-card-sized-edison-change/



https://www.clubic.com/pro/it-business/calcul-distribue/actualite-601866-supercalculateur-tianhe-2-premier-top500.html

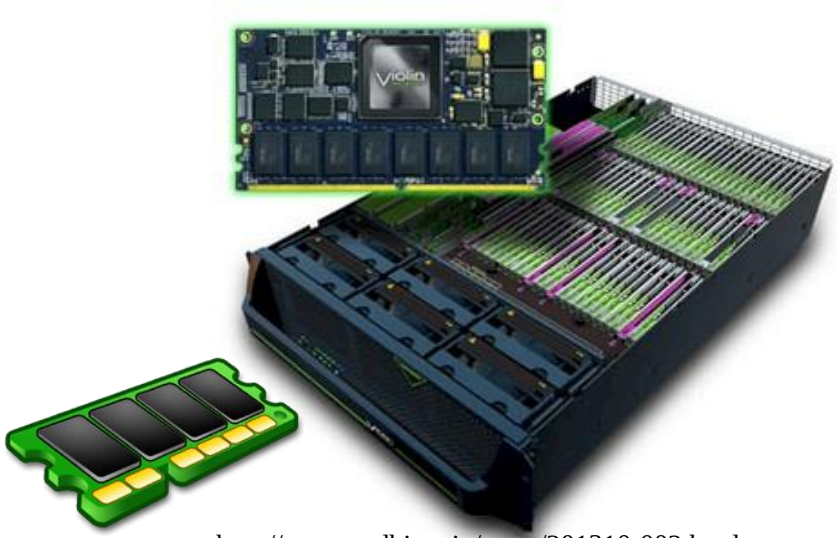
https://commons.wikimedia.org/wiki/File:Arduino_Ethernet_Board.jpg



https://gl.wikipedia.org/wiki/Raspberry_Pi

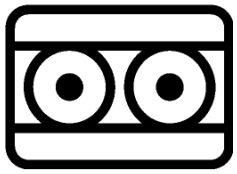
https://hatewait.ru/product/samsung_galaxy_a8_2018_black.aspx

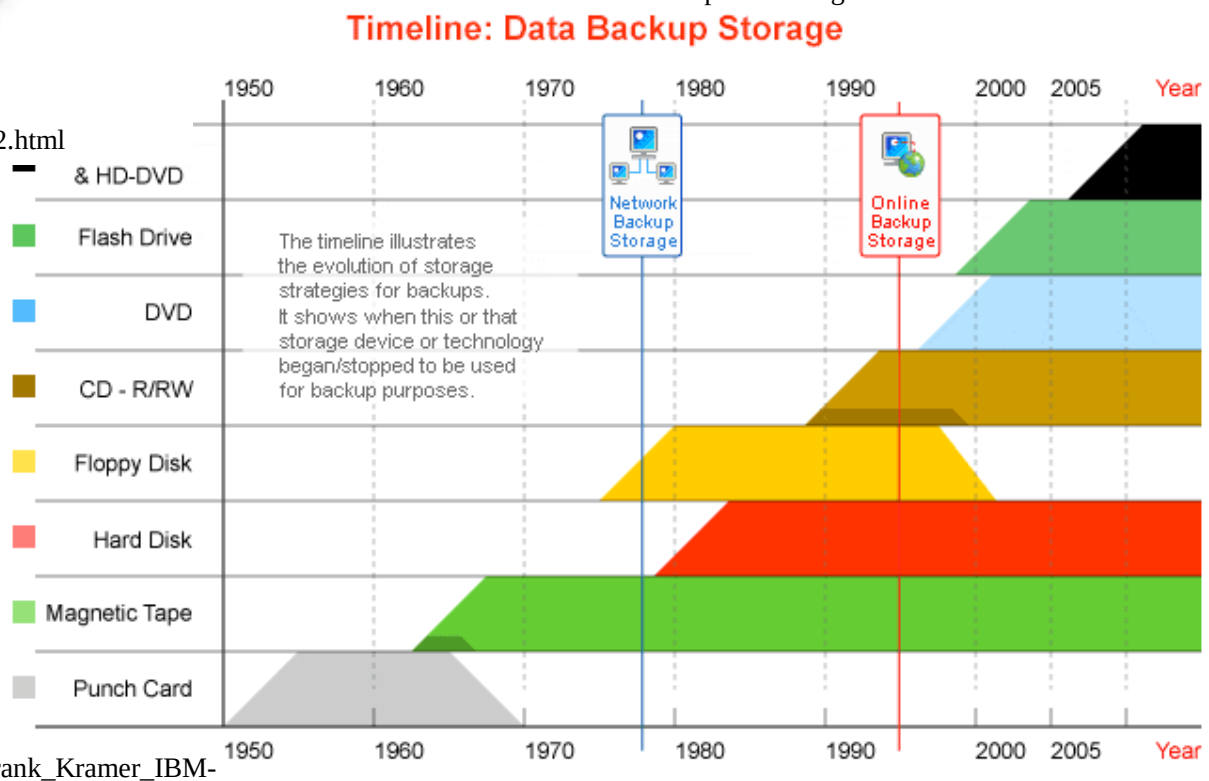
Storage Box: Storage Servers



http://www.nsdbi.co.jp/news/201310-002.html

http://www.bigfixtech.com/



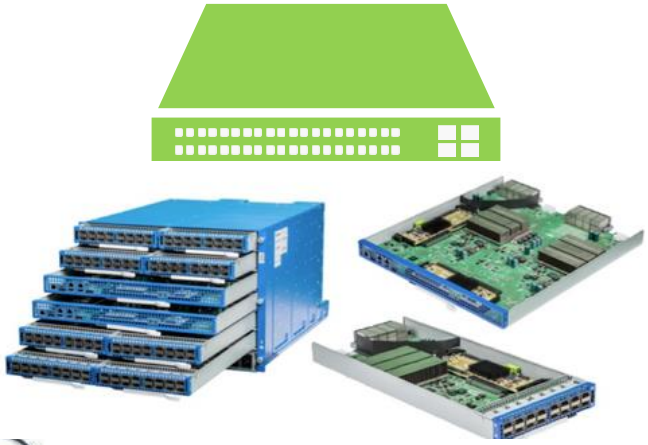


http://files.gpfsug.org/presentations/2018/Singapore/Frank_Kramer_IBM-DataManagement-for-ADAS-Scale-UserGroup-SIN-032018.pdf/

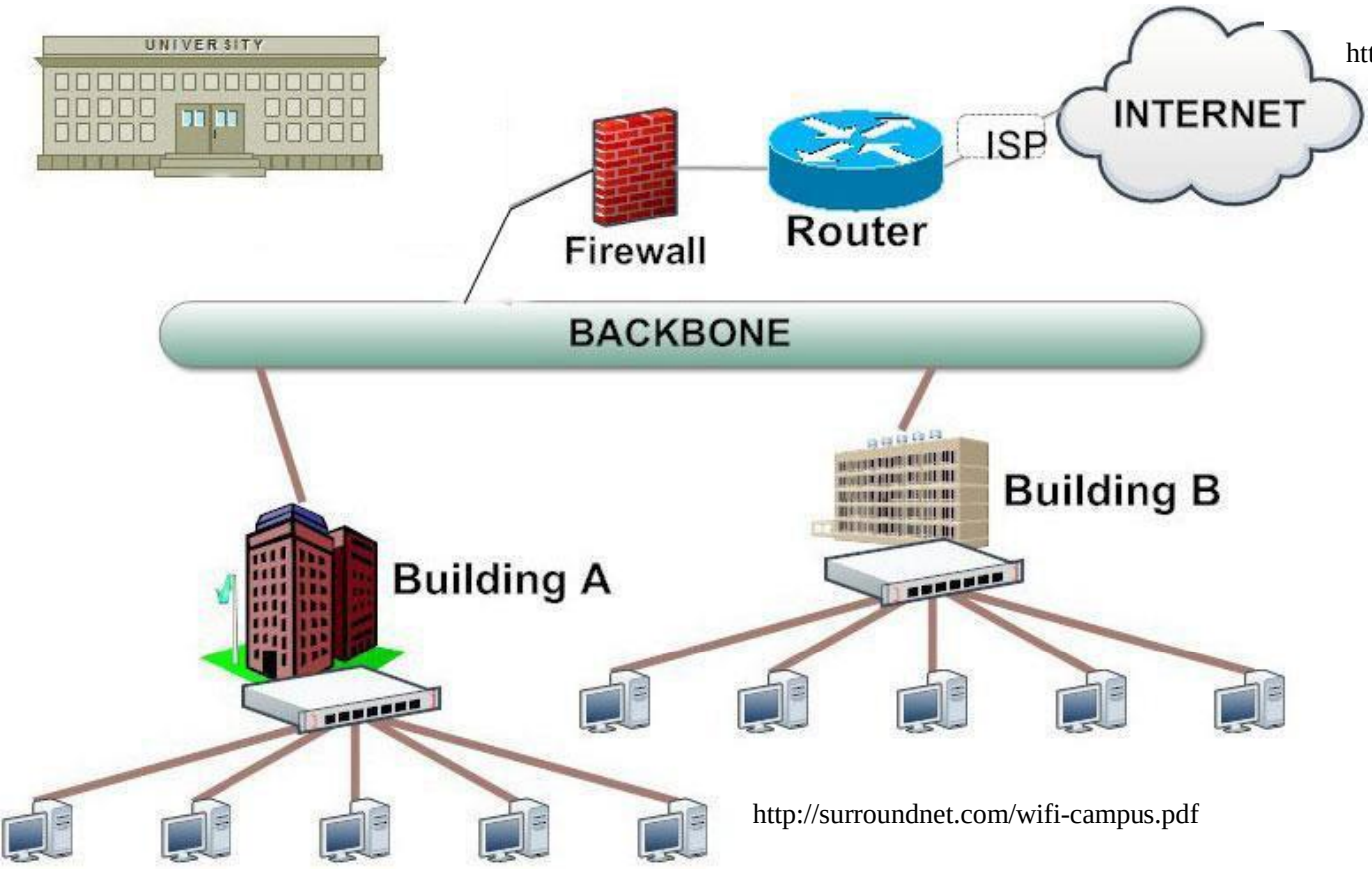
http://www.backuphistory.com/

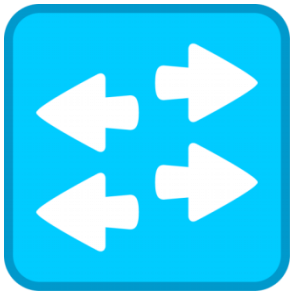
Networking Box: Switches & Routers

Router



https://www.jianshu.com/p/5bf4213d4f0a

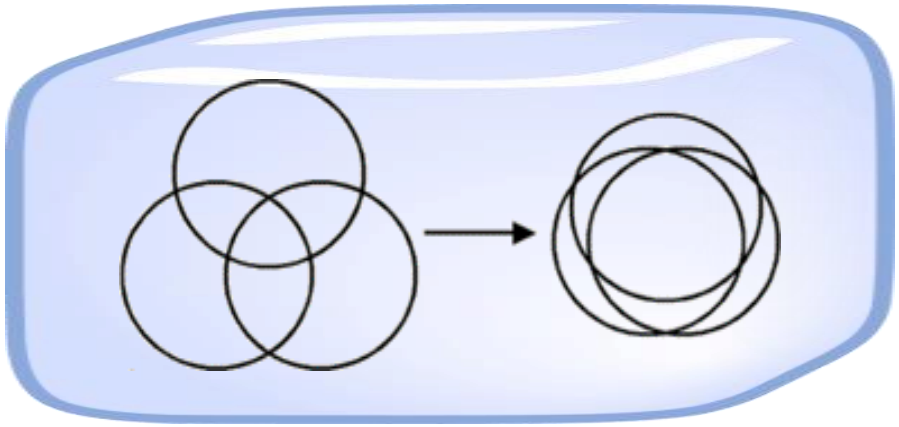


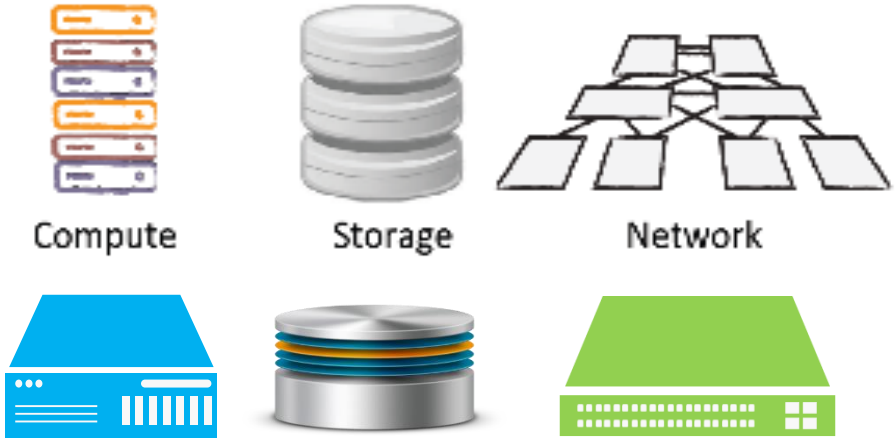


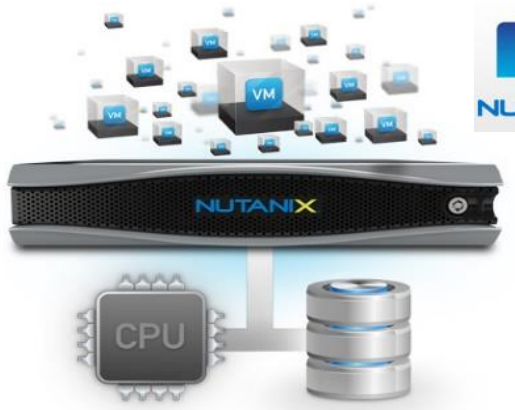
Switch

http://surroundnet.com/wifi-campus.pdf

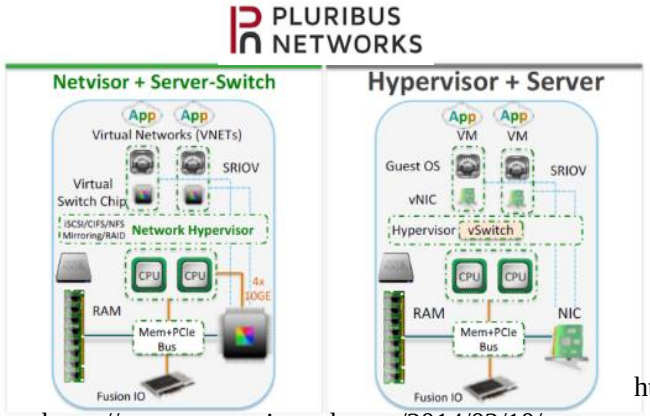
Futuristic Box: Hyper-Converged Infrastructure



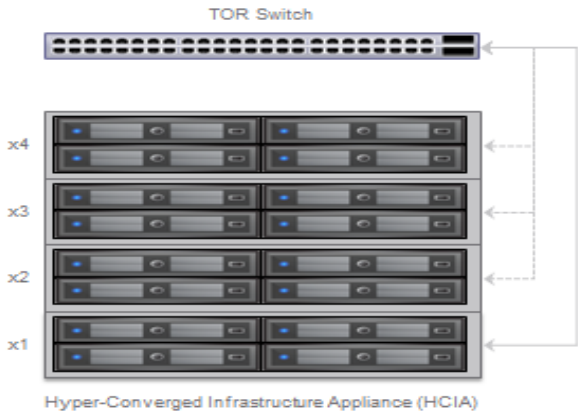




http://www.bytelife.com/blog/software-defined-andmekeskus-pariselt/



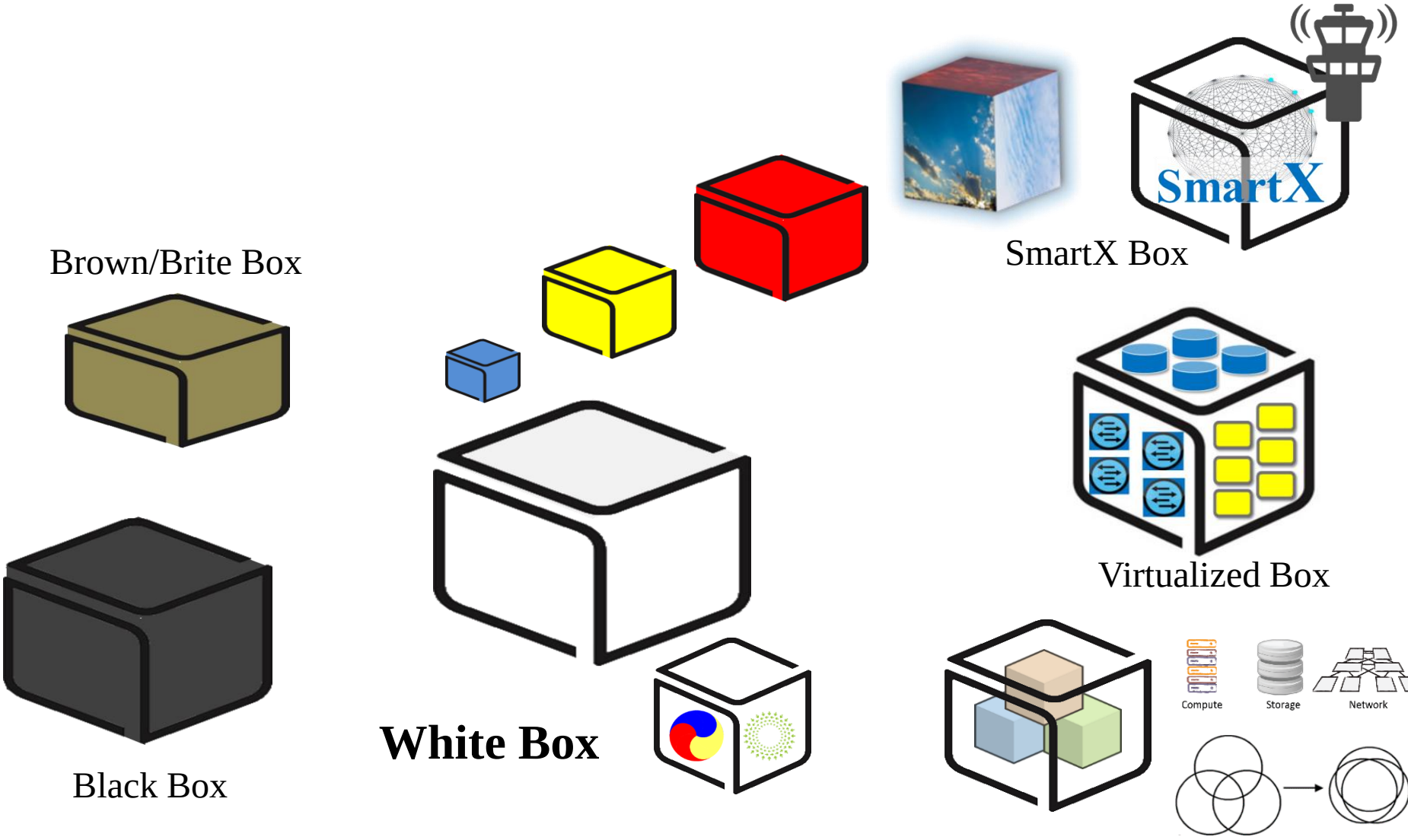
https://www.enterprisetech.com/2014/02/10/start up-slashes-latencies-server-switch-hybrid/



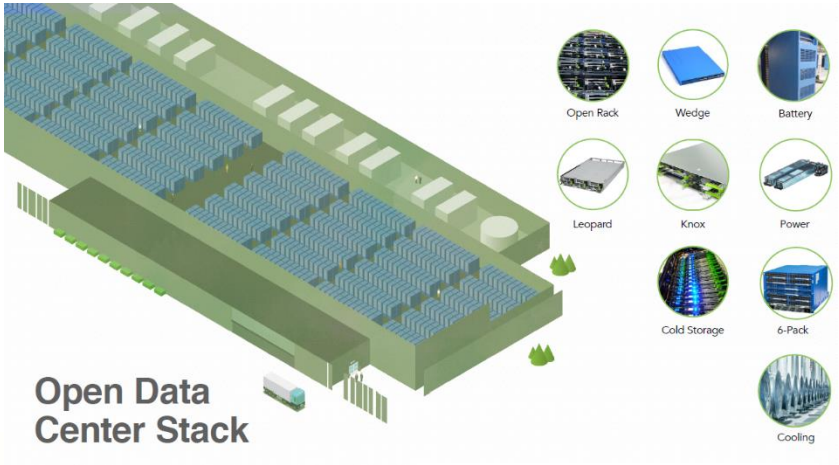
vmware EVO RAIL

http://www.wooditwork.com/2014/08/25/vmware-marvin-comes-alive-evorail-hyper-converged-infrastructure-appliance/

Multiple Box Abstractions:
Black/Brown/White and SmartX Boxes



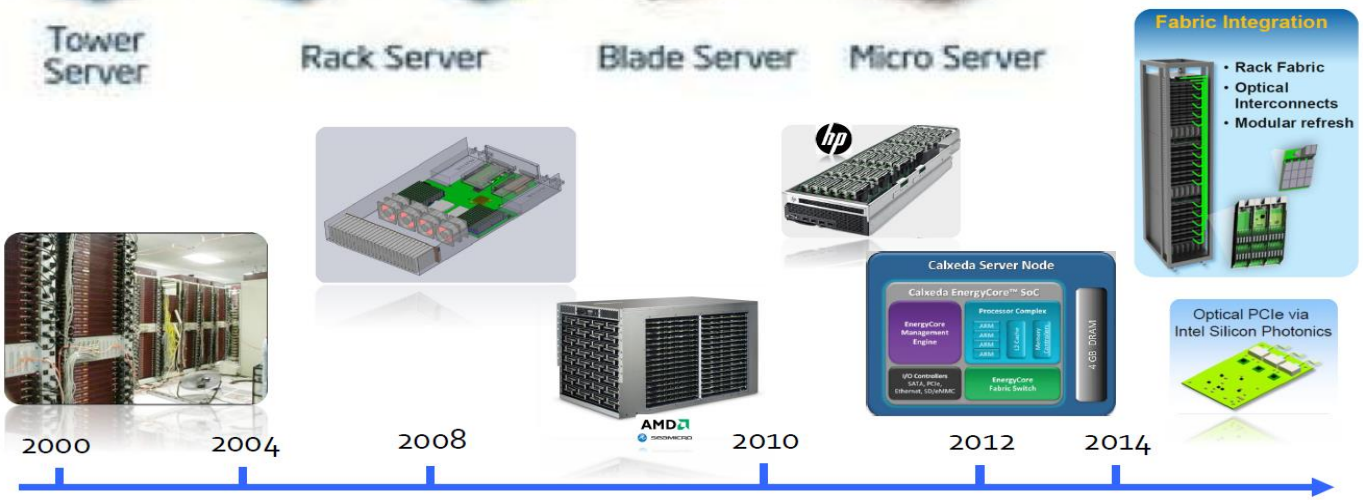
Converged/Disaggregated Boxes in Data Centers



https://internetofthingsagenda.techtarget.com/definition/microserver

OPEN Compute Project

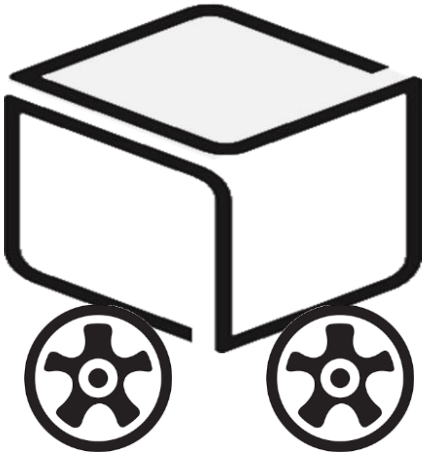
Open-Source Hardware



Rack Scale Computing

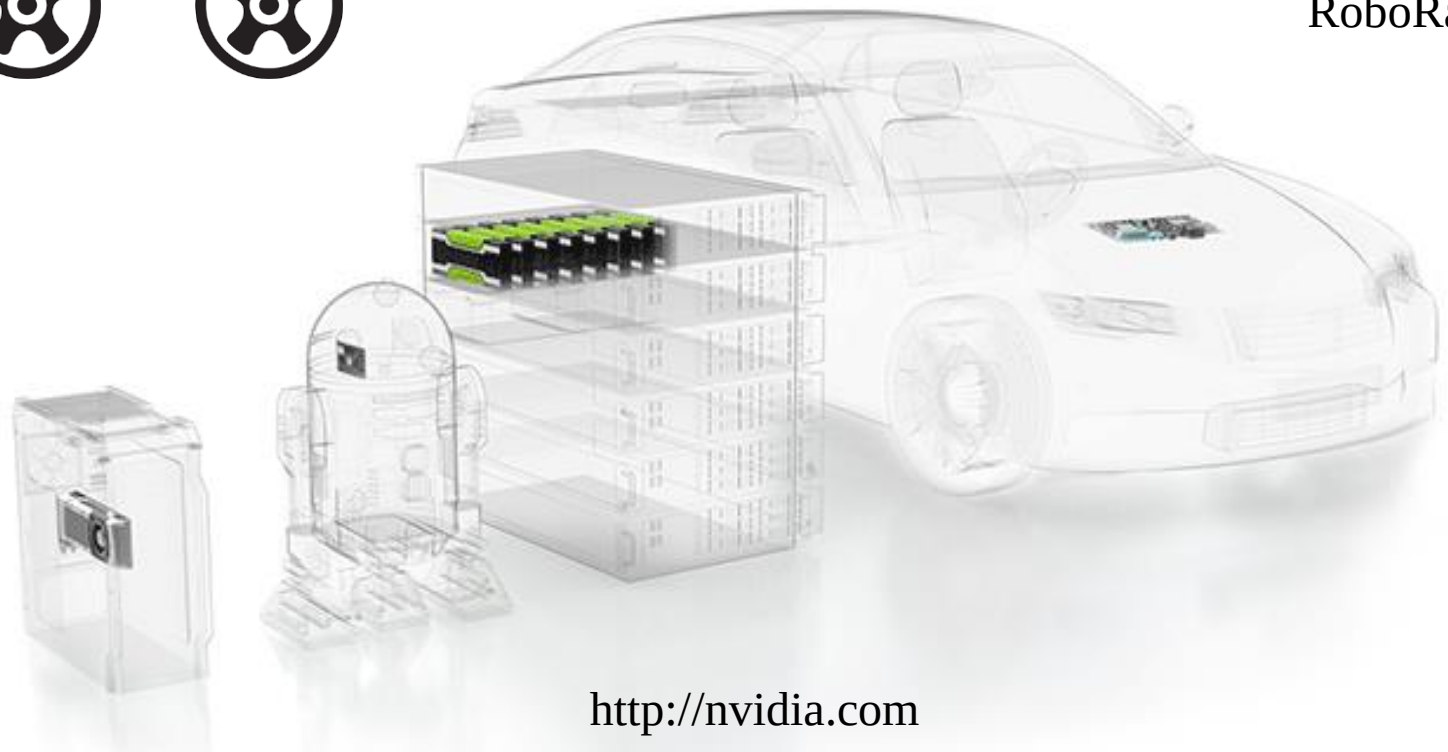
Silicon Photonics
High-bandwidth / low-latency interconnect (resource disaggregation)

Computer Systems Everywhere



http://poe.goha.ru/news/99/2016-04-01%2014:00:18

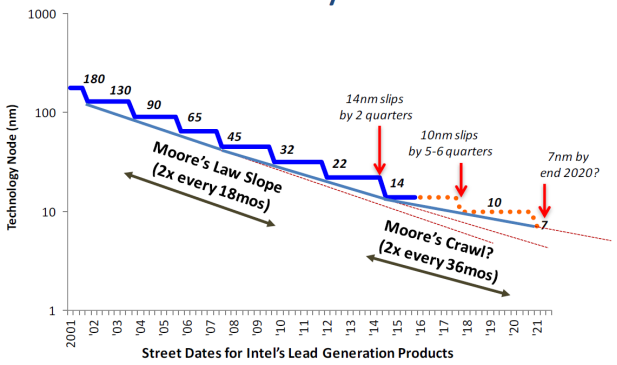
RoboRace



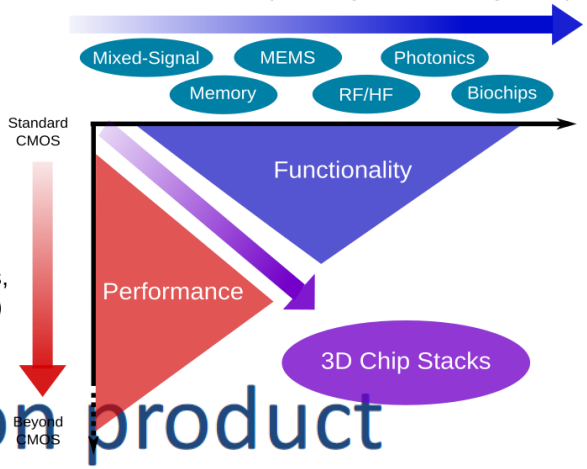
http://nvidia.com

Future of Compute Boxes

Moore's Law impact on product release cycles



"More than Moore" (Heterogeneous Integration)

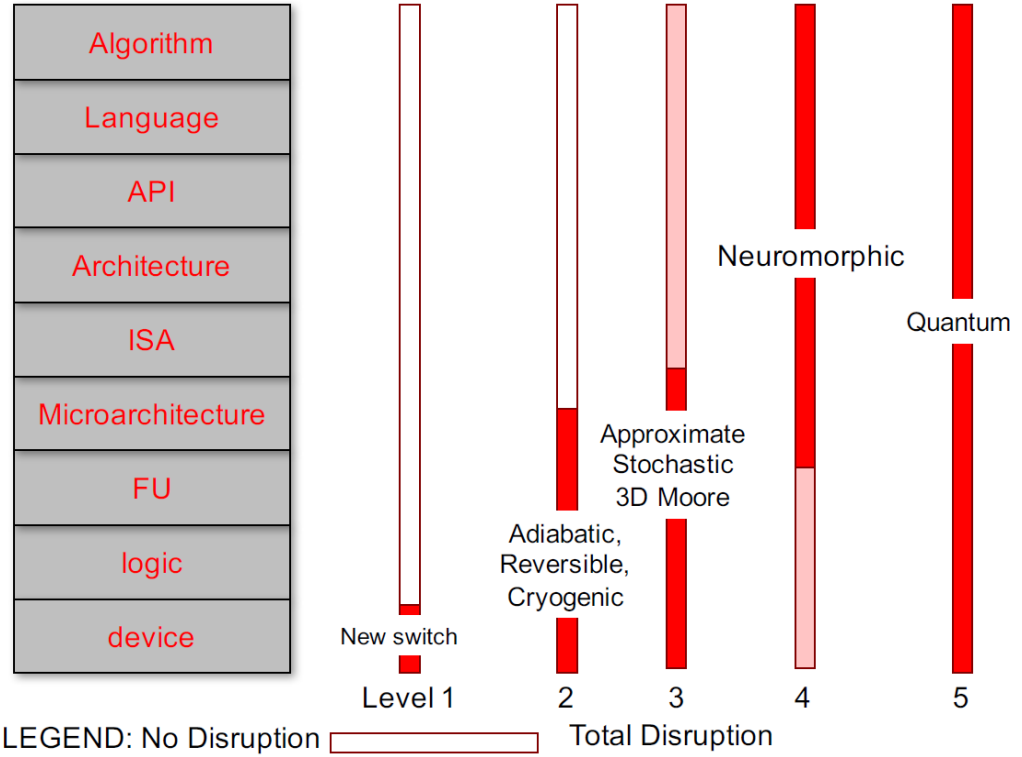


"More Moore" (Smaller Nodes, New Materials)

act on product

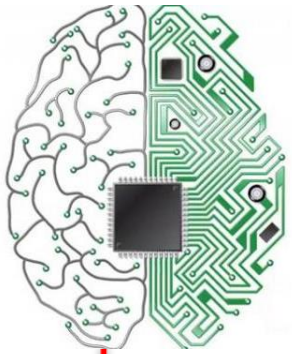
release cycles

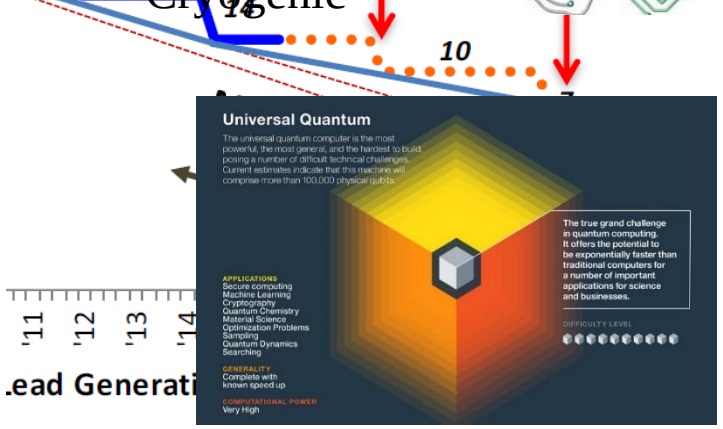
Differing Levels of Disruption in Computing Stack



Cryogenic

Neuromorphic





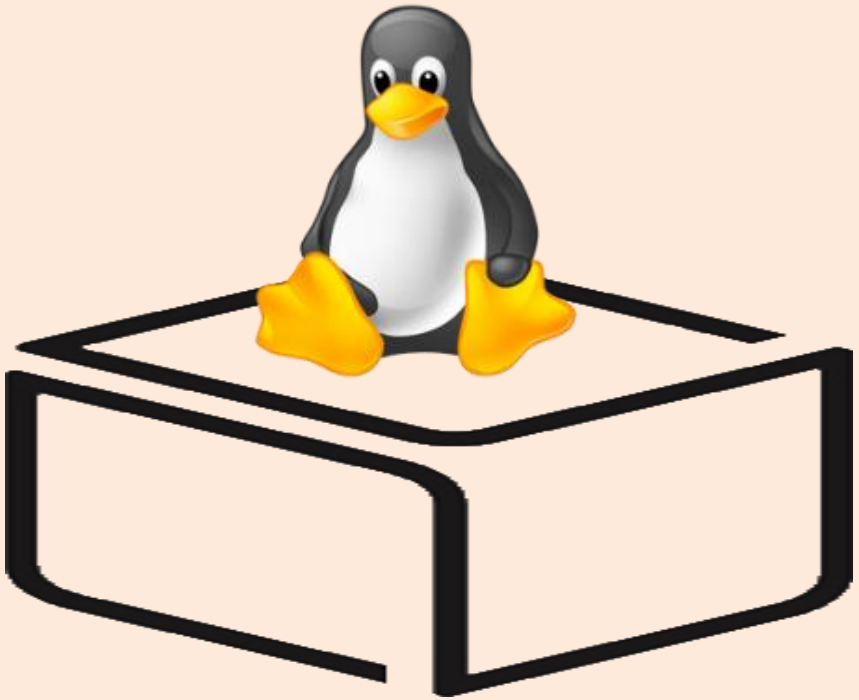
Gwangju Institute of
Science & Technology

Thank you!

Send Inquiry to jongwon@gist.ac.kr

http://nm.gist.ac.kr

Chapter 2: Computer System & OS Software



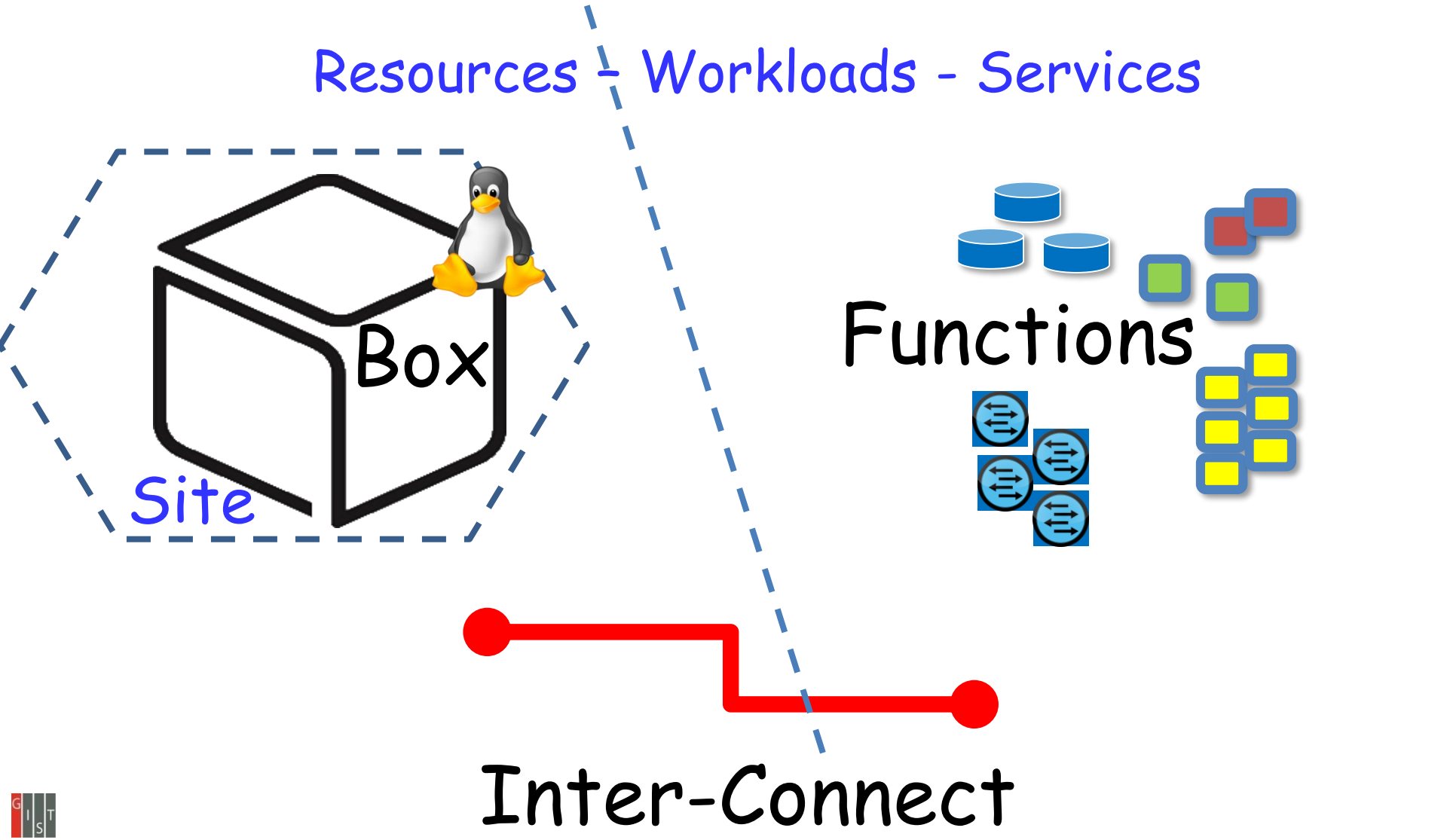
Chapter Keywords

Operating System (OS)

Kernel

Linux

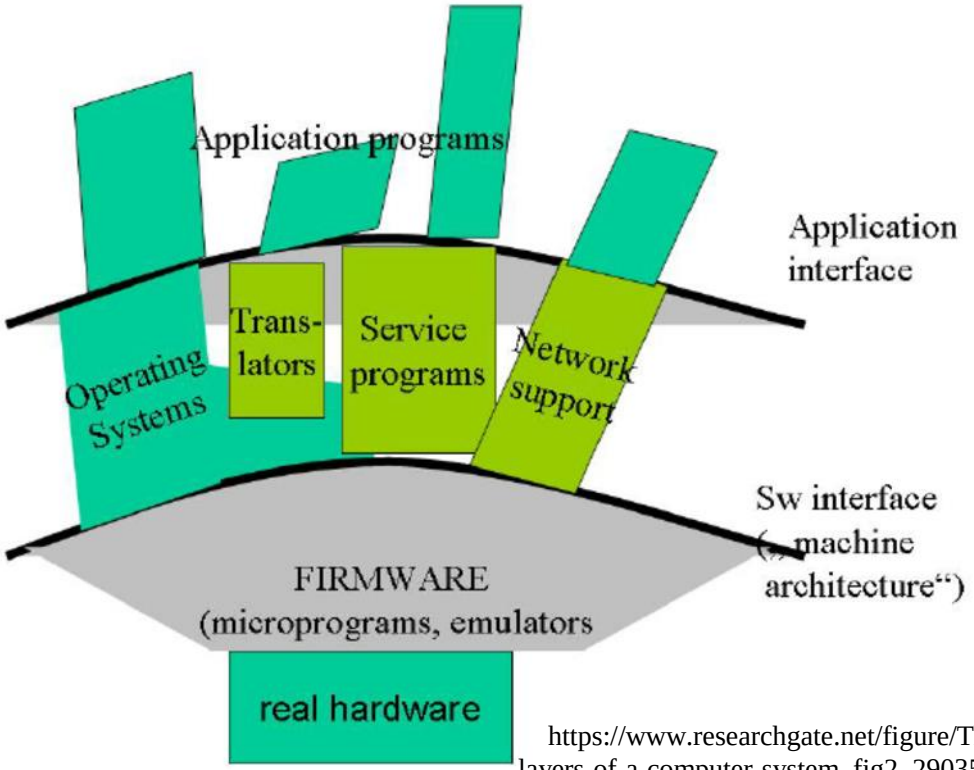
Computer System: Inter-Connected Functions inside/across Boxes/Sites



Computer System: Hardware & Software

Hardware vs Software

(Firmware, Operating System (OS), Middleware, Application, …)



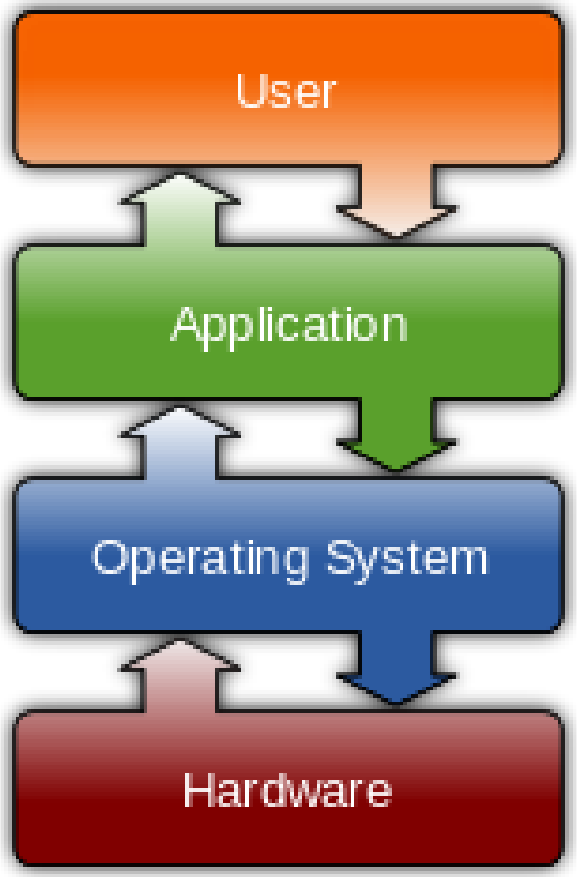
https://www.researchgate.net/figure/The-layers-of-a-computer-system_fig2_290352853

Middleware ("software glue"): Computer software that provides services to software applications beyond those available from OS; Helps to communicate and manage data of *distributed systems*.

Firmware: A block of program instructions for specific purposes, recorded in non-volatile memory, which establishes the lowest level logic that controls the electronic circuits of a device of any type; Helps to control the functionality of *the hardware or electronic devices*.

Computer System: Operating System (OS)

Operating System (OS): Software that manages computer hardware and software resources and provides common services for computer programs.



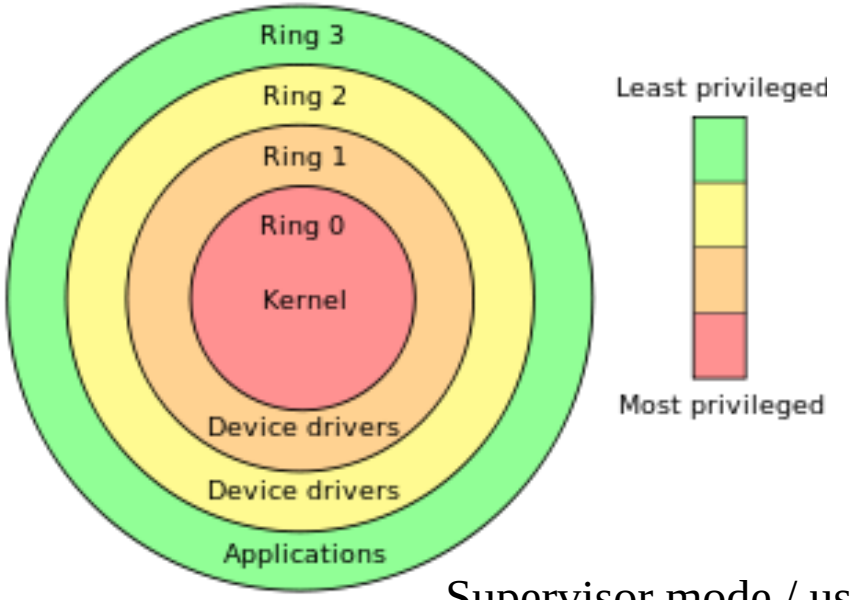
https://tkjbinpressa.wordpress.com/2016/09/05/arsitektur-sistem-operasi/

https://www.topsimages.com/images/utility-system-fe.html

Computer System: OS & Kernel

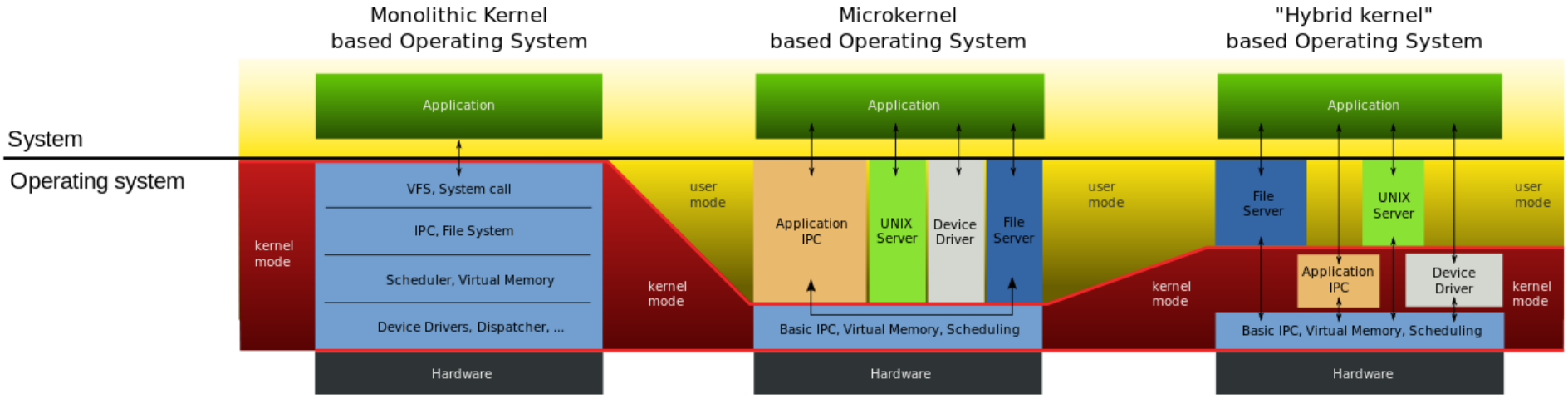
Kernel: a computer program that is the core of a computer's operating system, with complete control over everything in the system.

https://de.wikipedia.org/wiki/Datei:Priv_rings.svg

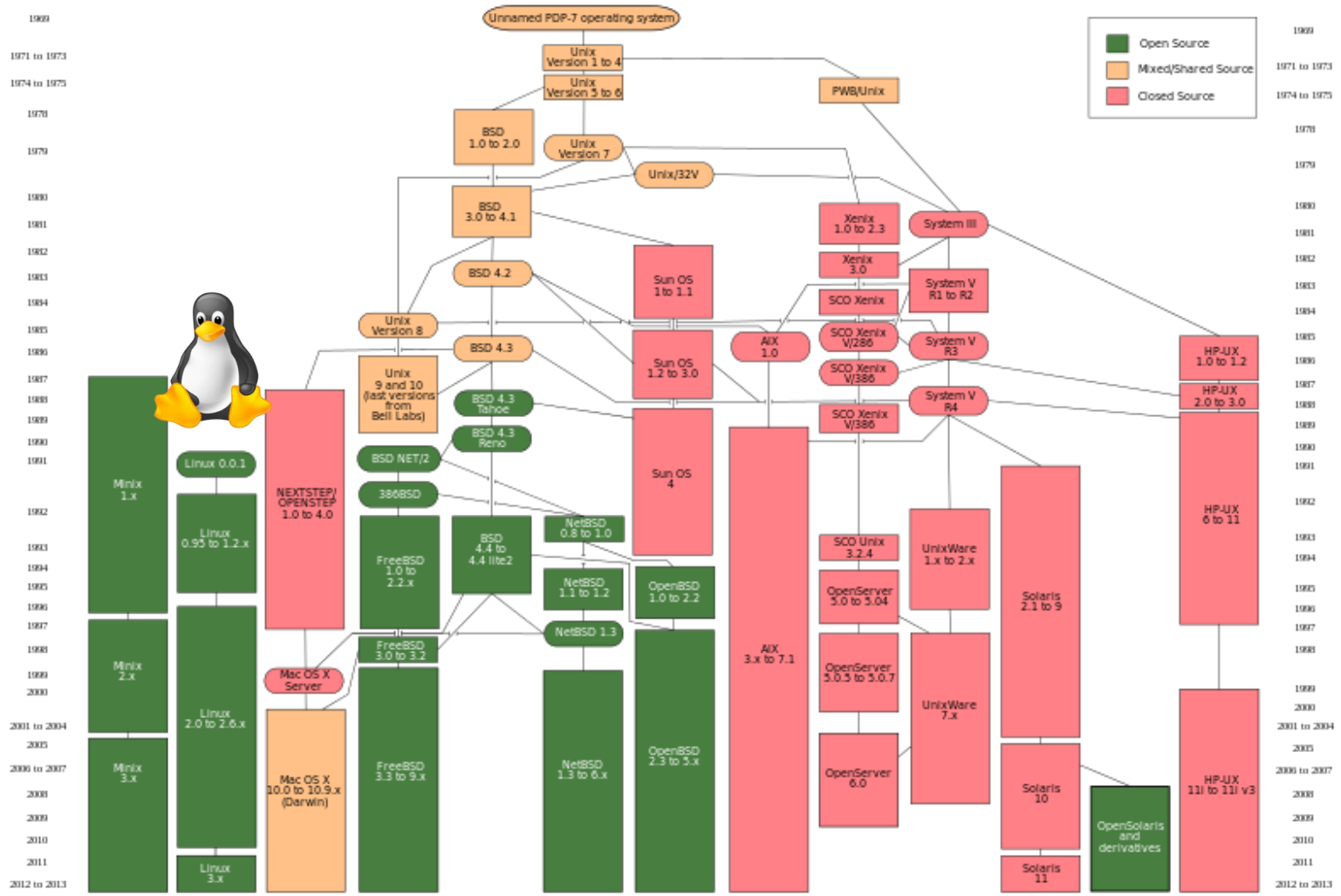


Supervisor mode / user mode

https://docs.apwg.org/reports/mobile/APWG_Mobile_Report_v1.9.pdf



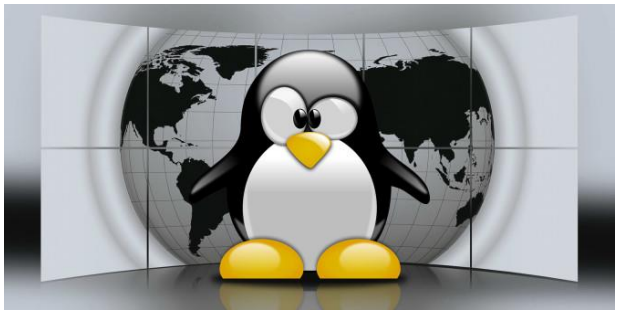
History of Unix-like Operating Systems



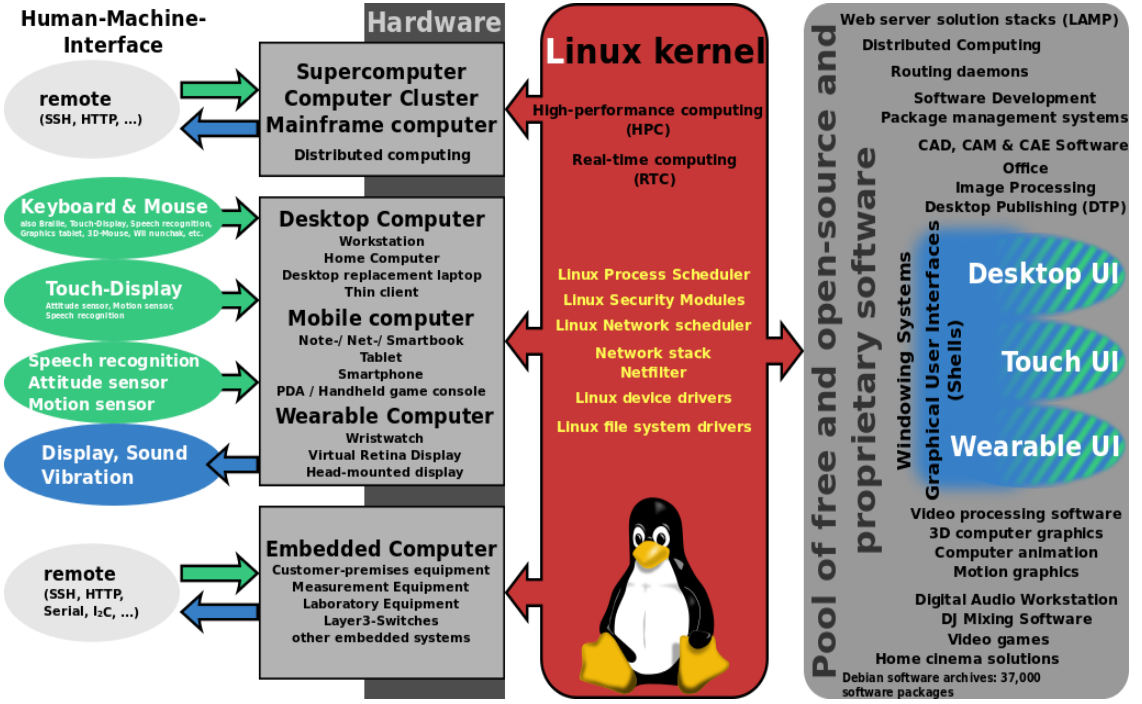
[Video] How Linux is built https://youtu.be/yVpbFMhOAwE?list=PLAbMs_G4N5lWpQC2fDpv-hQhbCf-MPPQL

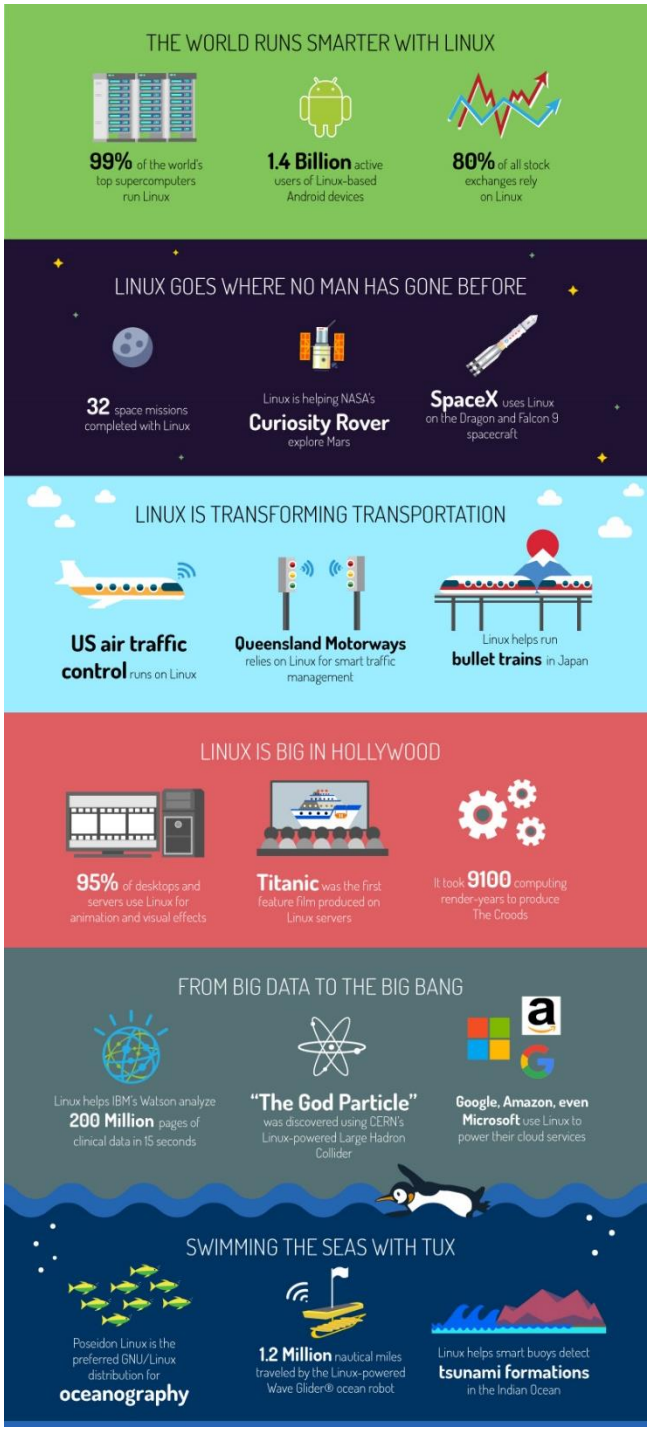
[Video] Linux Kernel Development, 1991-2015 https://youtu.be/5iFnzr73XXk

Linux OS Everywhere



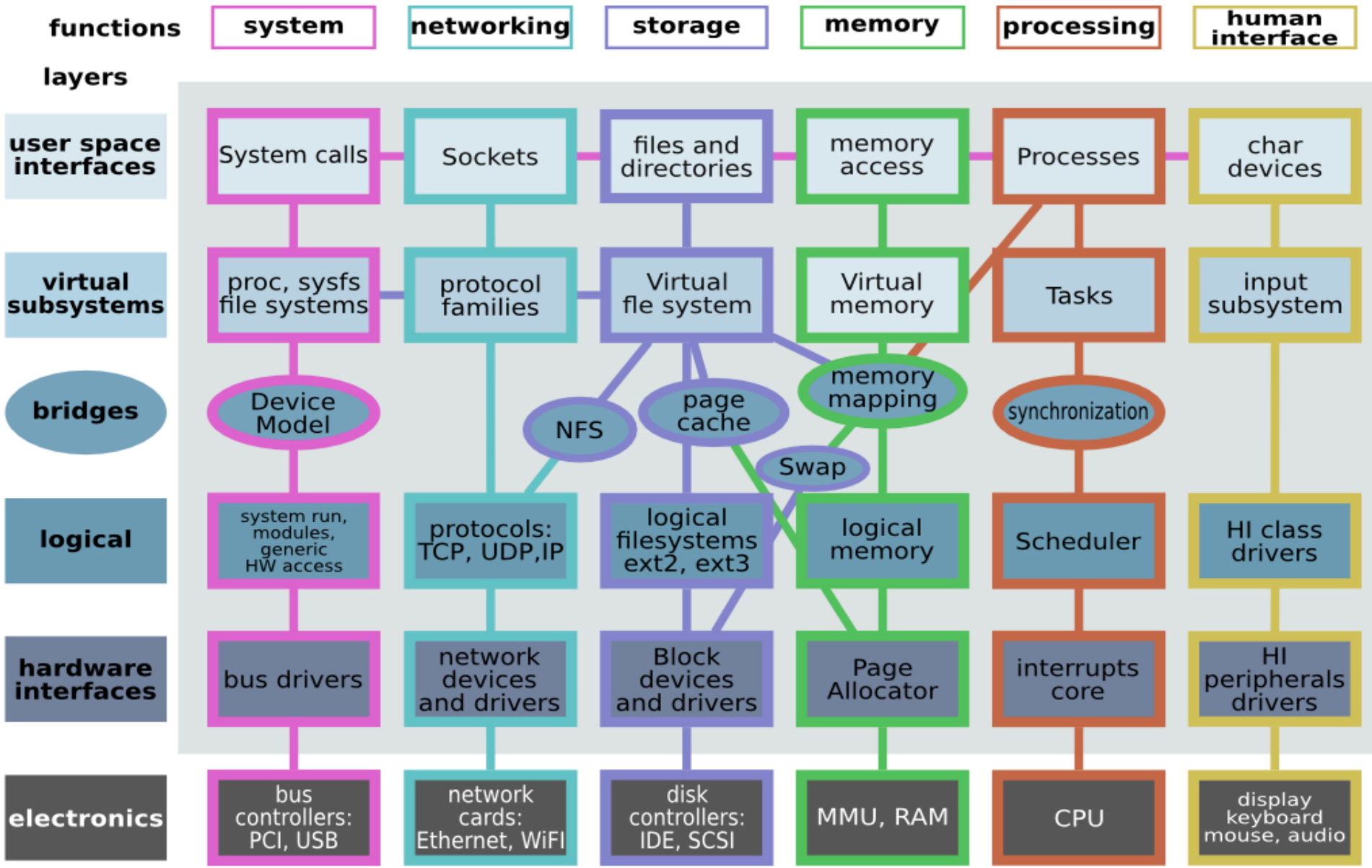
http://www.linuxsc.net/linux/windows-domina-el-escritorio-pero-linux-gana-el-mundo



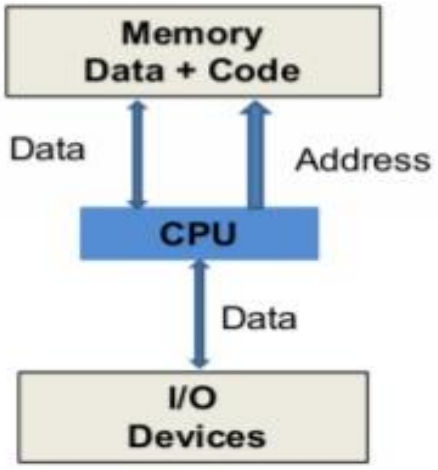


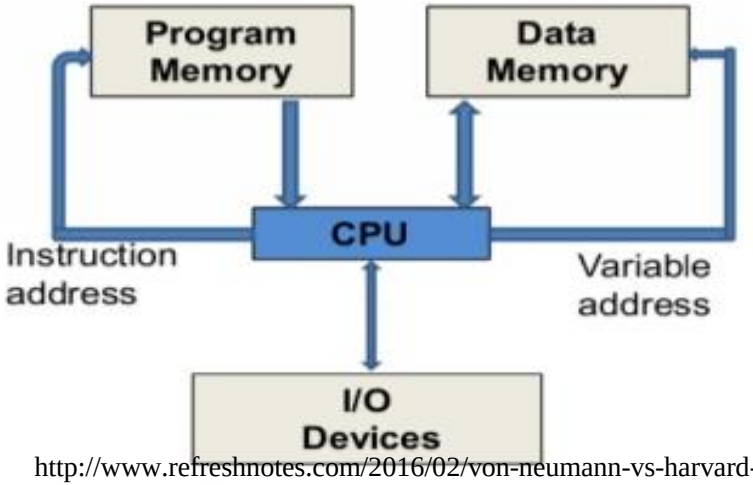
https://blog.netdevgroup.com/2016/11/linux-is-everywhere-infographic/

Linux Kernel Diagram



Computer System: Microcontroller Architecture

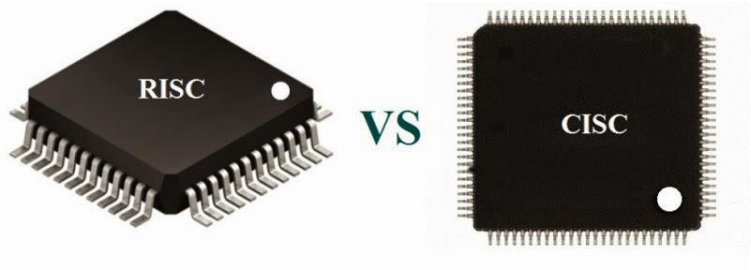




http://www.refreshnotes.com/2016/02/von-neumann-vs-harvard-architecture.html

Von Neumann Model	Harvard Model
Named after the mathematician and early computer scientist John Von Neumann.	Originated from "Harvard Mark I" a relay based computer.
Required only one memory for their instruction and data.	Required two memories for their instruction and data.
Design of the von Neumann architecture is simple.	Design of Harvard architecture is complicated.
Required only one bus for instruction and data.	Required separate bus for instruction and data.
Processor needs two clock cycles to complete an instruction.	Processor can complete an instruction in one cycle
Low performance as compared to Harvard architecture.	Easier to pipeline, so high performance can be achieve.
Cheaper.	Comparatively high cost.

Computer: CPU – RISC vs CISC



CISC	RISC
Emphasis on hardware	Emphasis on software
Multiple instruction sizes and formats	Instructions of same set with few formats
Less registers	Uses more registers
More addressing modes	Fewer addressing modes
Extensive use of microprogramming	Complexity in compiler
Instructions take a varying amount of cycle time	Instructions take one cycle time
Pipelining is difficult	Pipelining is easy

https://csarassignment.wordpress.com/2013/05/02/risc-vs-cisc/

- Intel x86: complex instruction set computing (CISC) architecture
- ARM, MIPS: reduced instruction set computing (RISC) → low power consumption

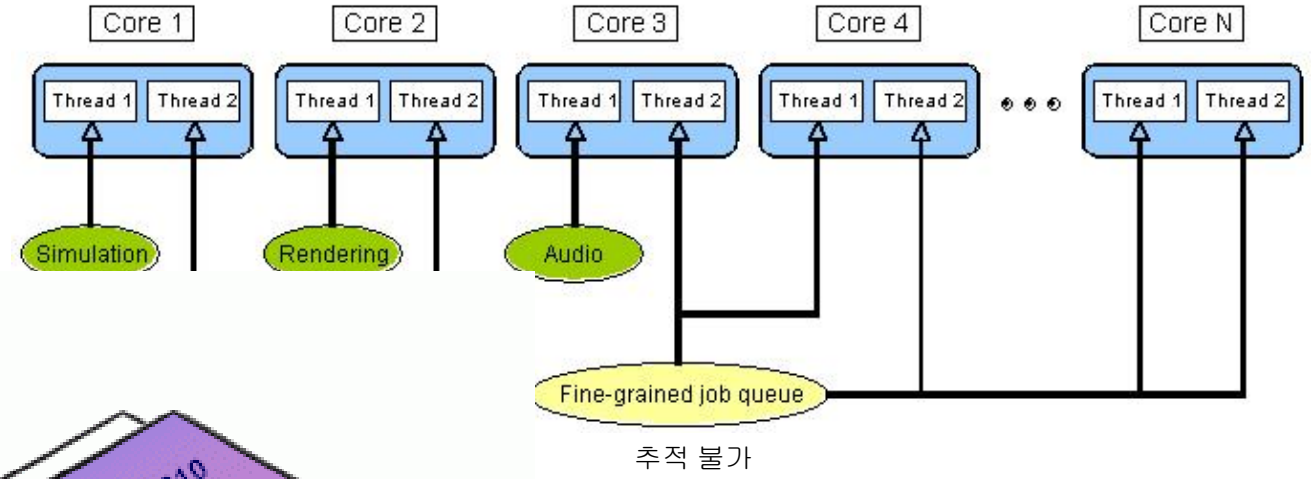
ARM:

A chips for high-performance application;

R chips for real-time processing;

M chips for micro-controllers.

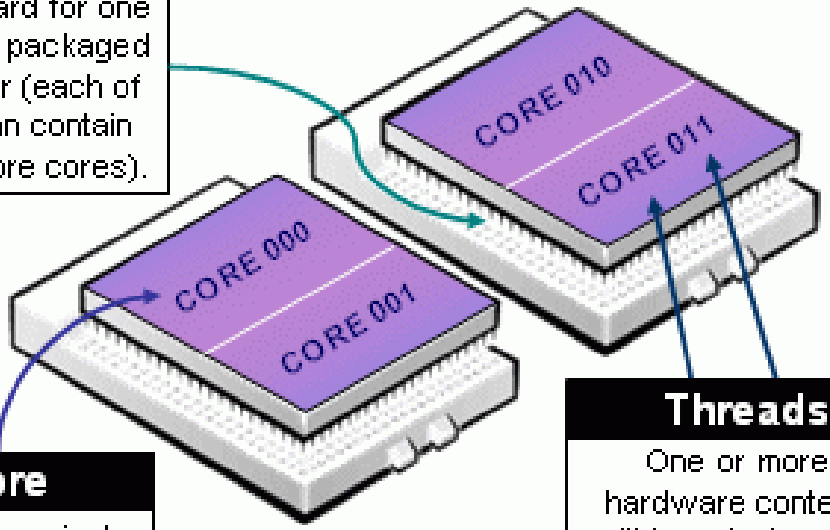
OS & Compute: Socket/Core & Threads



추적 불가

Socket

Receptacle on the motherboard for one physically packaged processor (each of which can contain one or more cores).



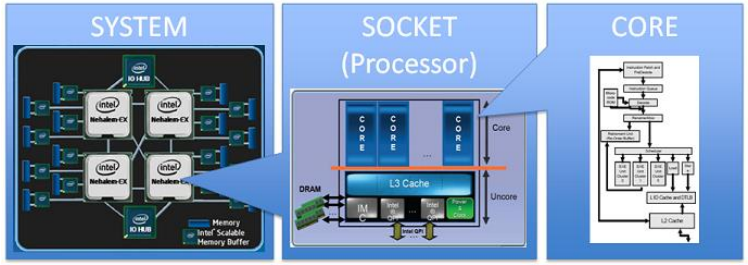
Core

A complete private set of registers, execution units, and retirement queues needed to execute programs.

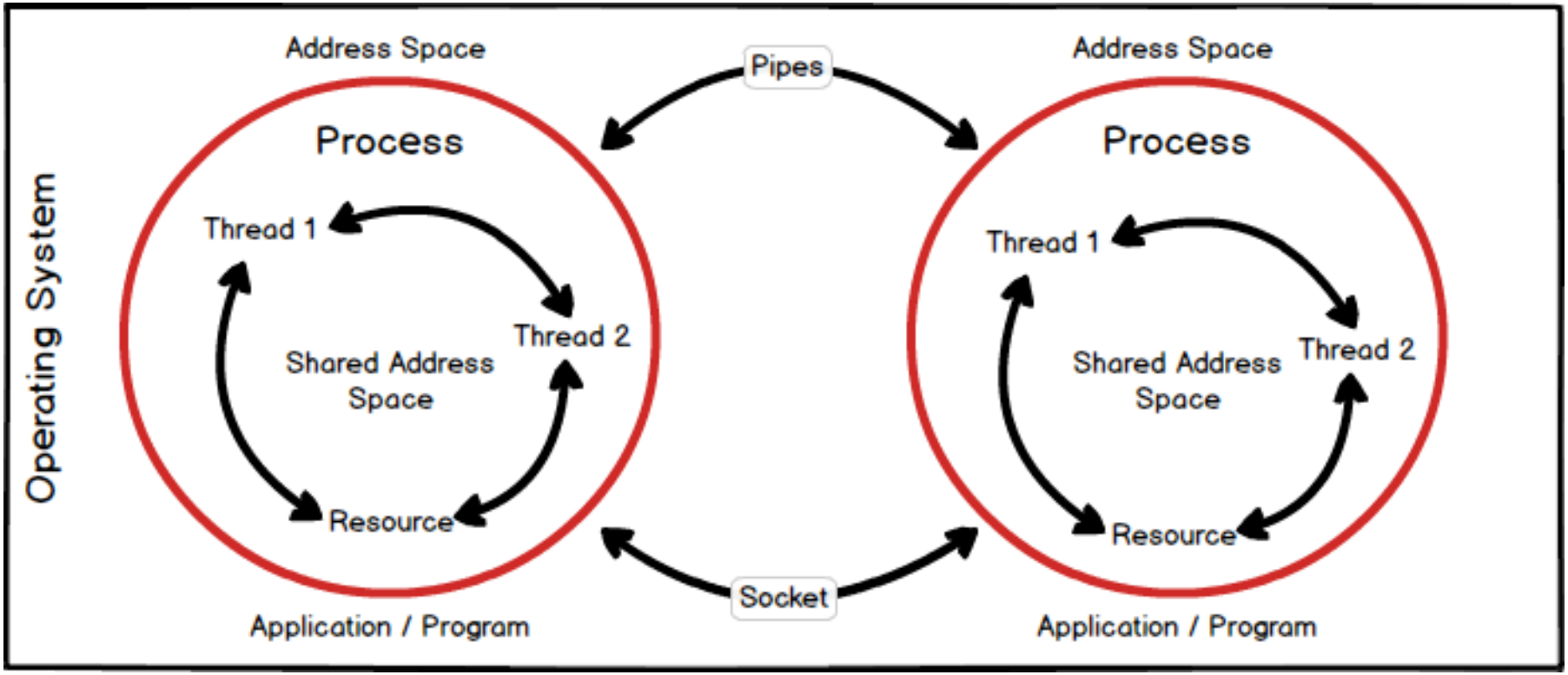
Threads

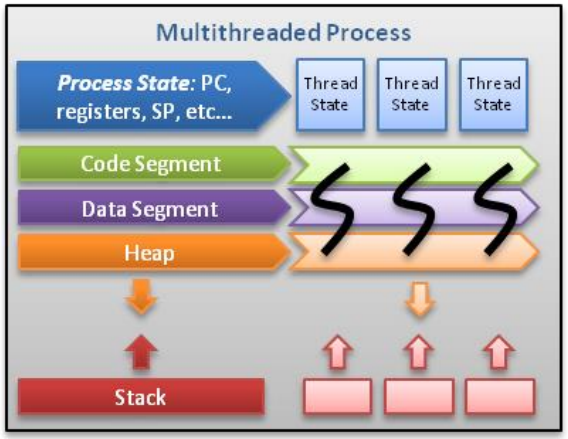
One or more hardware contexts within a single core. Each thread has attributes of one core; managed & scheduled as a single logical processor by the OS.

http://www.hpc.lsu.edu/training/weekly-materials/2018-Fall/HPC_UserEnv_Fall_2018_session_1.pdf



OS & Compute: Threads/Processes



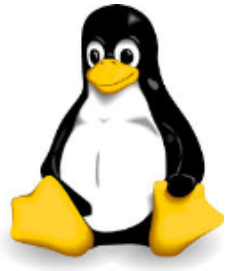


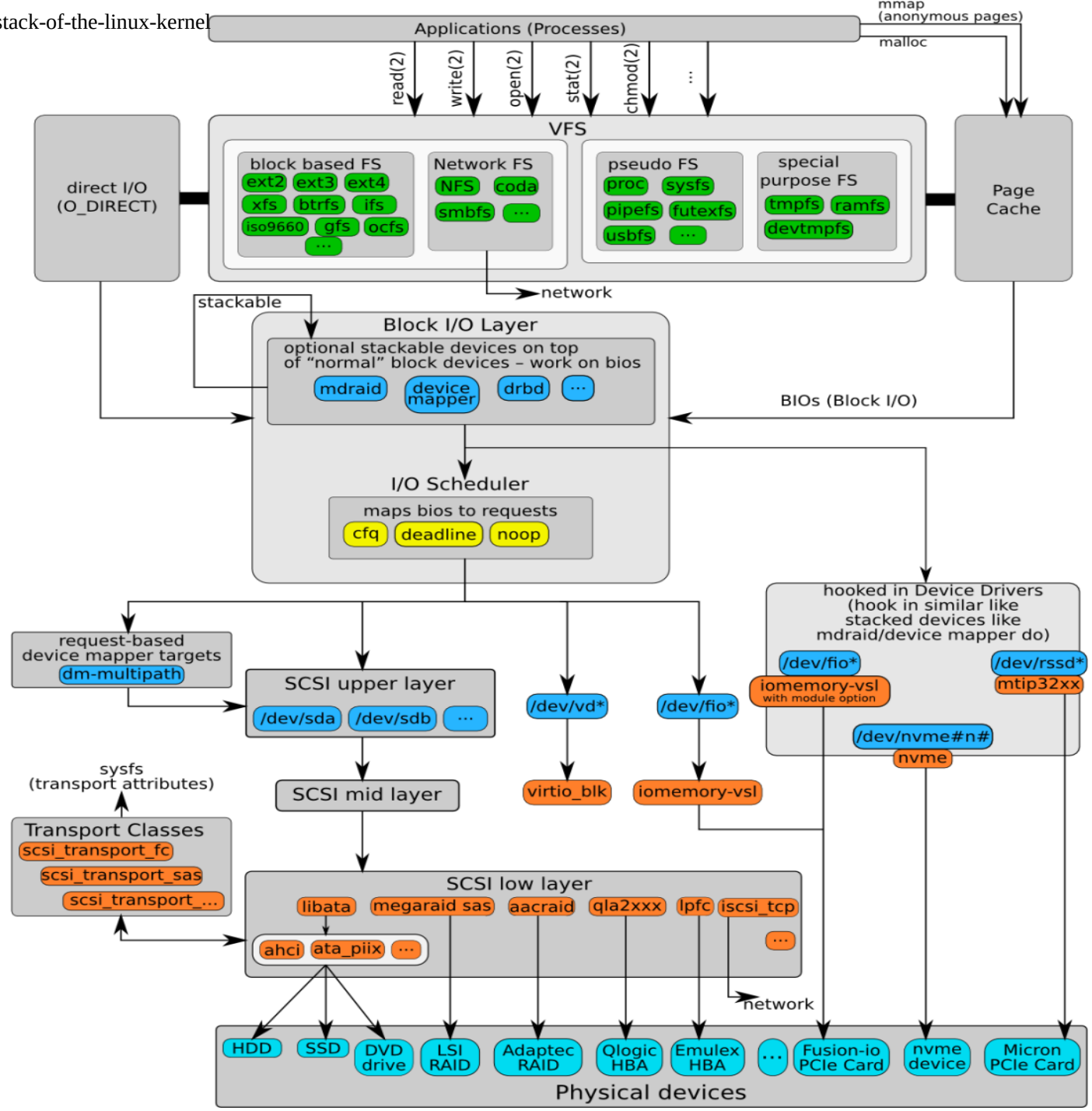
Threads contain only necessary information, such as a stack, a copy of the registers, program counter and any thread-specific data to allows them to be scheduled individually.

https://www.javaquery.com/2016/07/what-is-difference-between-process-and.html
https://randu.org/tutorials/threads/

https://www.iconspng.com/image/39434/io-stack-of-the-linux-kernel

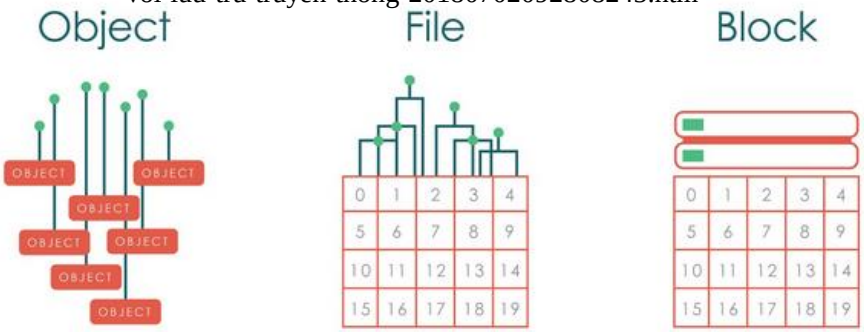
Linux OS: I/O Stack





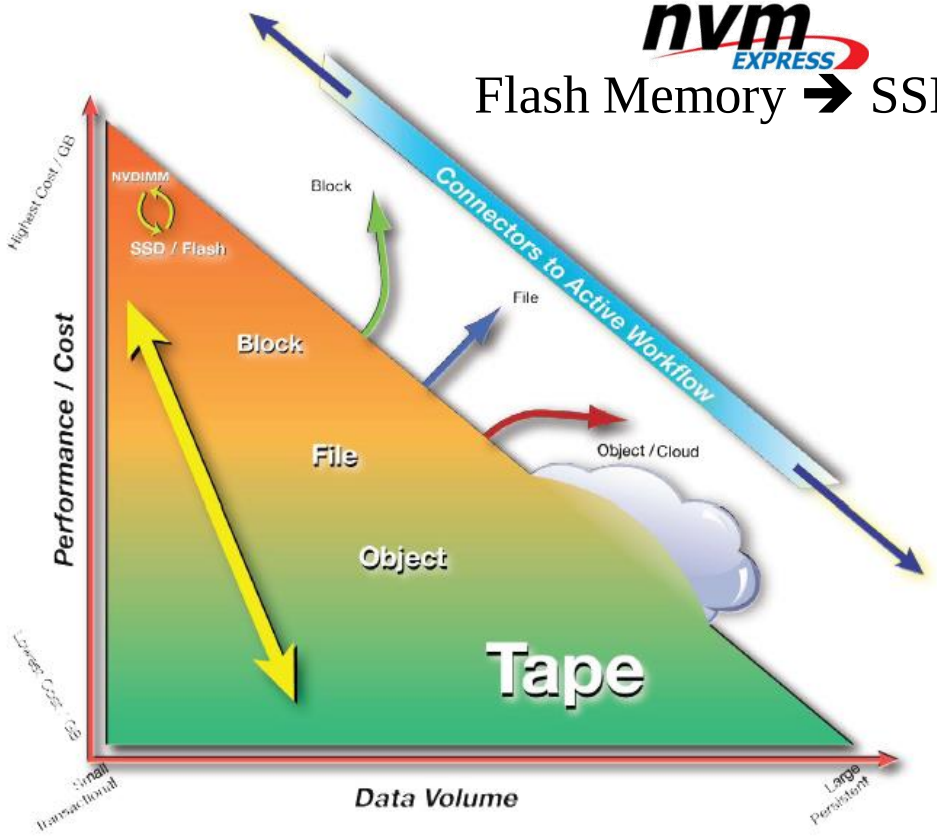
OS & Memory/Storage

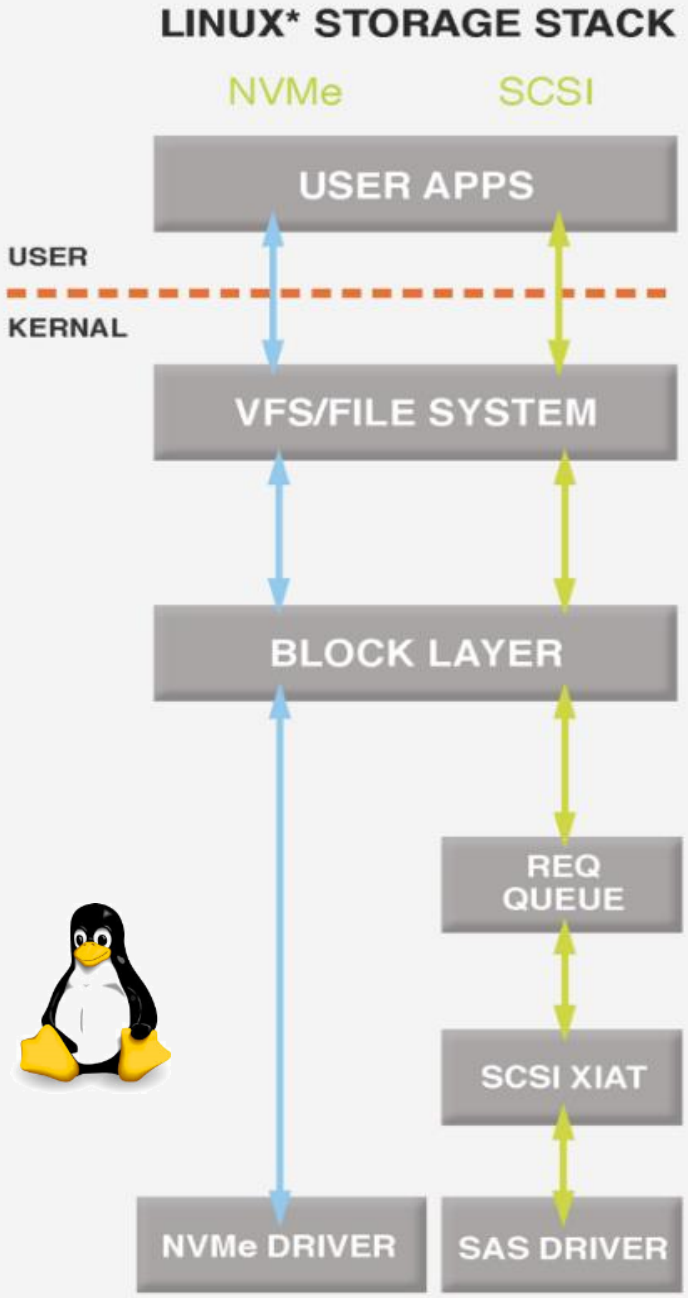
https://tech.vccloud.vn/object-storage-luu-tru-doi-tuong-la-gi-khac-gi-voi-luu-tru-truyen-thong-20180702092808245.htm



nvm EXPRESS

Flash Memory ➔ SSD

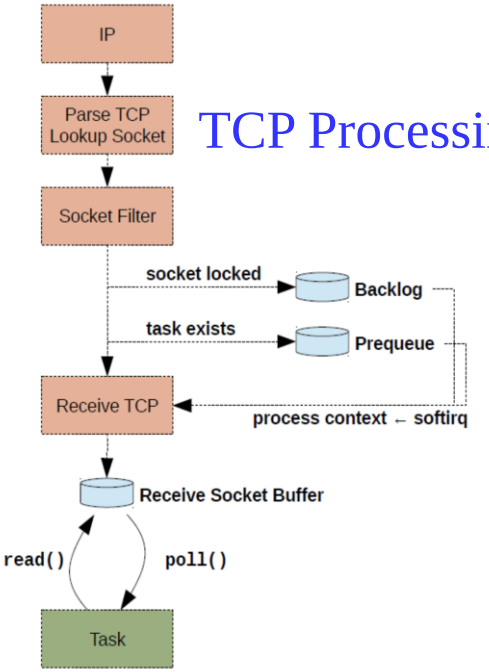




https://nvmexpress.org/about/why-nvm-express/

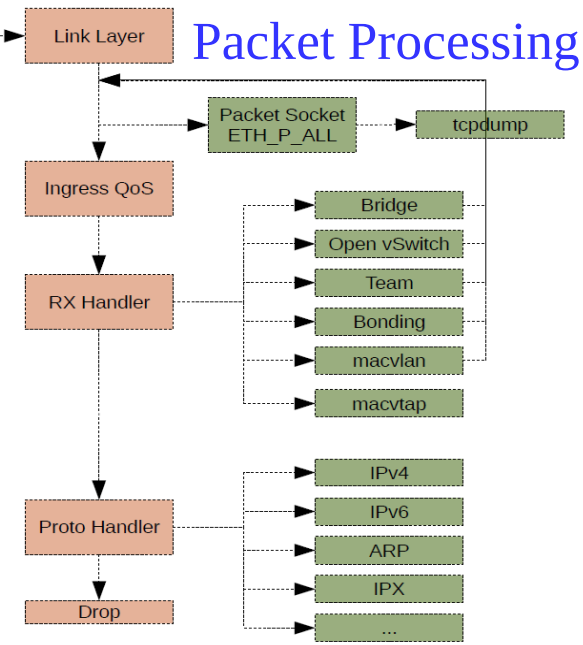
Linux Kernel Networking: L2/L3/L4…

https://www.slideshare.net/ThomasGraf5/devconf-2014-kernel-networking-walkthrough

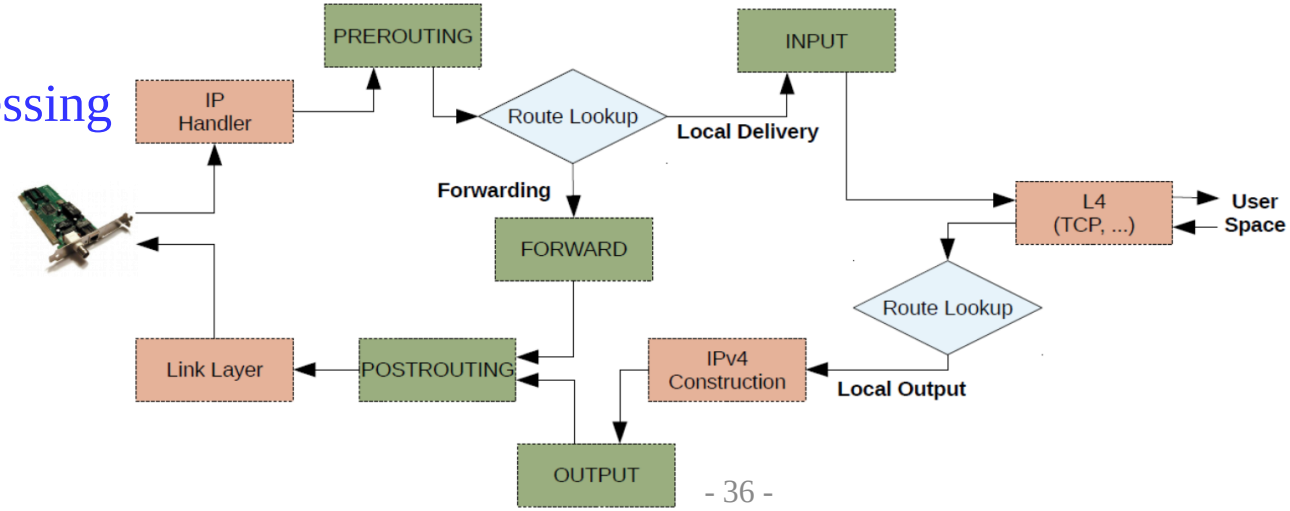


TCP Processing

Packet Processing

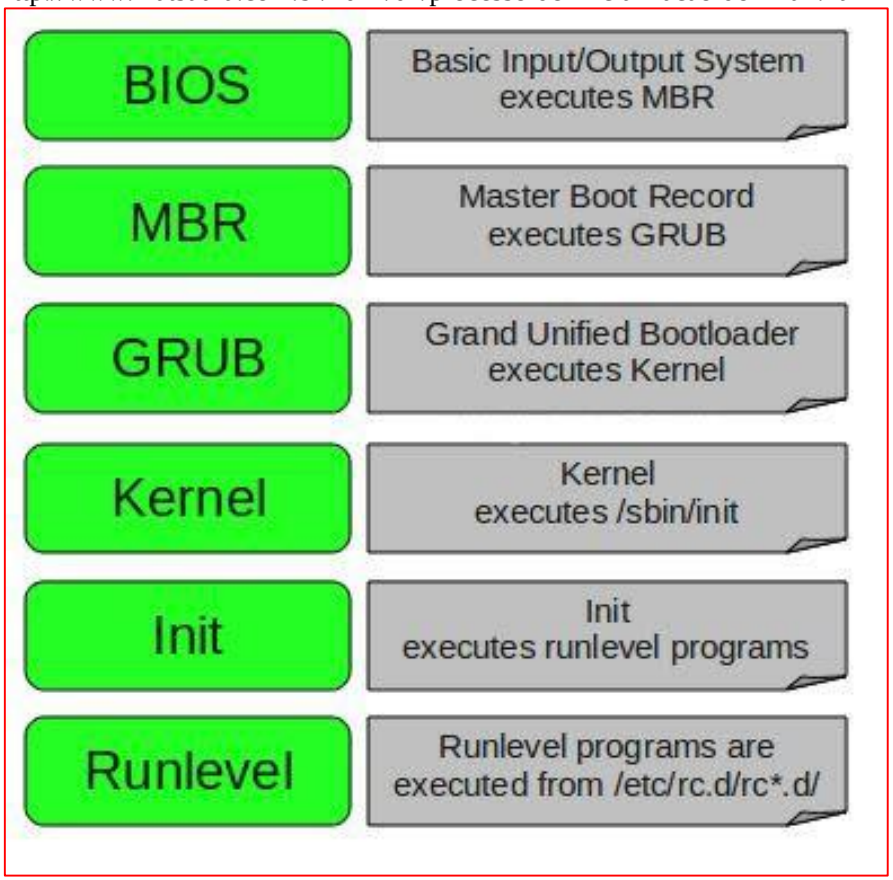


IP Processing



Linux OS: Boot Procedure

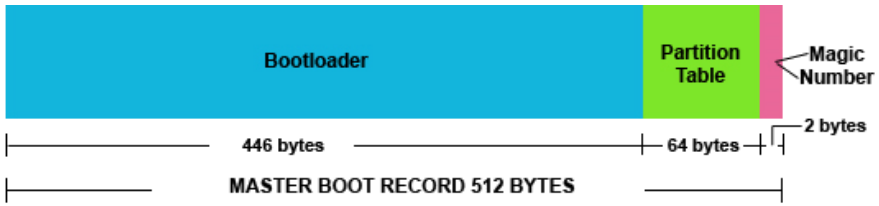
http://www.matsuura.com.br/2014/04/processo-de-inicializacao-do-linux.html



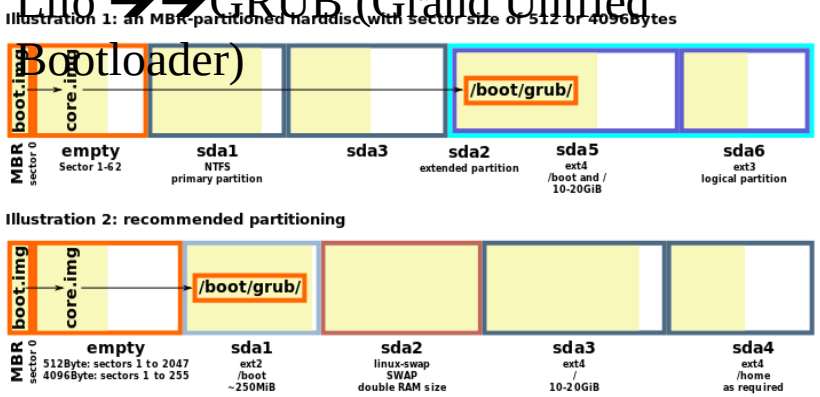
Run Level	Name	Description
0	*Halt*	Shuts down all services when the system will not be rebooted.
1	*Single User*	Used for system maintenance. No Networking capabilities.
2	*MultiUser* *No Network Support*	Used for maintenance and system testing.
3	*MultiUser* *Network Support*	Non-Graphical Text Mode operations for server systems.
4	-	Custom Mode, used by SysAdmin
5	*Graphical* *X11*	Graphical login with same usability of Run Level 3.
6	*Reboot*	Shuts down all services when the system is being rebooted.

https://docplayer.es/4085195-Systemd-software-freedom-day-2015-alex-callejas.html

Lilo ➔➔GRUB (Grand Unified Bootloader)



https://www.thegeekdiary.com/centos-rhel-7-booting-process/



https://unix.stackexchange.com/questions/111237/how-does-linux-deal-with-a-separate-boot-partition

Gwangju Institute of
Science & Technology

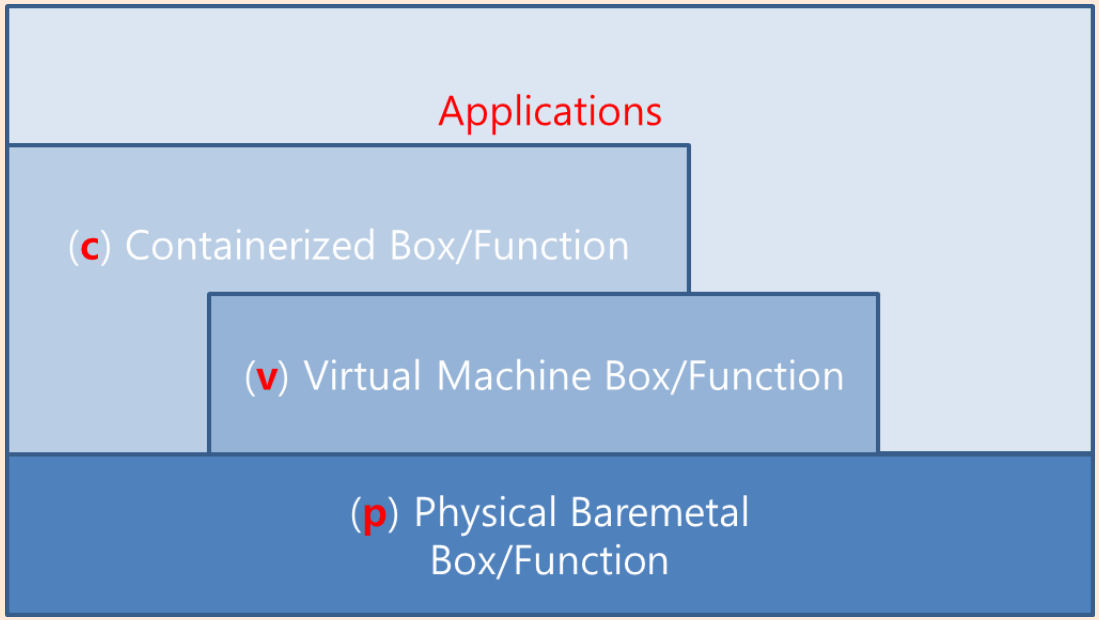
Thank you!

Send Inquiry to jongwon@gist.ac.kr

http://nm.gist.ac.kr

Chapter 3: Computer System

Virtualization & Containers



Chapter Keywords

Virtualization

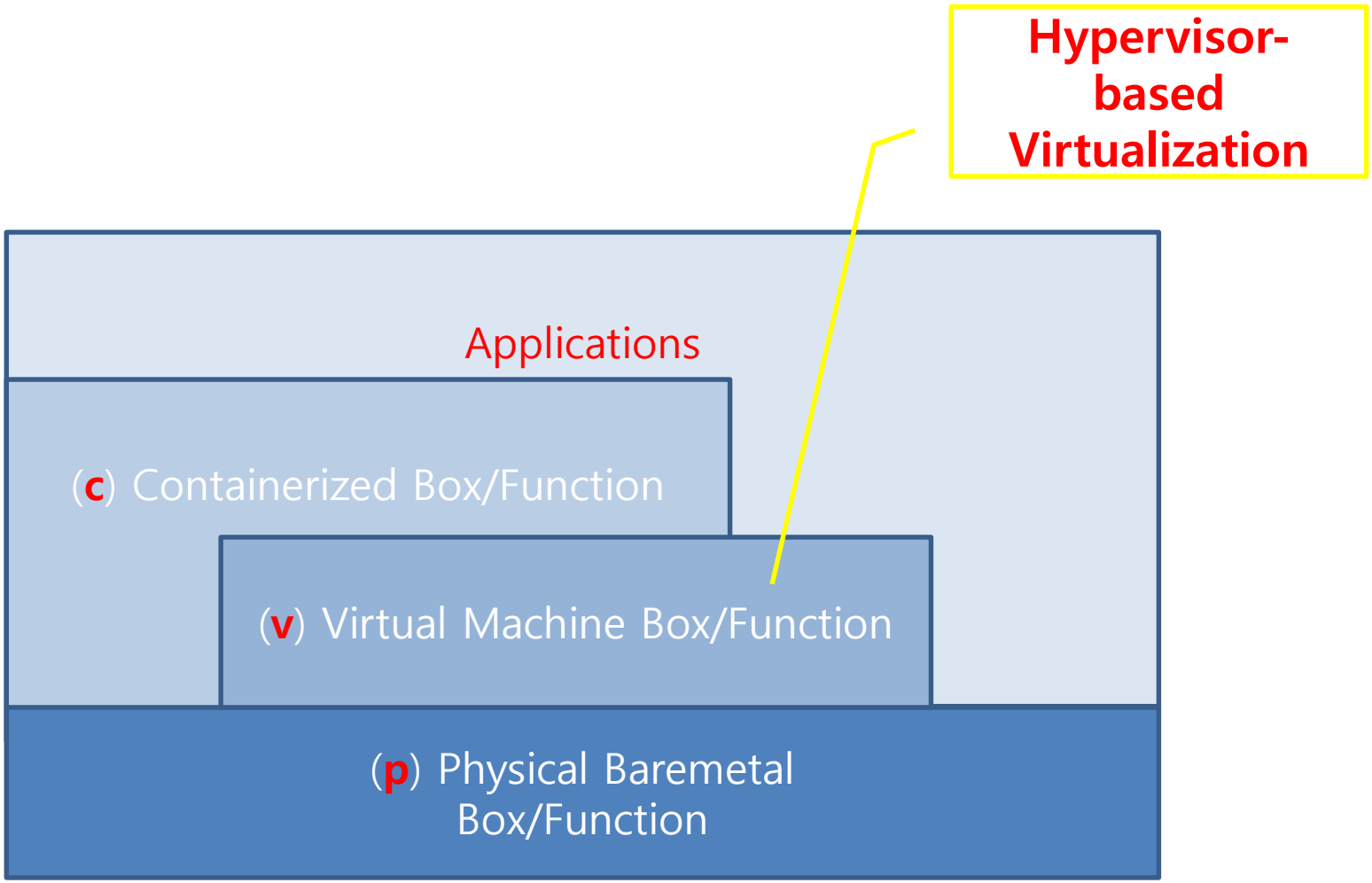
Virtual Machine

Hypervisor

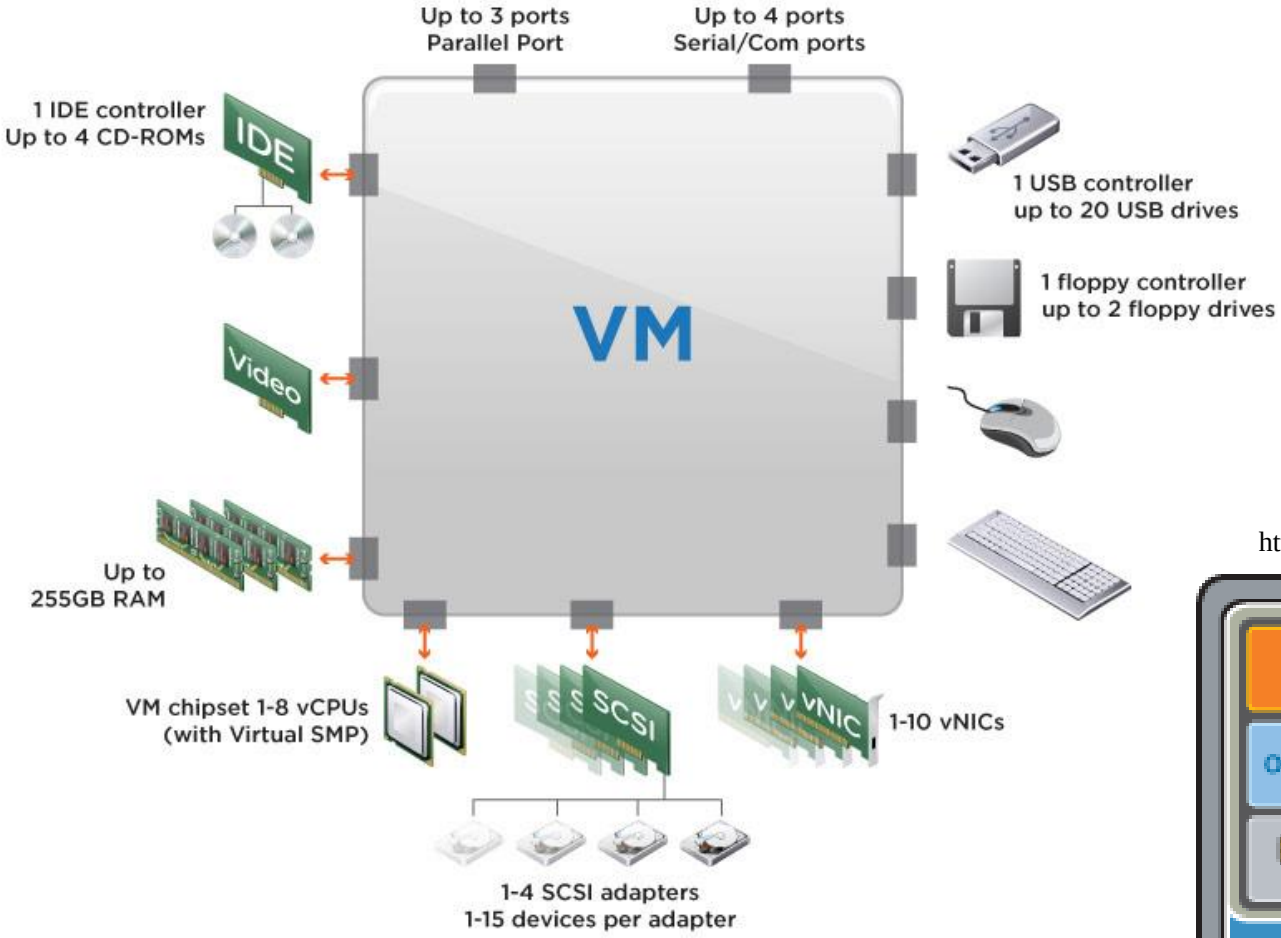
Containers

p(Baremetal) + V(Virtual Machine) + C(Container)

Harmonization

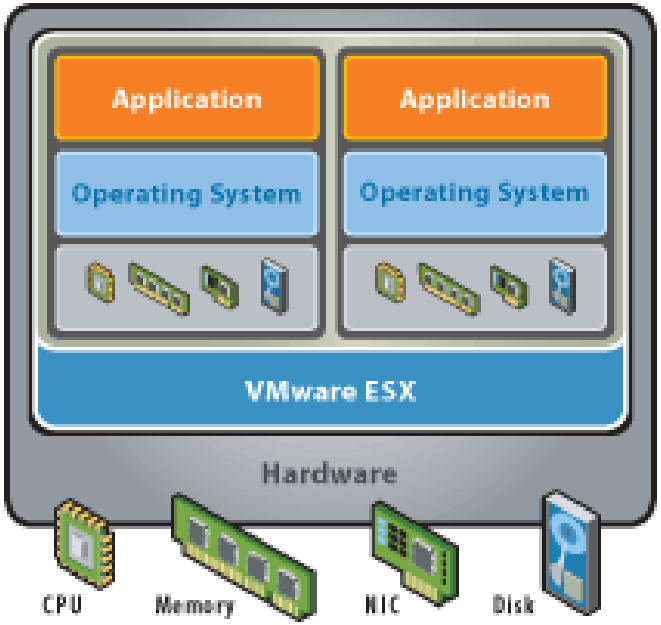


Virtual Machines (VMs)

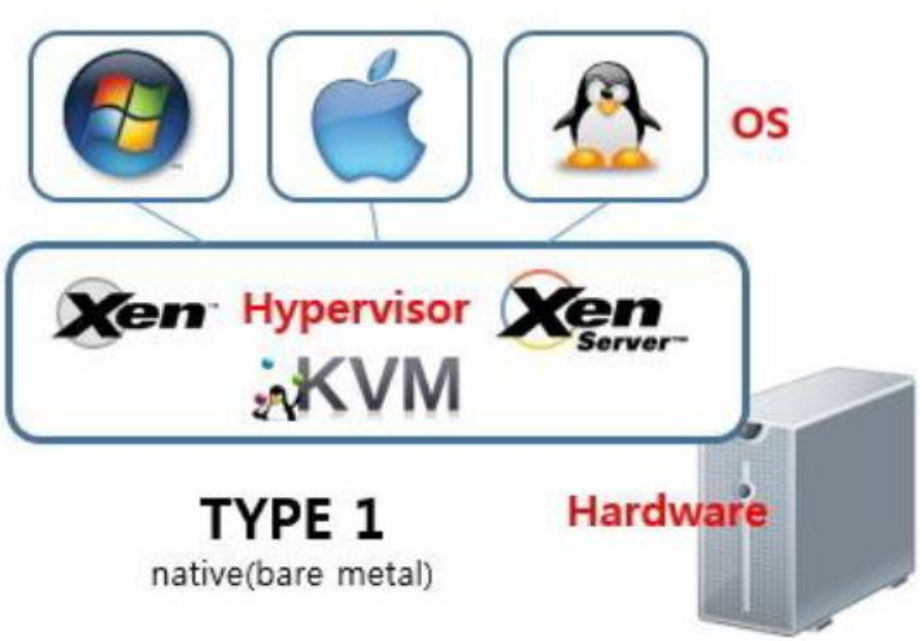


http://kuas1095108129.blogspot.com/

http://hesed.info/blog/virtuelle-maschine.abp



Hypervisor Type 1 & 2 for Virtualization

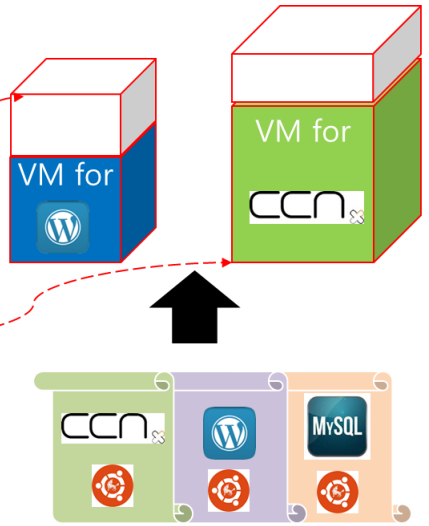


http://microstrong.pe.kr/wordpress/?cat=37

VMs (Functions) with Hypervisor-based Virtualization

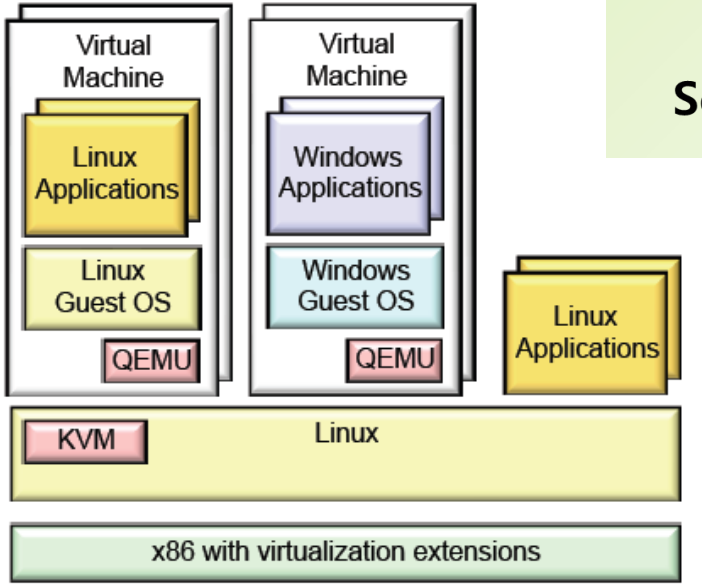
Name	vCPU	RAM	Root Disk
Nano	1	64 MB	0 G
Micro	1	128 MB	0 G
Heat	1	512 MB	0 G
Tiny	1	512 MB	1 G
Small	1	2048 MB	20 G
Medium	2	4096 MB	40 G
Large	4	8192 MB	80 G
X large	8	16384 MB	160 G

Selected VM Flavors

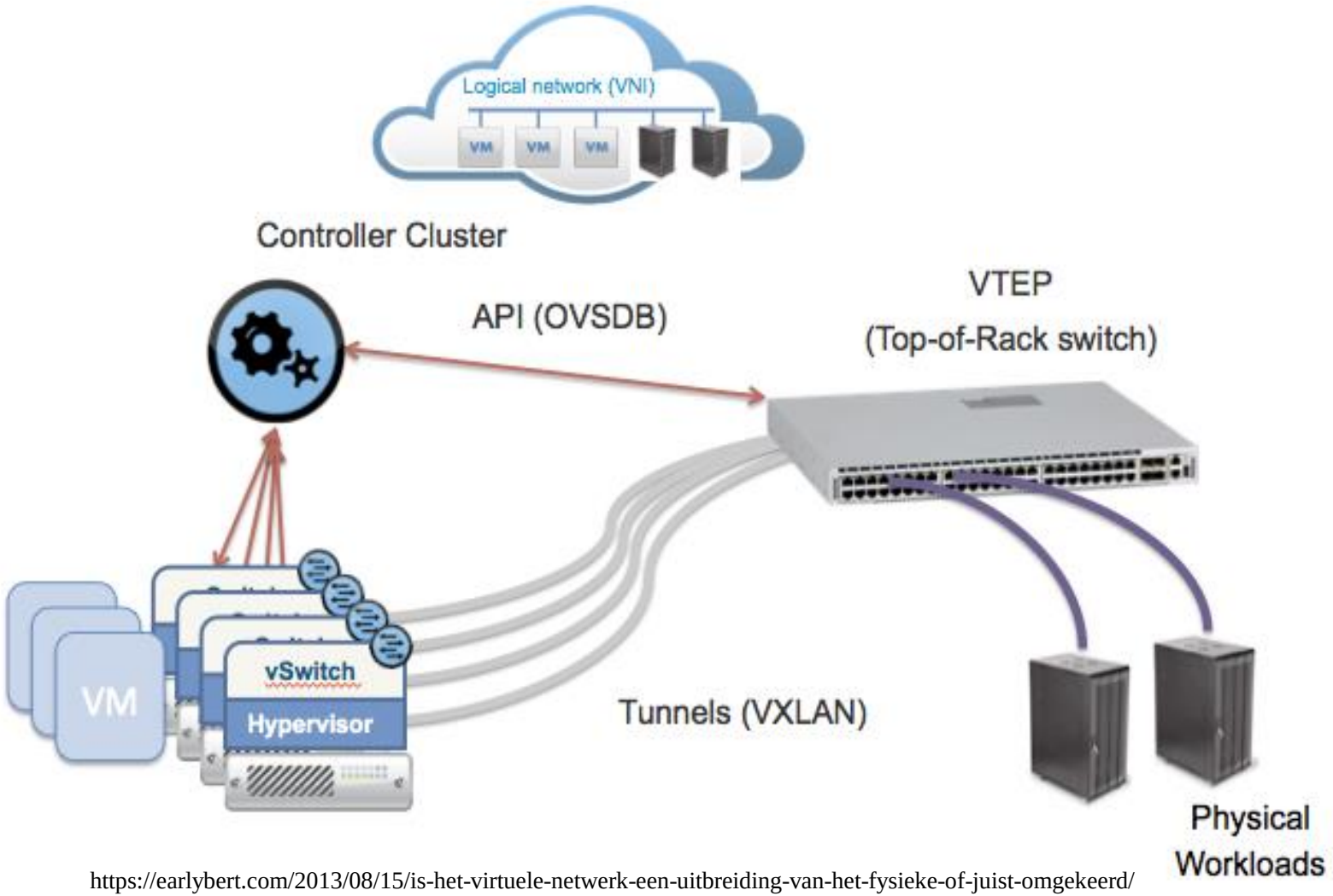


VM images with preinstalled Functions

추적 불가



Physical and Virtual Machines: Inter-connection



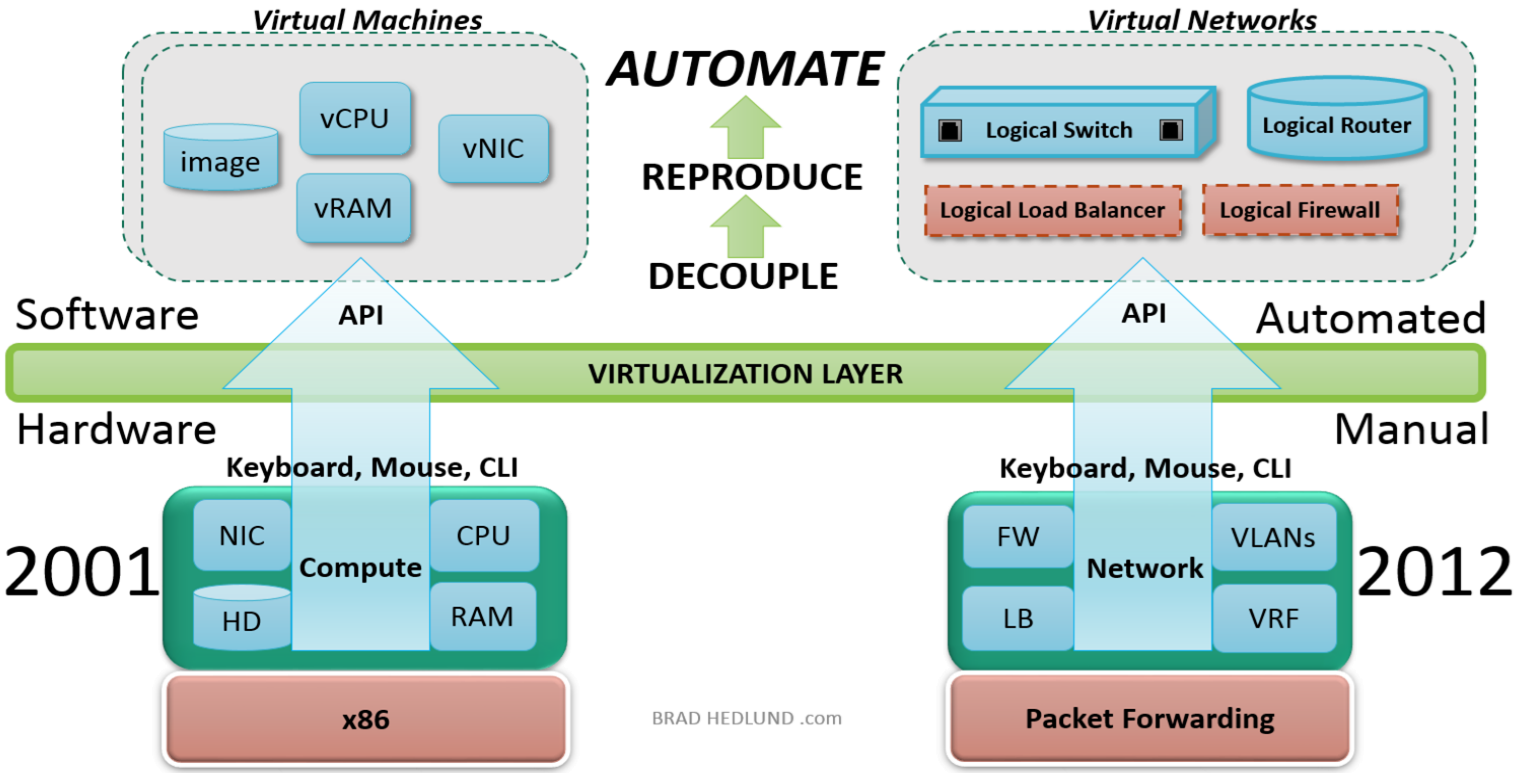
https://earlybert.com/2013/08/15/is-het-virtuele-netwerk-een-uitbreiding-van-het-fysieke-of-juist-omgekeerd/

Virtualization for Compute/Network

Virtualization: Basic act of **decoupling** an infrastructure service from the physical assets on which that service operates.

Compute Virtualization

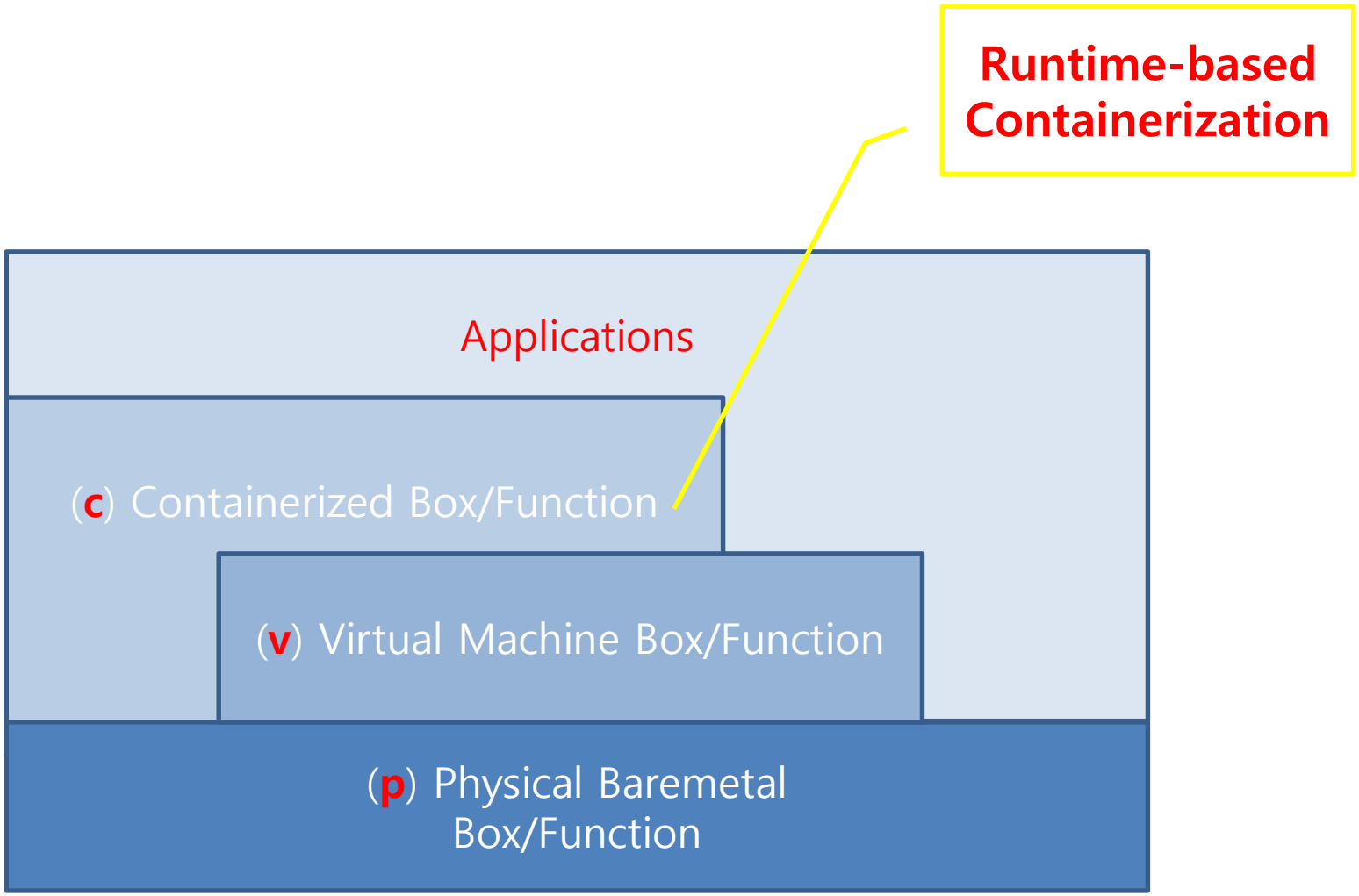
Network Virtualization



http://bradhedlund.com/2013/05/28/what-is-network-virtualization/

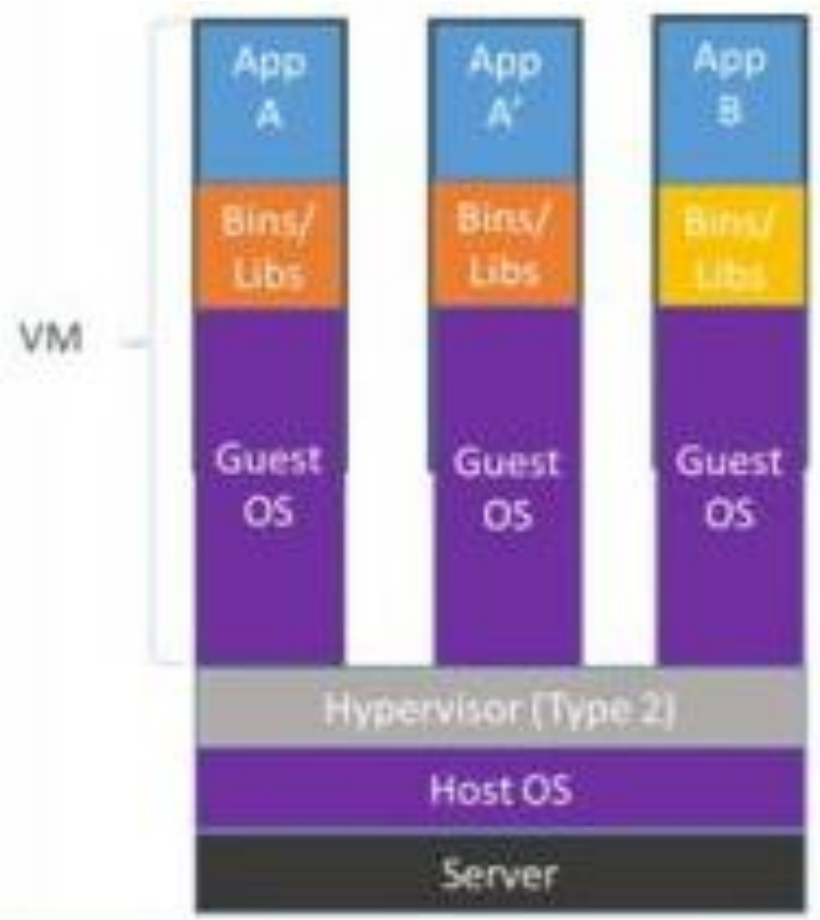
p(Baremetal) + V(Virtual Machine) + C(Container)

Harmonization

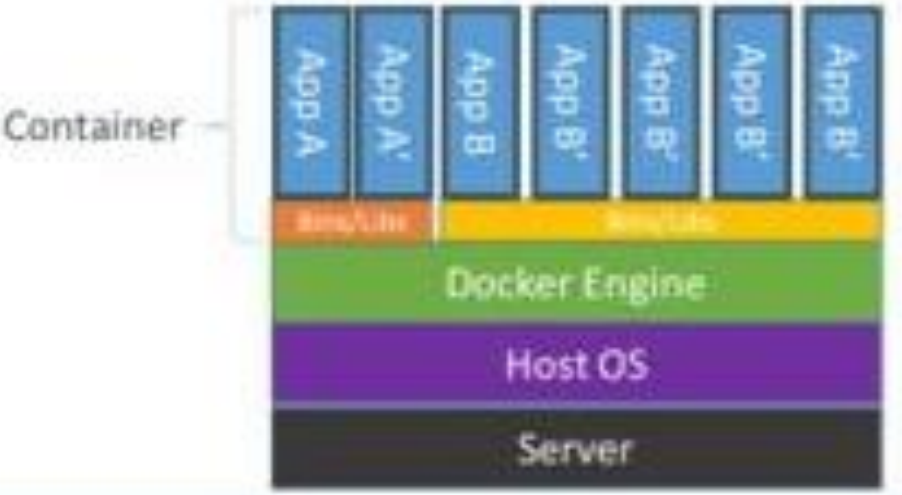


Containers vs VMs

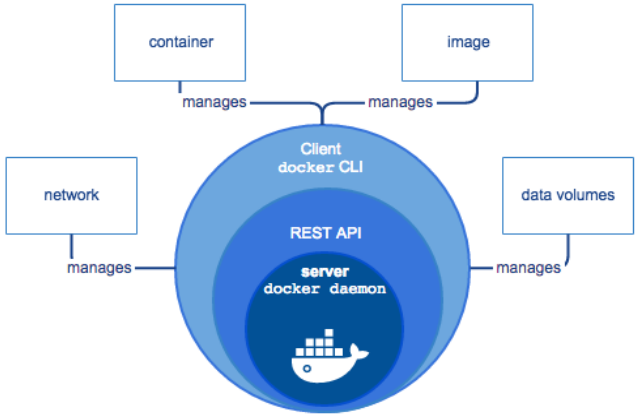
Packaging workload tasks and Scaling …



Containers are isolated, but share OS and, where appropriate, bins/libraries

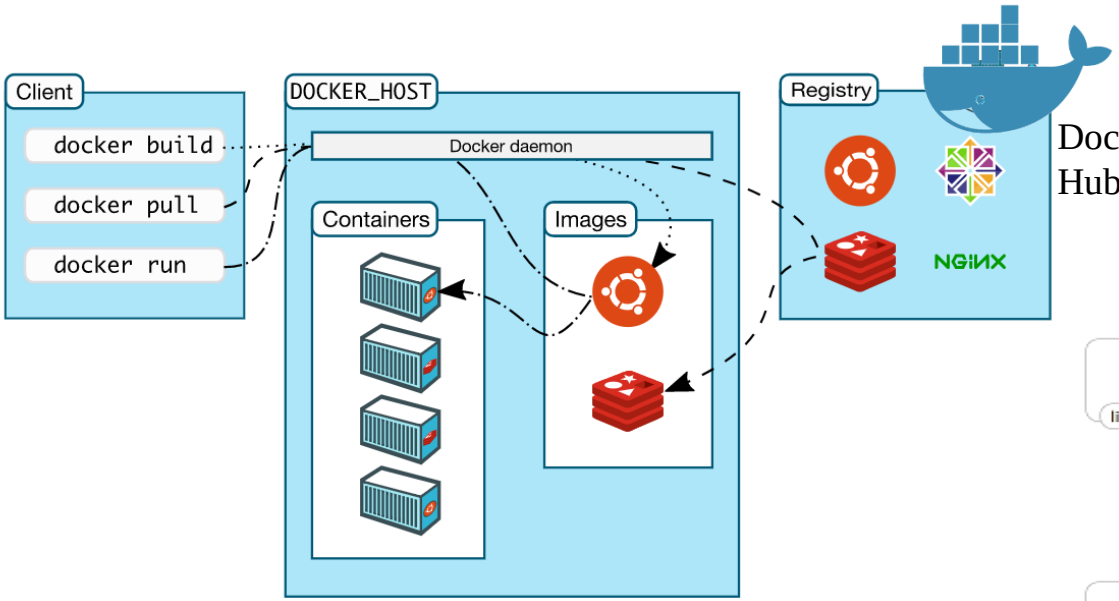


Docker: Light-weight Process (Application) Container



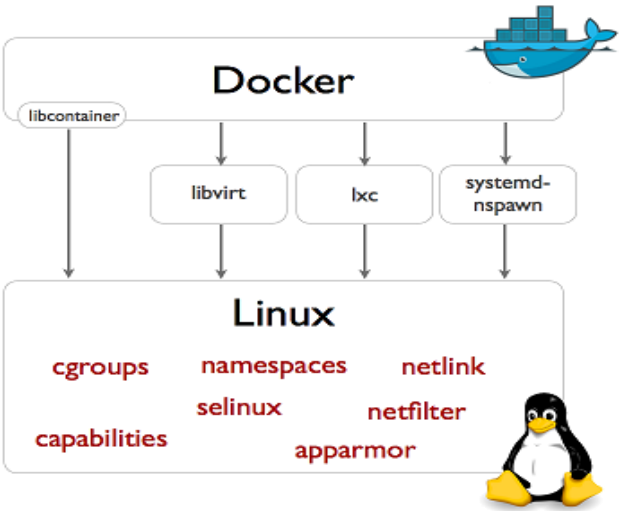
Docker Engine

https://conf.phprs.com.br/slides/Palestra-Docker.pdf



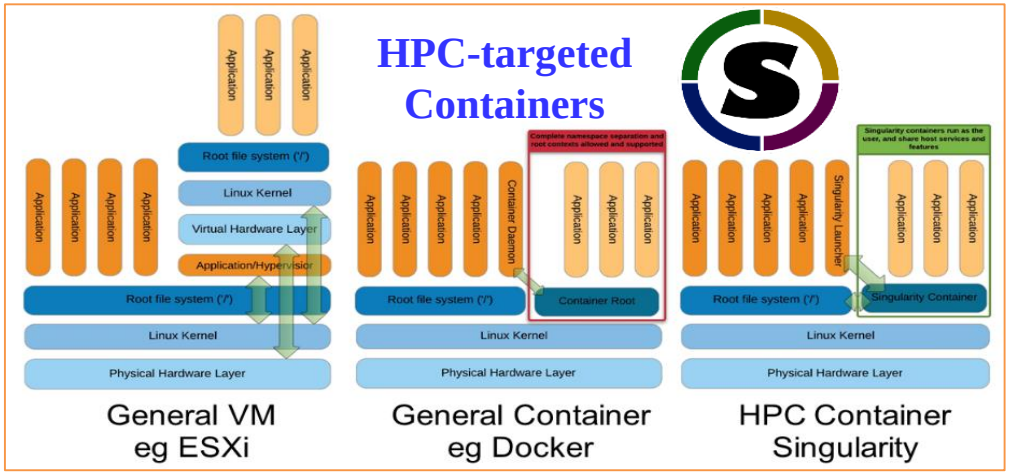
Docker Hub

https://ecs.victoria.ac.nz/foswiki/pub/Courses/NWEN406_2018T1/LectureSchedule/NWEN406-presentation-summary-10.pdf



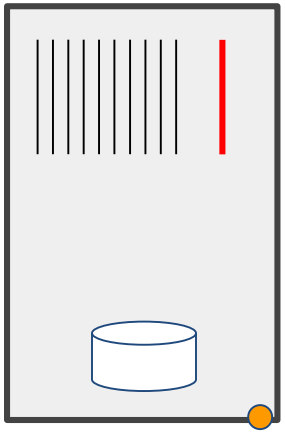
https://www.cnblogs.com/lijuanhu321/archive/2018/07/15/9313159.html

Containers



http://technodocbox.com/71051449-Windows/Singularity-for-gpu-and-deep-learning.html

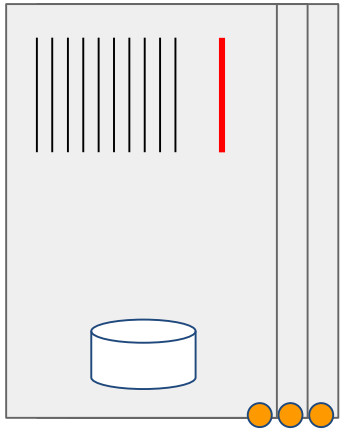
Virtual Machines



Traditional operations

KVM

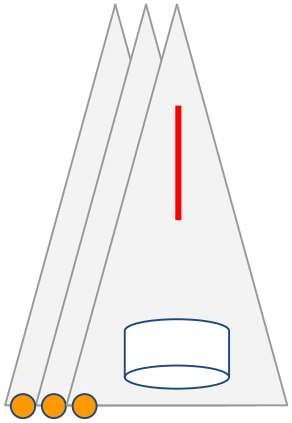
Machine Containers



Traditional operations

LXD

Process Containers

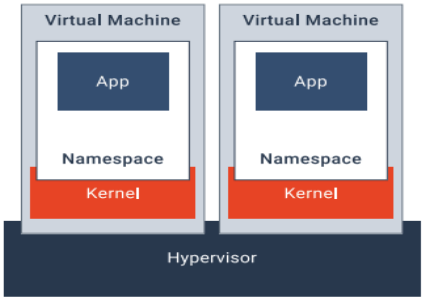


Mesos / Kubernetes / Swarm

Docker + RunC / Rkt

http://ju.outofmemory.cn/entry/337394

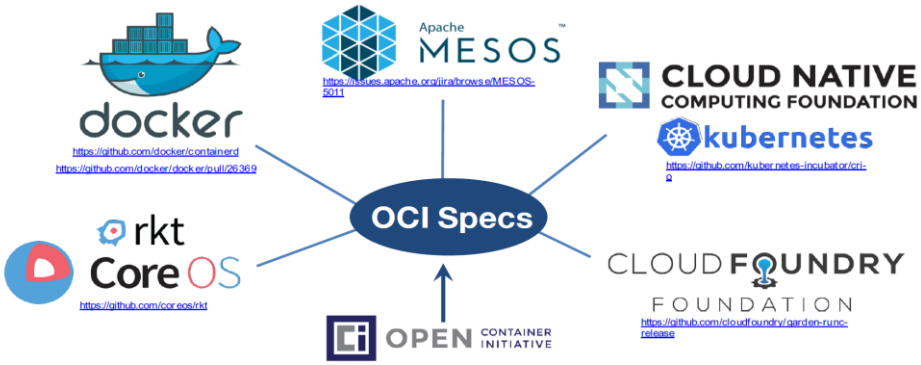
kata containers

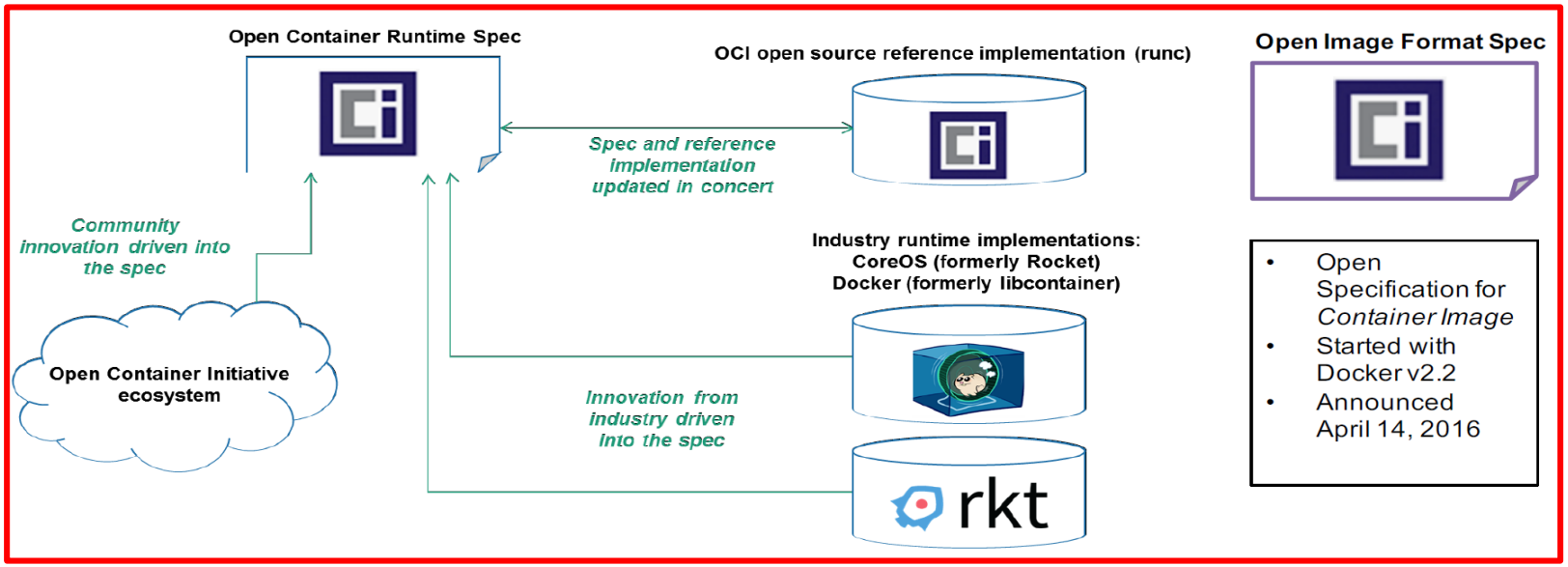


Sandbox-isolated Containers

OCI (Open Container Initiative)

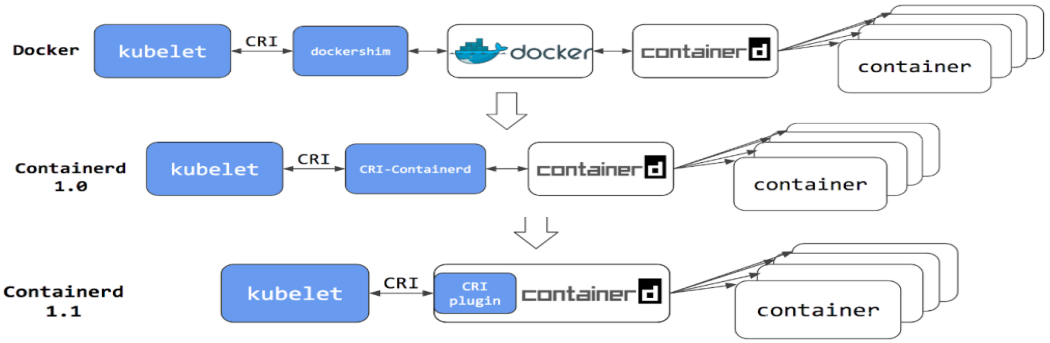
To **encapsulate a software component** and **all of its dependencies** in a format that is self-describing and **portable**, so that **any compliant runtime** can run it **without extra dependencies**, regardless of the underlying machine and contents of the container.





https://www.slideshare.net/caniszczyk/cloud-native-landscape-cncf-and-oci

CRI(Container Runtime Interface): Containerd, rkt, CRI-O, …



Containerd: An industry-standard container runtime with an emphasis on simplicity, robustness and portability.

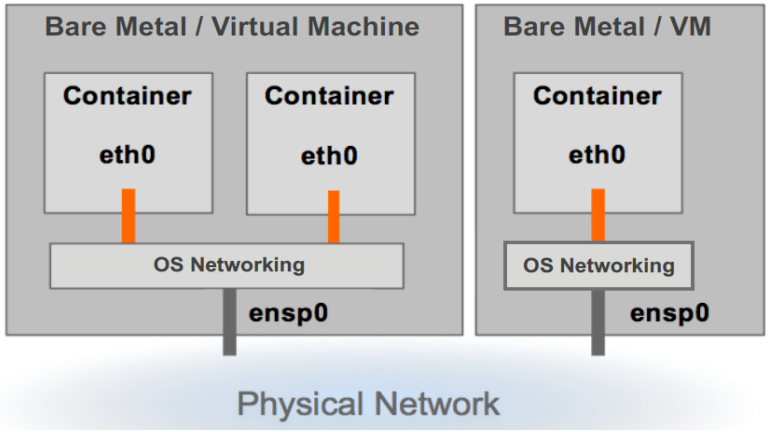
rkt: CRI designed for composability, security, and speed.

CRI-O: OCI-based implementation of Kubernetes CRI; vs cri-containerd.

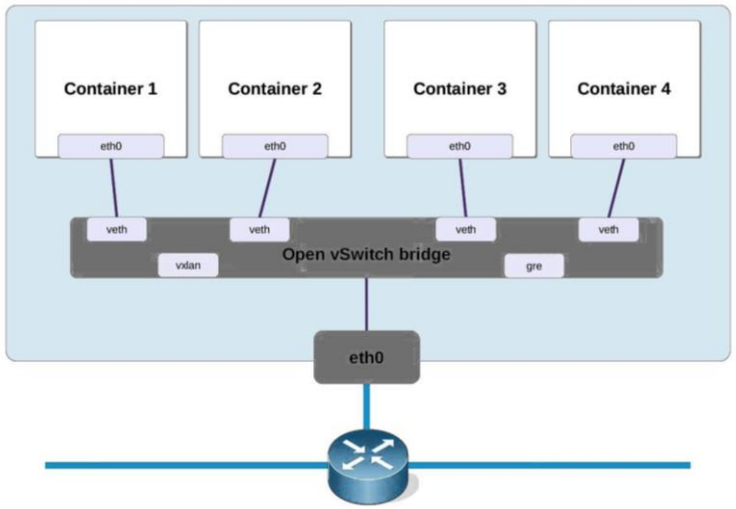
https://kubernetes.io/blog/2018/05/24/kubernetes-containerd-integration-goes-ga/

p+v+c Harmonized Networking

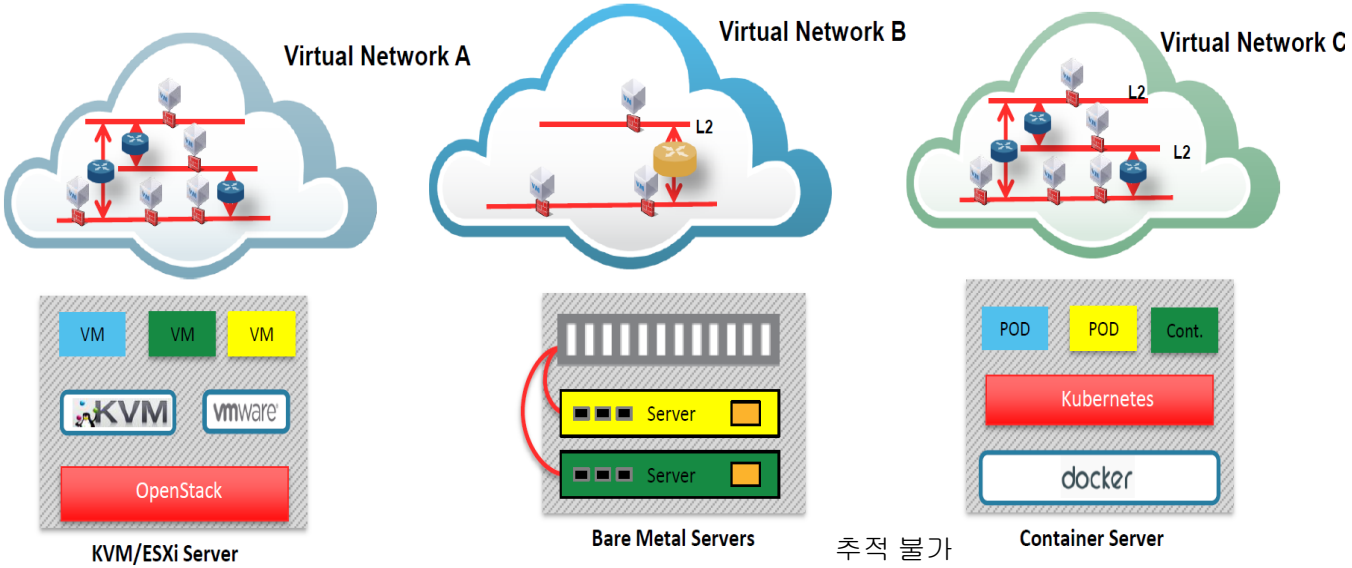
추적 불가



추적 불가



p(Baremetal) + V(Virtual Machine) + C(Container) Harmonization



추적 불가

Gwangju Institute of
Science & Technology

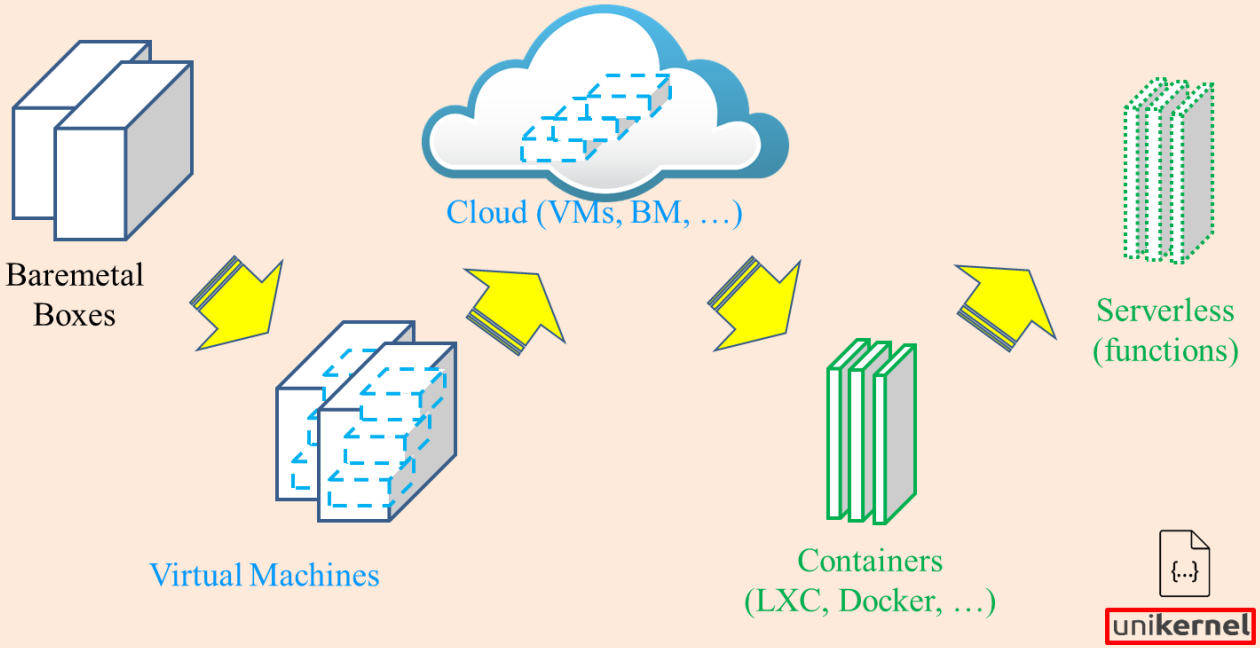
Thank you!

Send Inquiry to jongwon@gist.ac.kr

http://nm.gist.ac.kr

Chapter 4: Computer System

Cloud-native Computing



Chapter Keywords

Serverless Computing

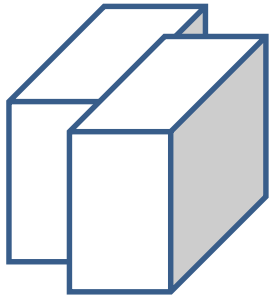
Cloud-native Computing

Orchestration

Open Interface

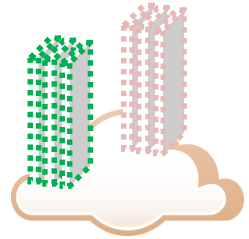
From Baremetal to Containers / Serverless

Monolithic Apps N-tier Apps Micro-services Nano-services

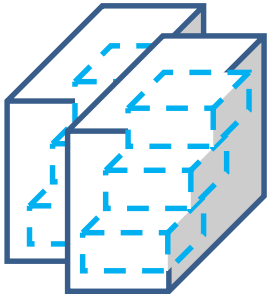


Baremetal Boxes

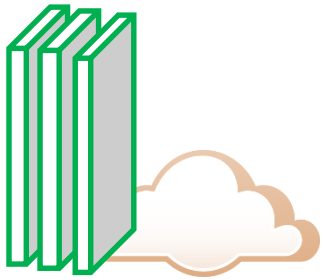
Cloud (VMs, BM, …)



Serverless (functions)



Virtual Machines

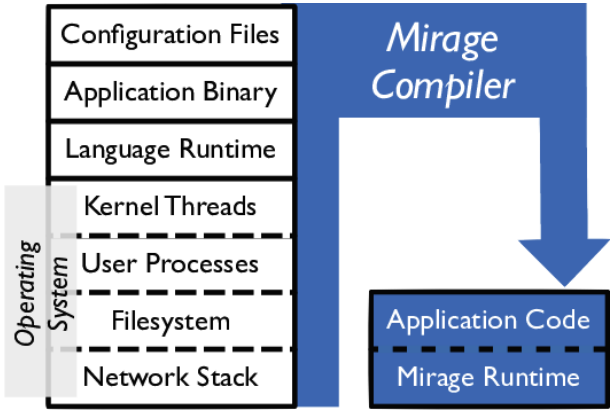


Containers (Docker, Singularity, LXD, …)

unikernel

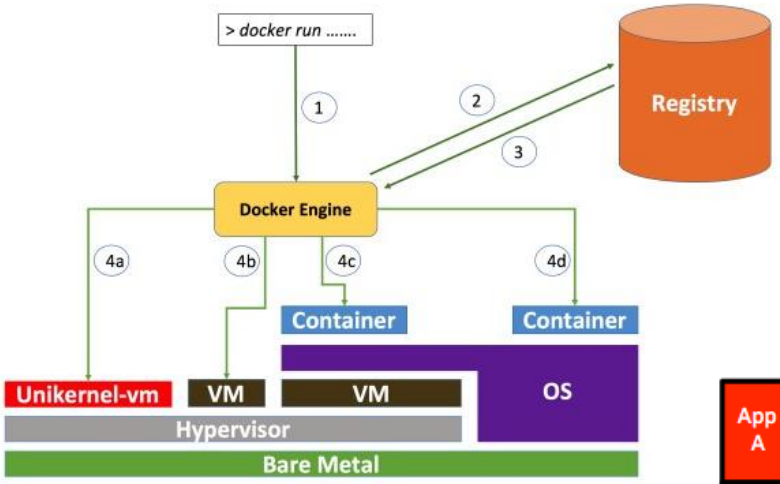
unikernel

A specialized, single address space machine image constructed by using **library operating systems**.



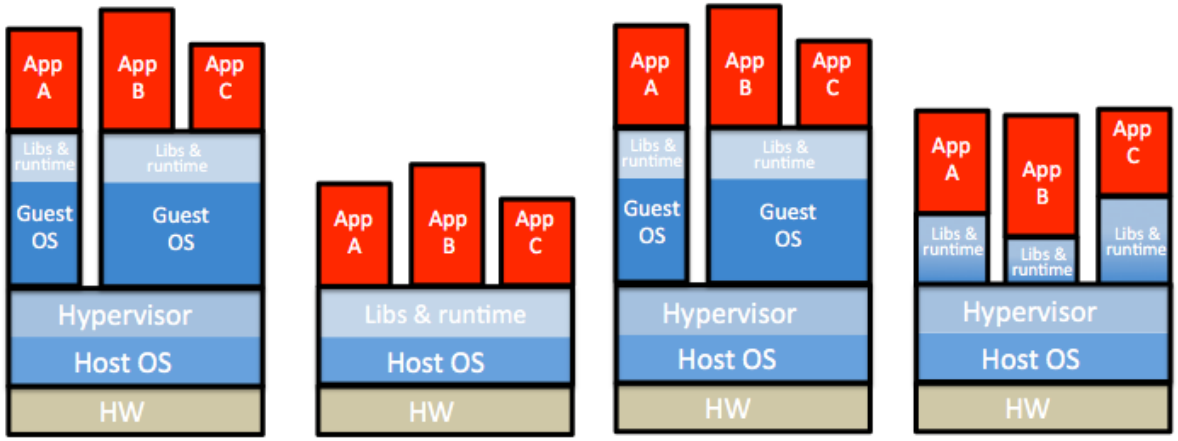
https://manuzhang.github.io/2016/01/28/unikernel.html

unikernel



추적 불가

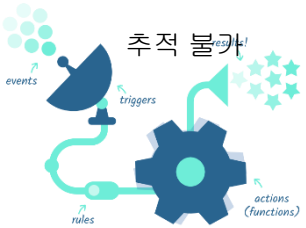
https://www.industrynetwork.nl/tag/security/



Serverless (FaaS) computing

https://www.researchgate.net/publication/319234373_Status_of_Serverless_Computing_and_Function-as-a-ServiceFaaS_in_Industry_and_Research

Event-driven,
Continuous-scaled,
Pay-by-use



Apache
OpenWhisk

https://hackernoon.com/creating-a-serverless-python-api-using-aws-lambda-chalice-d321dc43ce2

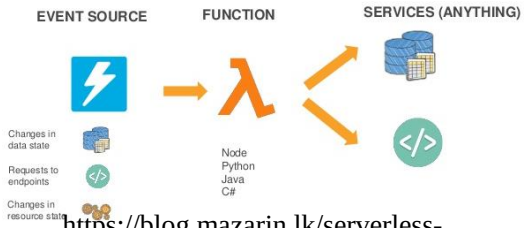
https://www.smoothterminal.com/articles/exploding-rails-knative-k8s-serverless-elixir-qol-js-fundamentals-stable-apis

http://wxec.info/knative-istio.html

Knative

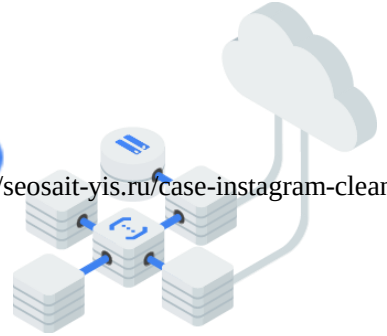
https://medium.com/horizon-four/lets-talk-about-serverless-que-tal-na-azure-bc307f11952a

AWS Lambda



https://blog.mazarin.lk/serverless-architecture-aws-lambda/

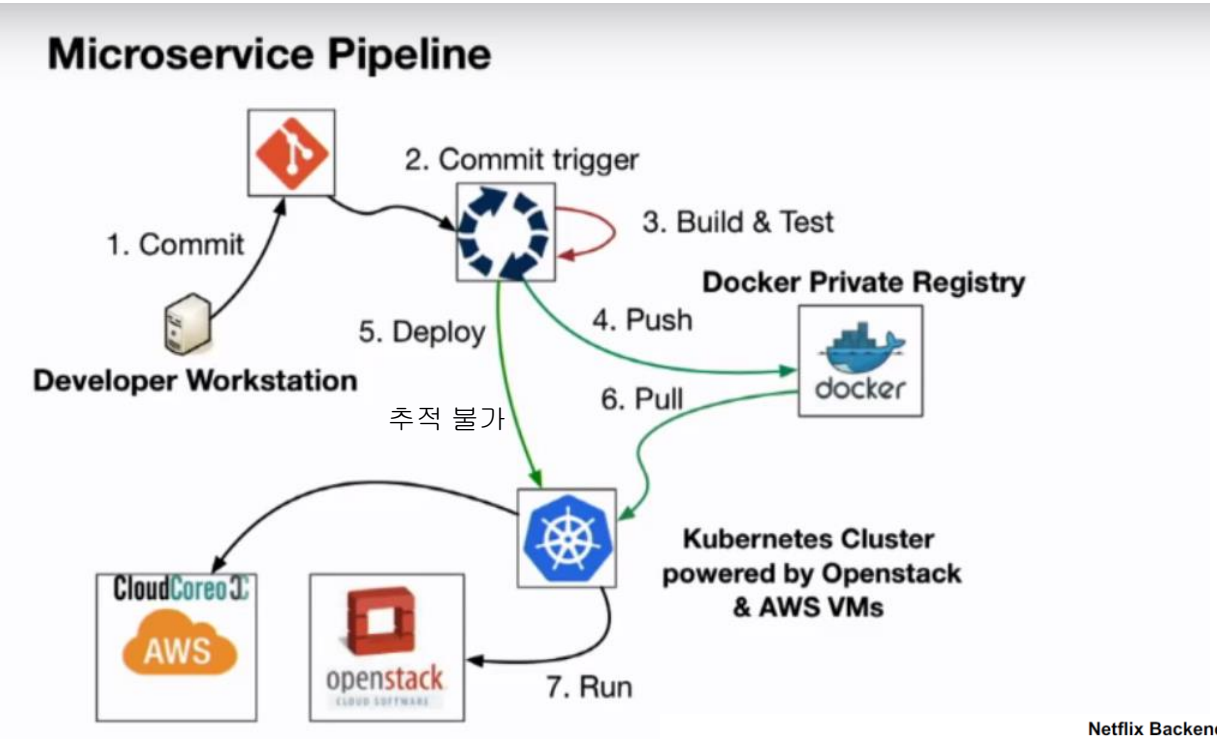
Azure Functions



https://seosait-yis.ru/case-instagram-cleaning

Google Cloud Functions

Container-leveraged Microservices Architecture for Agile & Automated Service Realization

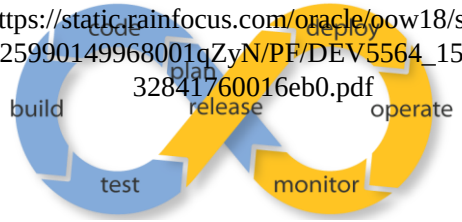


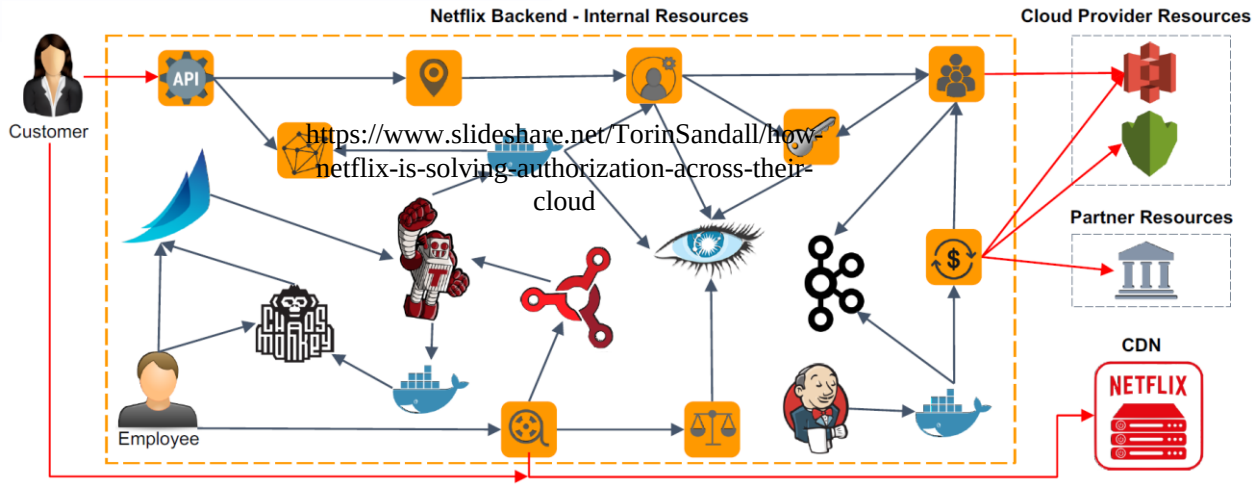
Container-leveraged Orchestration of Service Composition

&

Dynamically-scaled Resource Pooling

https://static.rainfocus.com/oracle/oow18/sess/1525990149968001qZyN/PF/DEV5564_154057328417600 16eb0.pdf





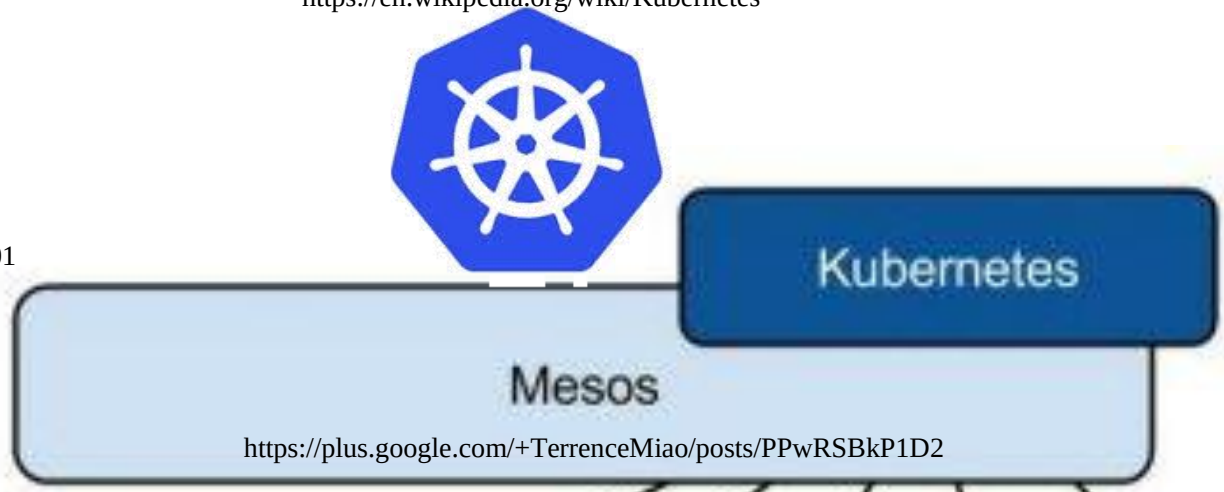
https://www.slideshare.net/TorinSandall/how-netflix-is-solving-authorization-across-their-cloud

Container Orchestration Early View (2015):

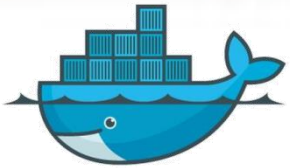
Docker Containers + Mesos Scheduler + Kubernetes Orchestration

https://en.wikipedia.org/wiki/Kubernetes

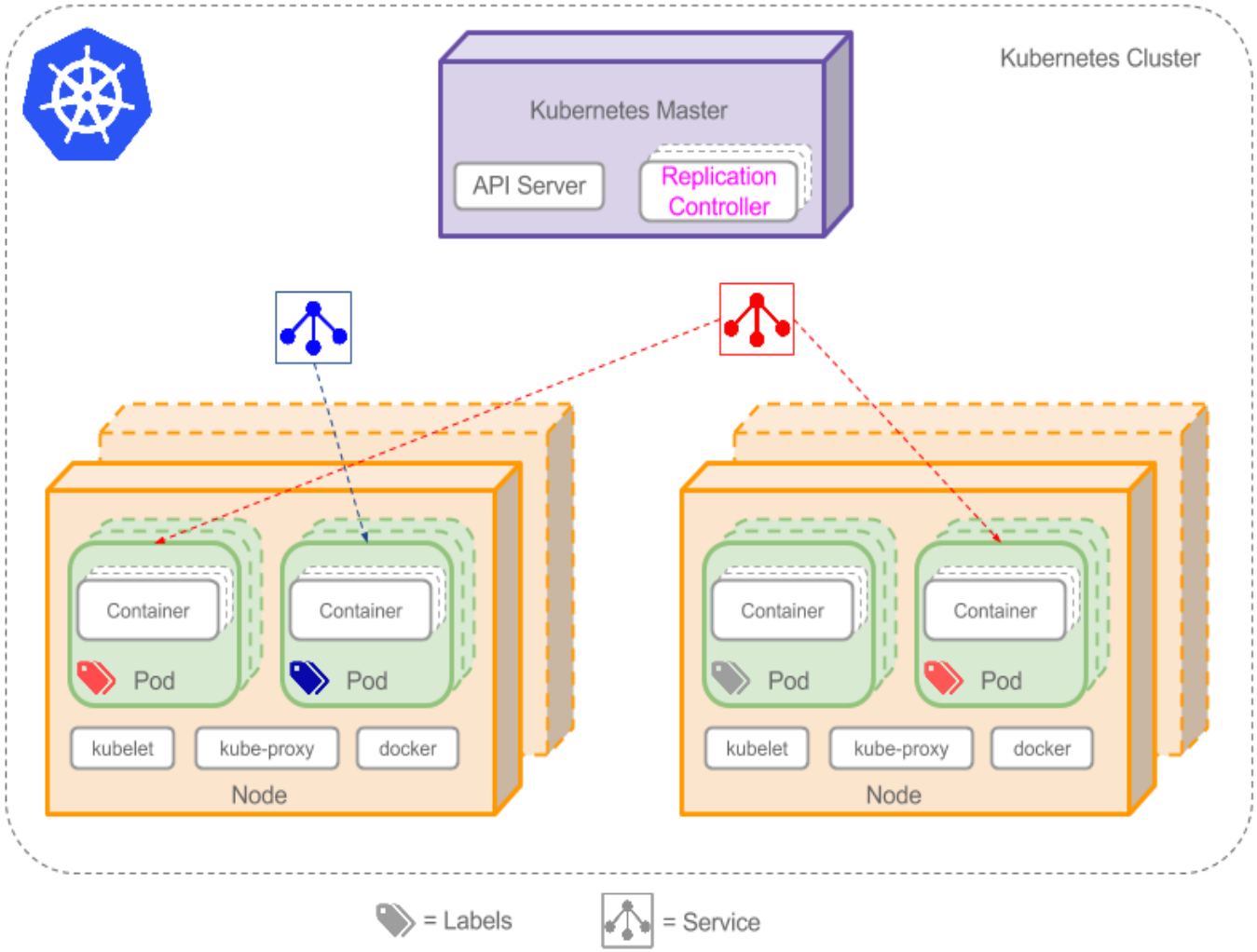
https://www.brandeps.com/logo/M/Mesos-01



https://plus.google.com/+TerrenceMiao/posts/PPwRSBkP1D2



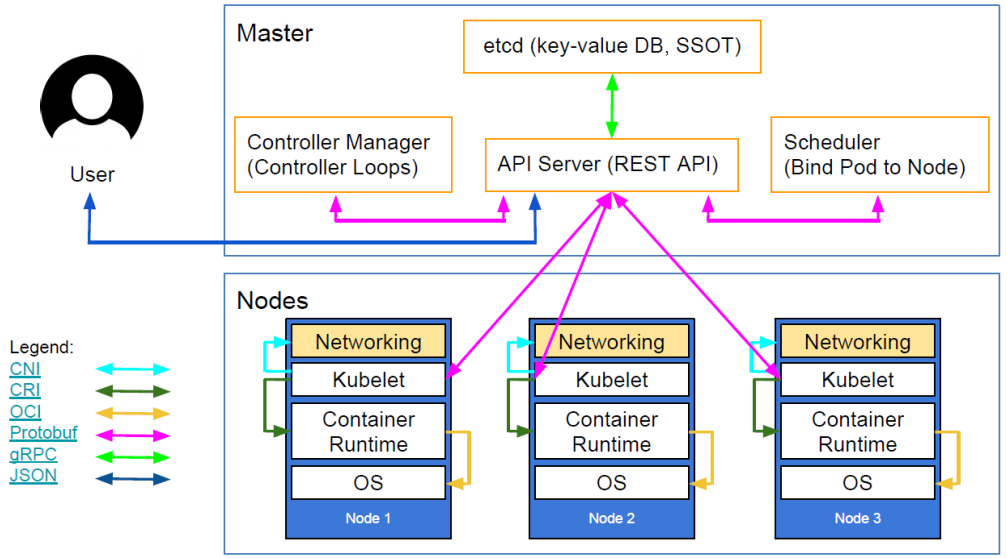
Kubernetes for Large-scale Container Orchestration: Architecture



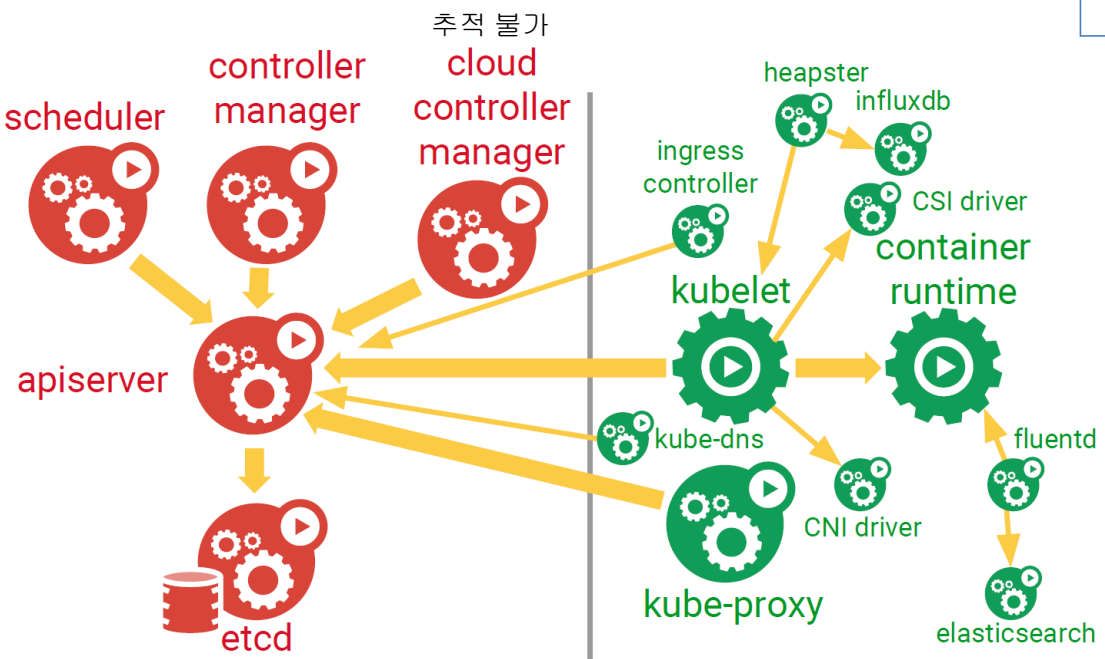
Kubernetes (k8s) is an open-source system for automating deployment, scaling, and management of containerized applications.

http://omerio.com/2015/12/18/learn-the-kubernetes-key-concepts-in-10-minutes/

Kubernetes for Large-scale Container Orchestration: Operation



추적 불가



Drivers
- Network (CNI)
- Storage (flex, CSI)
- Device (e.g. GPU)
- Cloud providers

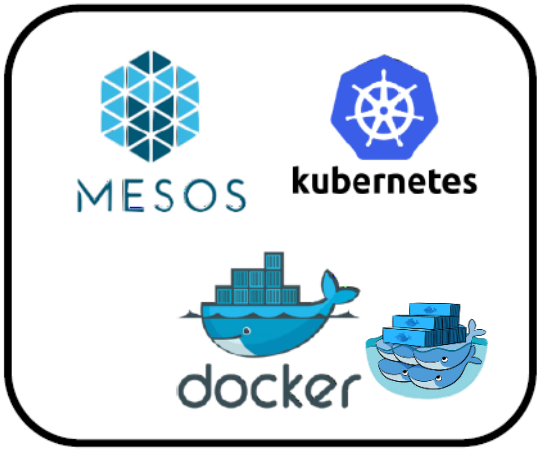
Container runtimes

Operators / controllers

Add-ons
- e.g. logging, monitoring

Container Platforms & Orchestration Tools (2017)

Container Orchestration Engine

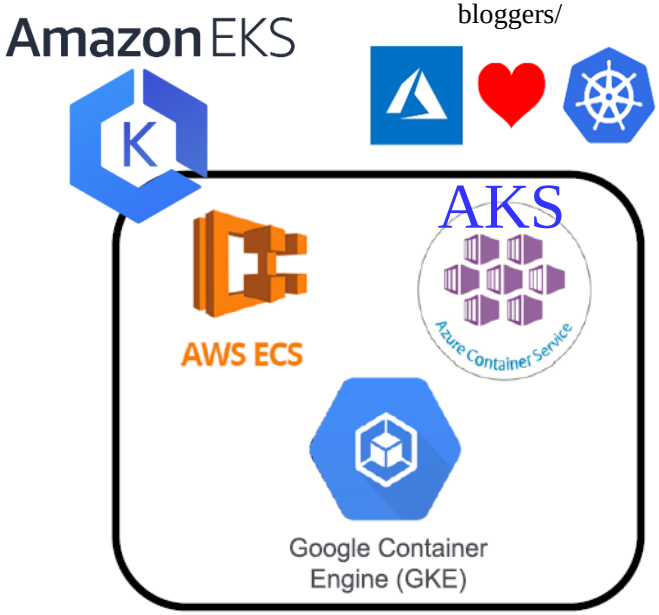


https://docs.docker.com/samples/library/swarm/

Platform-as-a-Service (PaaS)

Container-as-a-Service (CaaS)

https://chrisdennig.me/tag/dotnetge
bloggers/



CNCF & K8S

Kubernetes
Orchestration

Prometheus
Monitoring

OpenTracing
Distributed Tracing API

Fluentd
Logging

linkerd
Service Mesh

gRPC
Remote Procedure Call

CoreDNS
Service Discovery

containerd
Container Runtime

rkt
Container Runtime

CNI
Networking API

Envoy
Service Mesh

Jaeger
Distributed Tracing

Notary
Security

TUF
Software Update Spec

CLOUD NATIVE
COMPUTING FOUNDATION

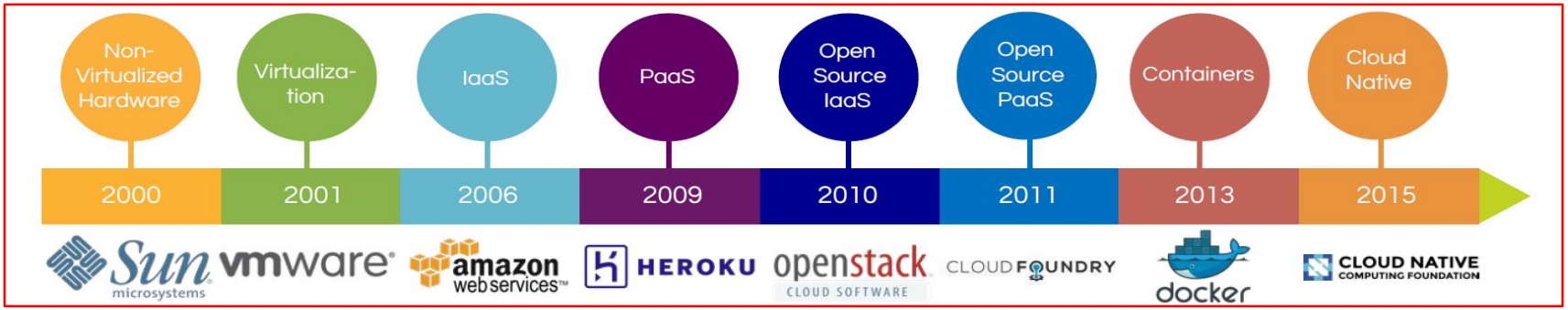
Platinum Members

Alibaba Cloud, aws, cisco, CoreOS, DELL Technologies, docker, FUJITSU, Google Cloud, HUAWEI, IBM, intel, MESOSPHERE, Microsoft, ORACLE, Pivotal, redhat, SAMSUNG SDS, SAP, vmware

https://blog.netsil.com/kubernetes-kontainers-and-kubernetes-native-in-2018-f5d6fb851ad0

Cloud-native Computing

CLOUD NATIVE COMPUTING FOUNDATION



https://opensource.com/article/18/2/how-kubernetes-became-solution-migrating-legacy-applications

Cloud native computing uses an open source software stack to be:

- Containerized

https://twitter.com/singularityapp/media?lang=bg

https://linuxcontainers.org/

rkt

https://twitter.com/tekgirl/status/665799935904915456

- Dynamically orchestrated

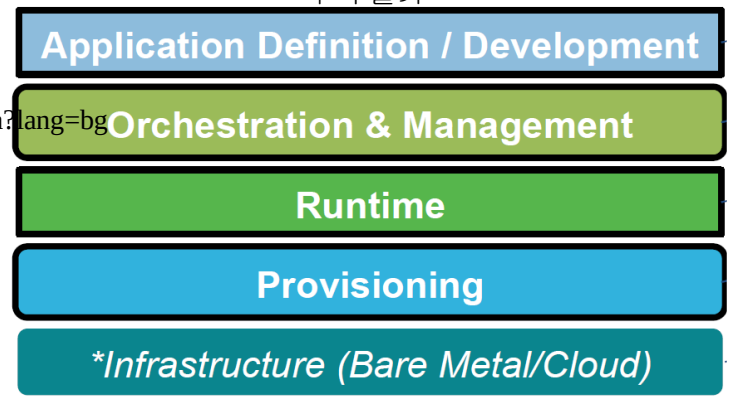
- Microservices oriented

OPEN CONTAINER INITIATIVE

CSI

CNI

추적 불가



microservices + automation + DevOps

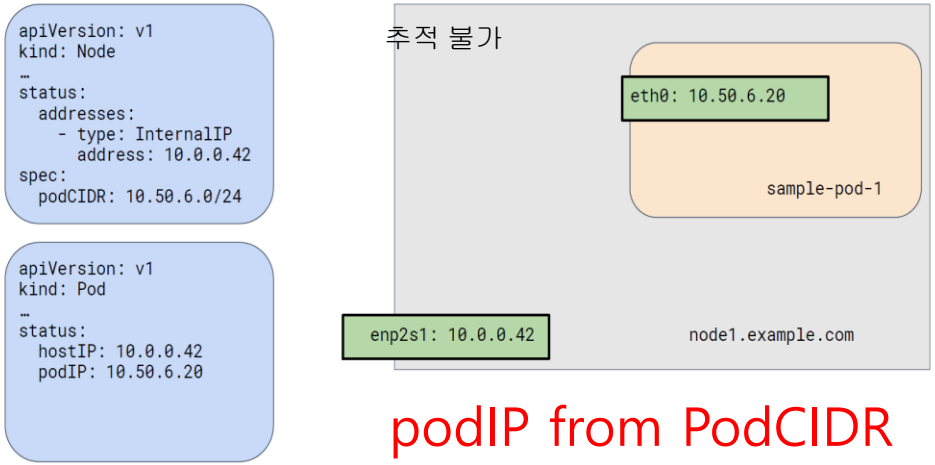
➔➔

Agility of software teams + Resilience of applications.

CNI (Container Network Interface)

CNI is at least three different things:

- A vendor-neutral protocol used by container runtimes to make request to networking providers (Not just for kubernetes!)
- A set of commonly used network plugins maintained by the community
- A “kubelet network plugin” (e.g. “--network-plugin=cni” on the command line)



CNI Plugins for

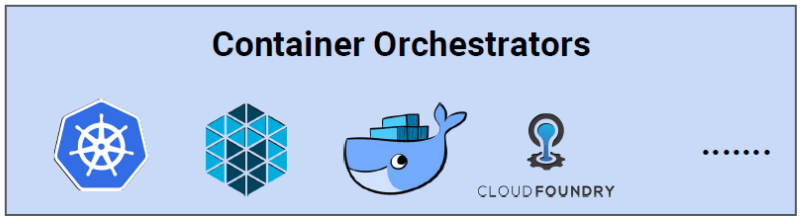
- **Connectivity**: Create a “veth” (a point-to-point virtual tunnel) pair → Move one end of the pair in to the container’s namespace → Configure an ip and route in the container’s namespace
- **Reachability**: Make every PodCIDR reachable from every Node (by announcing dynamic routes to some peers) with a per-host daemon that programs the network with learned routes; Programming via 1) Overlay networks (Flannel, Weave, Calico), 2) Cloud provider APIs (cp-azure, Flannel), 3) Routing protocols (Calico, Romana)

CSI (Container Storage Interface)

Problems with existing storage interfaces: CLI-based interface, Lack of idempotency on APIs, In-tree interface, Tightly coupled with an implementation, Too heavyweight

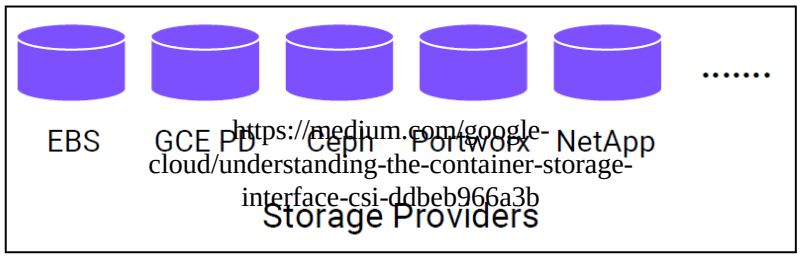
➔ **CSI** for Interoperability + Vendor neutral + Focus on specification + Control plane only + Keep it simple and boring

- Docker volume plugins [link]
- K8s FlexVolume [link]
- K8s In-tree volume plugins [link]
- Libstorage storage drivers [link]
- OpenSDS volume drivers [link]



Pluggable Storage Interface

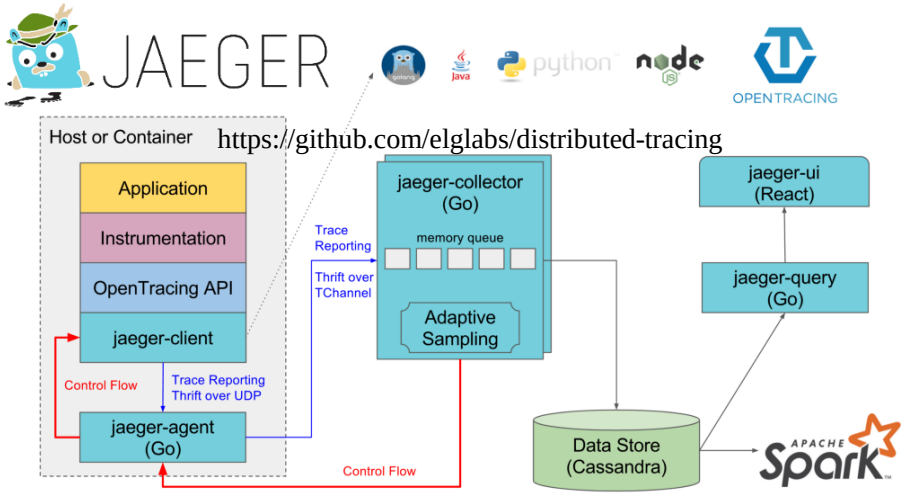
Create/Delete volumes
Attach/Detach volumes
Mount/Unmount volumes
Format volumes
Create snapshots
...

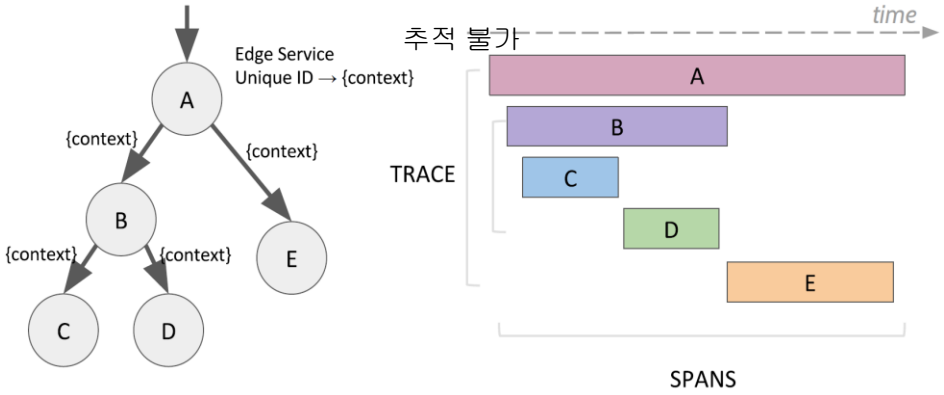


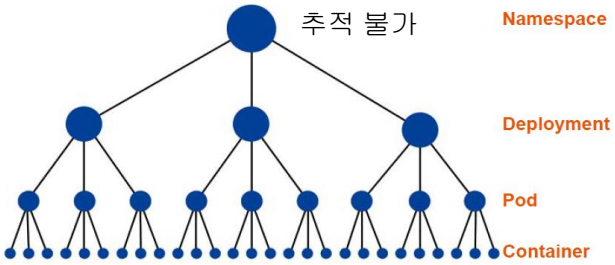
https://medium.com/google-cloud/understanding-the-container-storage-interface-csi-ddbeb966a3b

Unified Visibility (Monitoring/Tracing) for Kubernetes-orchestrated Services

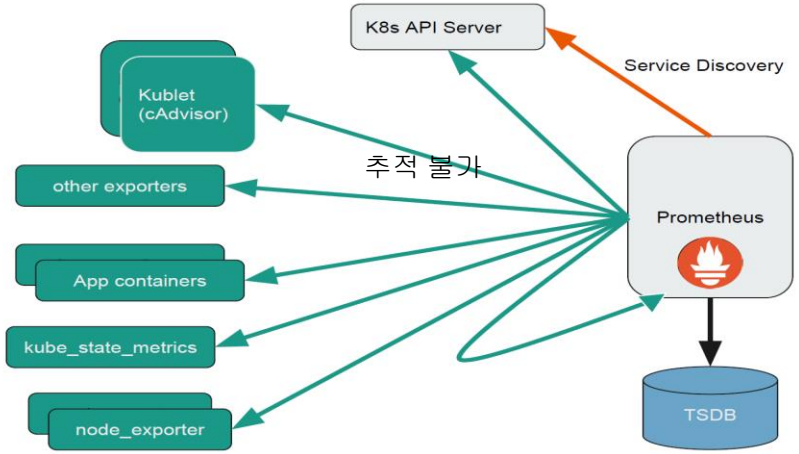
OpenTracing: Vendor-neutral / Cross-language Instrumentation API for Context Propagation + Distributed tracing + Contextualized logging/metrics







Core metrics aggregation

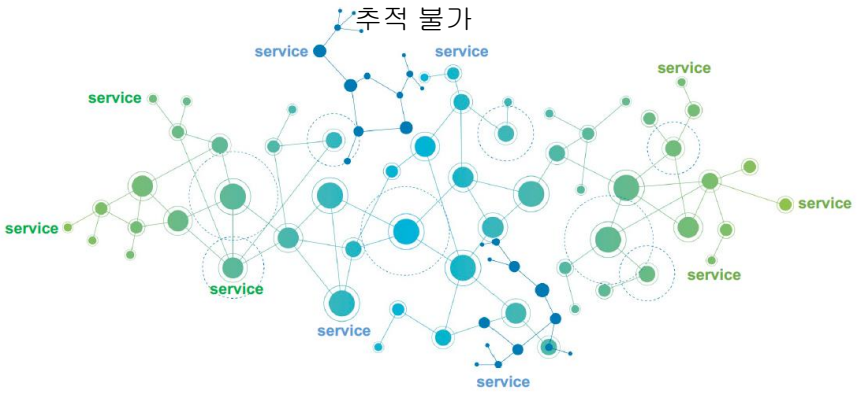


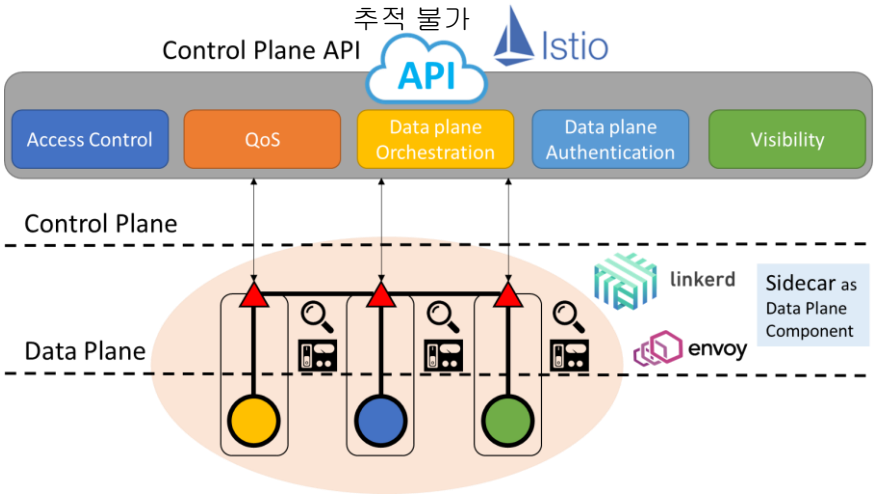
Visibility sources in Kubernetes: Node via the node_exporter + Container metrics via the kubelet and cAdvisor + Kubernetes API server + etcd + Derived metrics via kube-state-metrics

Service Mesh: Thin-layer for Reliable Microservices

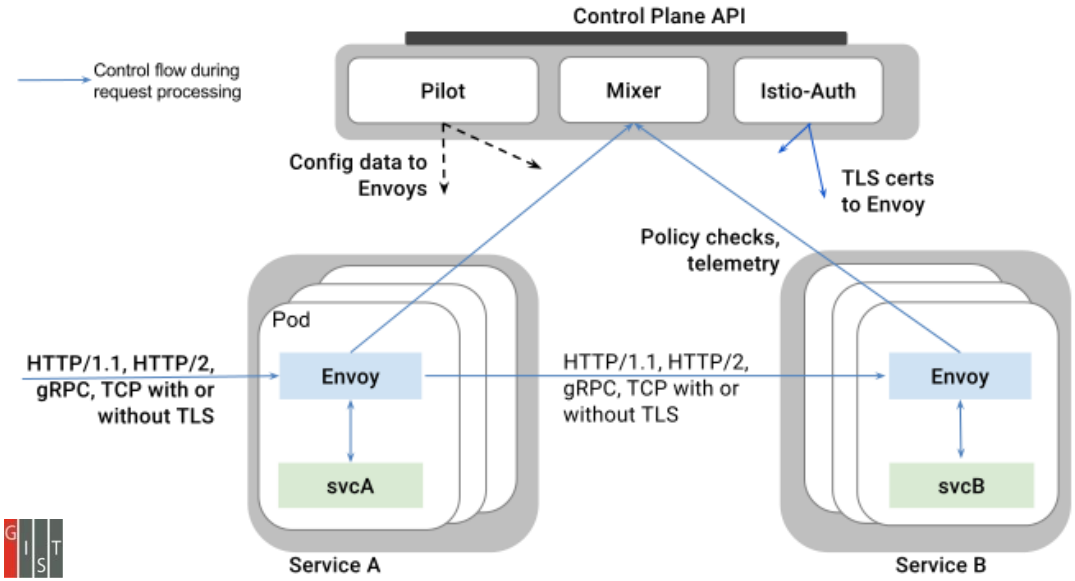
with Traffic Monitoring & fine-grained QoS/Access Control

To solve common issues with routing/re-routing for graceful degradation as services fail, secure inter-service communication and rate limiting between services.





https://developer.ibm.com/courses/how-istio-works-dwc024/



Micro services

Service Mesh

Container-based Orchestration

Istio

linkerd

envoy

kubernetes

Gwangju Institute of
Science & Technology

Thank you!

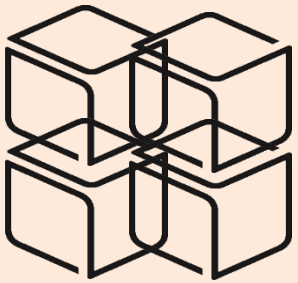
Send Inquiry to jongwon@gist.ac.kr

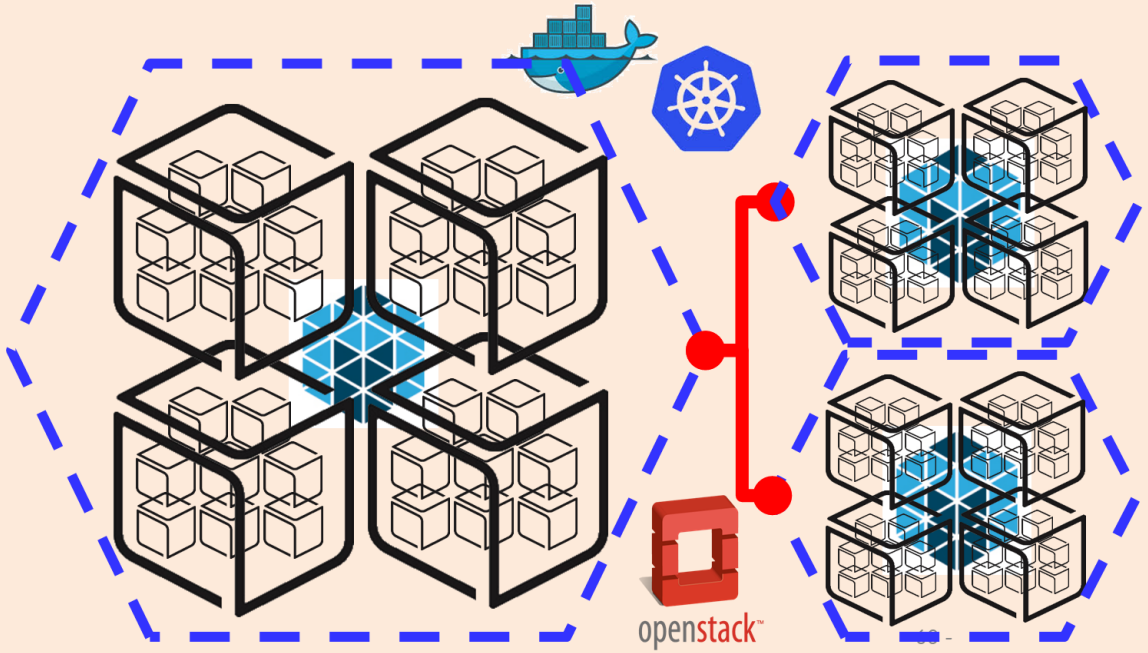
http://nm.gist.ac.kr

Chapter 5: Computer System

Clusters for HPC/BigData & AI

Scale Out





Chapter Keywords

Scale-Out/Scale-Up

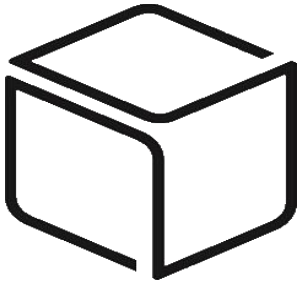
Cluster / Grid / Cloud

HPC Cluster

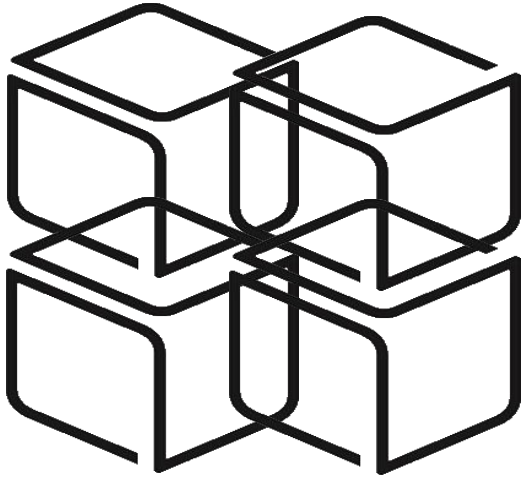
Storage/BigData Cluster

Data & AI Cluster

Computer Systems: Scaling Options

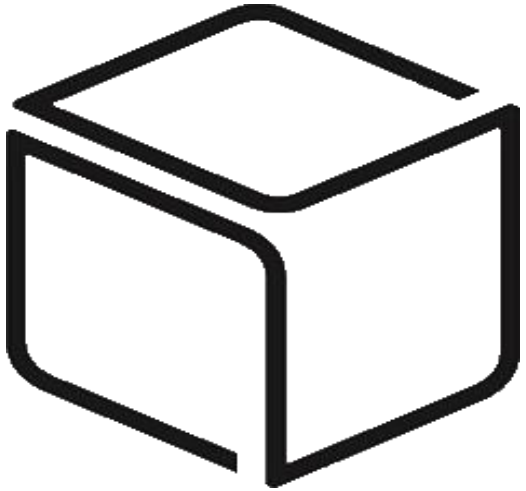


Scale Out



vs

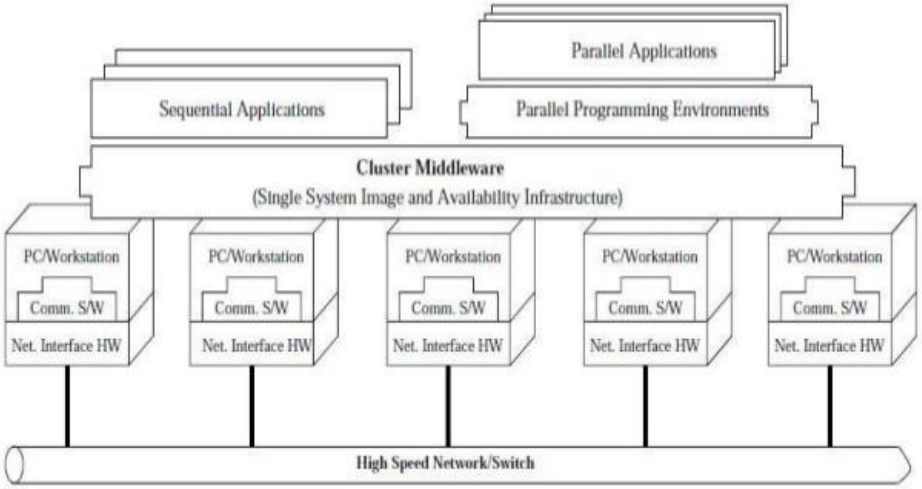
Scale Up



Computer Systems: Cluster Computing

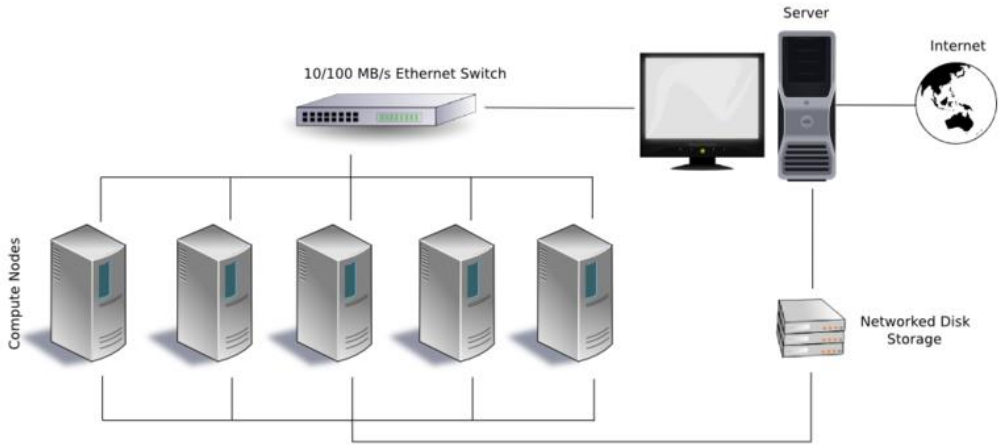
Computer Cluster (Wikipedia): A set of loosely or tightly connected computers that work together so that, in many respects, they can be viewed as a single system. Unlike grid computers, computer clusters have each node set to perform the same task, controlled and scheduled by software.

https://www.slideshare.net/anjalibhandari11011995/cluster-computing-53768699



Cluster architecture

http://www.ppcr.tj/documents/ADBTA8090Inception_Report.pdf

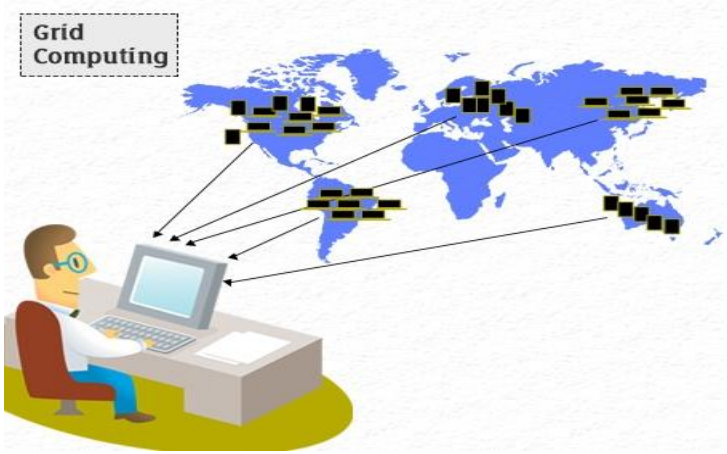


BeoWulf cluster (1994 ~): A computer cluster with identical/commodity computers for high-performance processing, which are networked into a small LAN with shared libraries and programs.

Computer Systems: Grid Computing

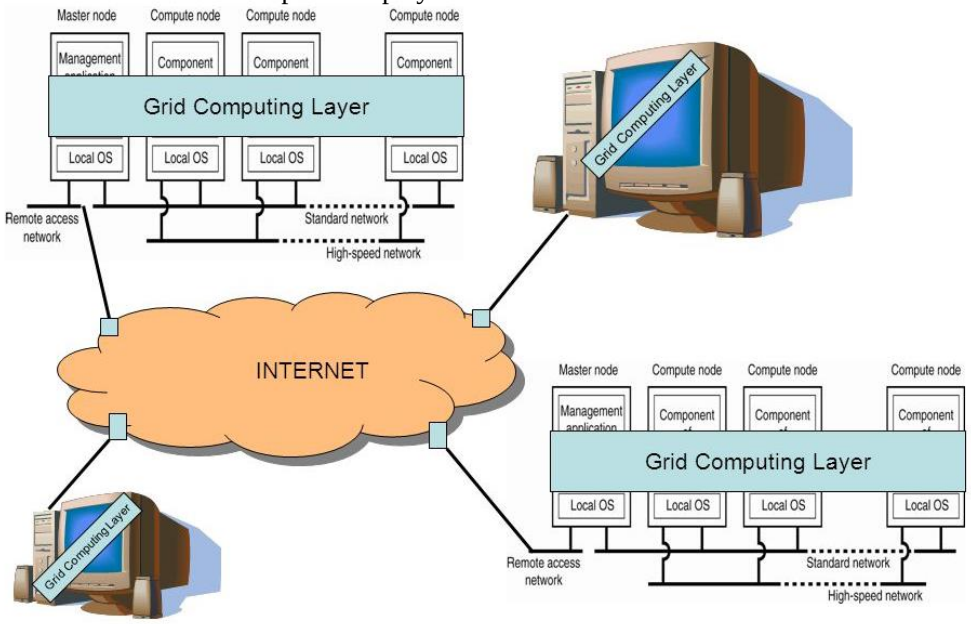
Grid computing: The use of geographically distributed and heterogeneous computer resources to reach a common goal.

- Using distributed computers and resources collectively.
- Usually associated with geographically distributed computers and resources on a high-speed network.



http://rhodyezekiel.blogspot.com/2017/05/grid-computing.html

https://slideplayer.com/slide/4620863/



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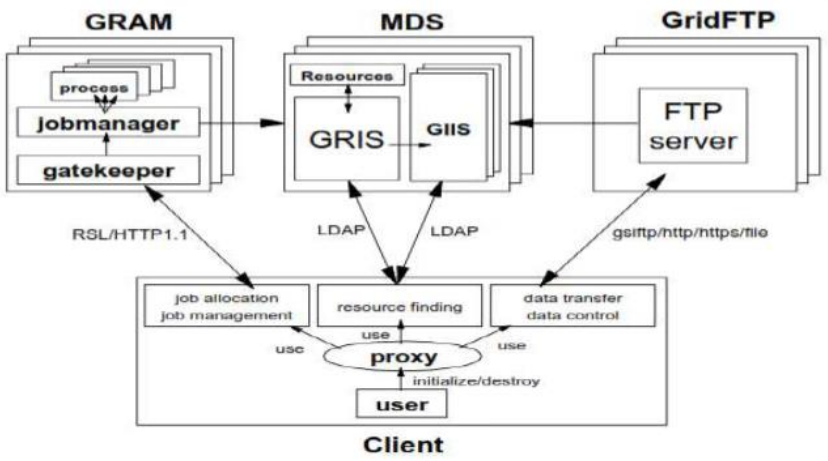
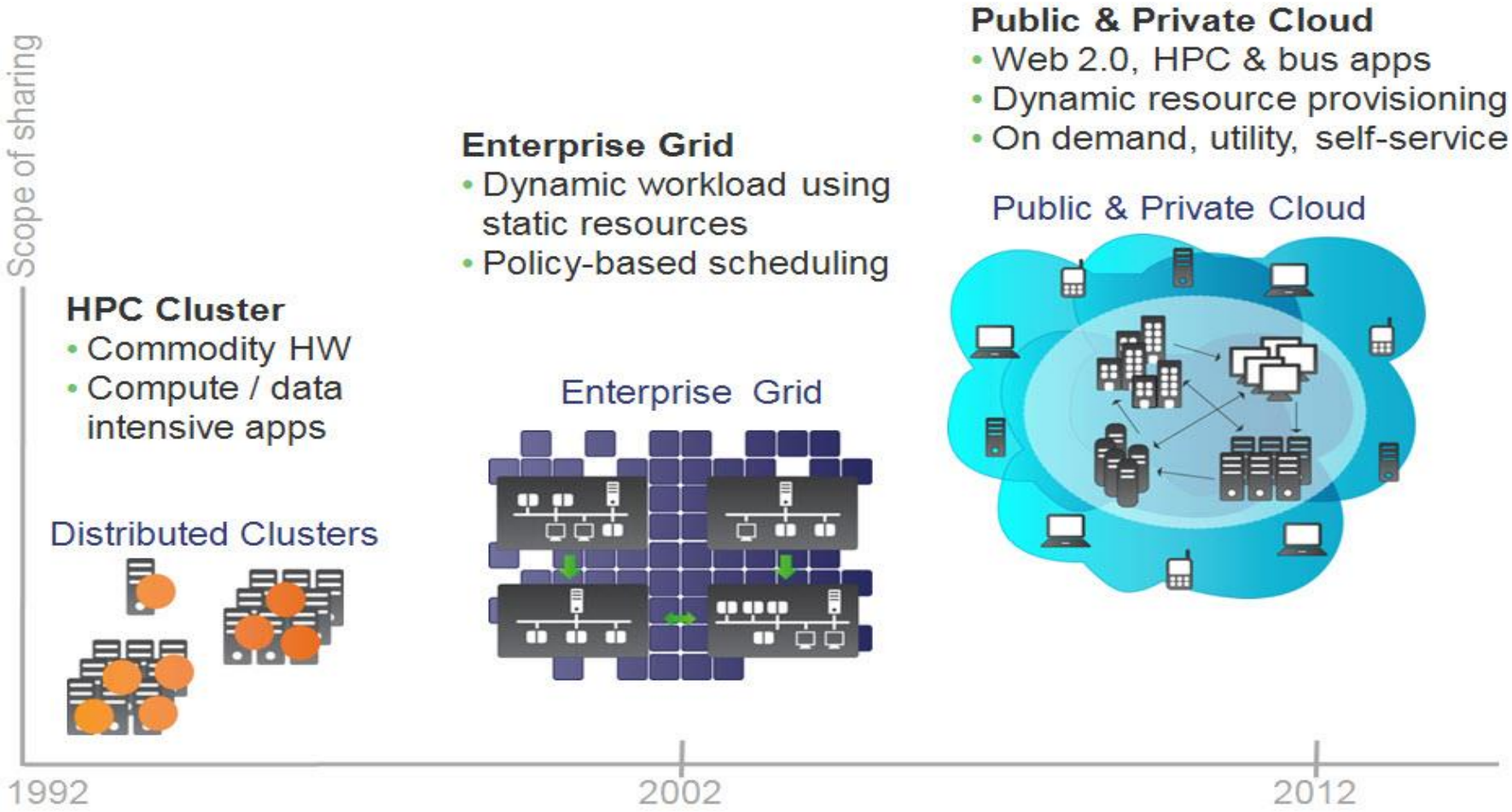


globus

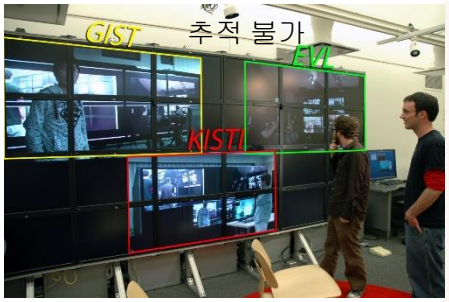
Computer Systems - Evolution: Cluster / Grid / Cloud Computing



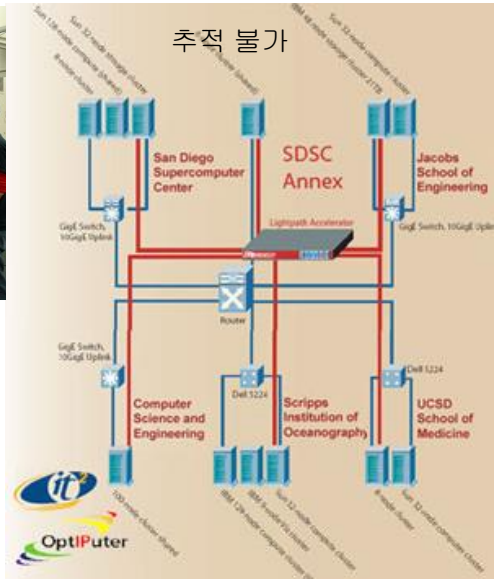
https://slidex.tips/download/sistemas-distribuidos-22

Computer Systems - Evolution:
Enabled by High-Performance Optical Networking

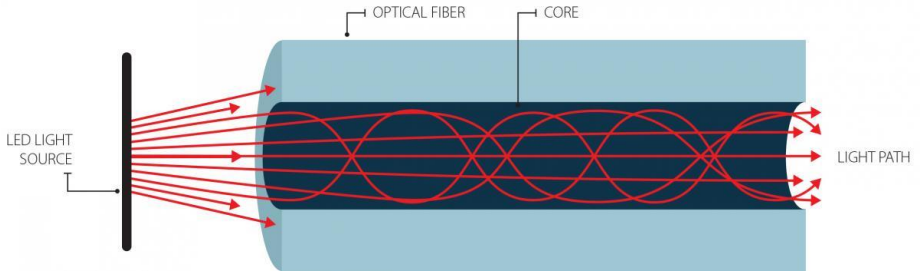
Cluster/Grid/Cloud Computing Enabled by Global-scale Lambda (Optical Light Path) Networking



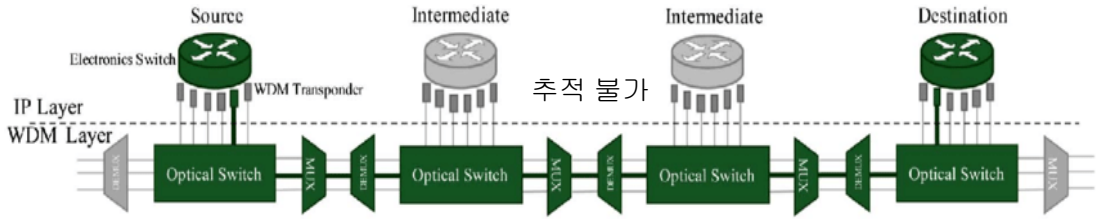
OptIPuter & SAGE Visual Sharing



https://www.fibre-systems.com/viewpoint/reducing-measurement-uncertainty-multimode-optical-fiber

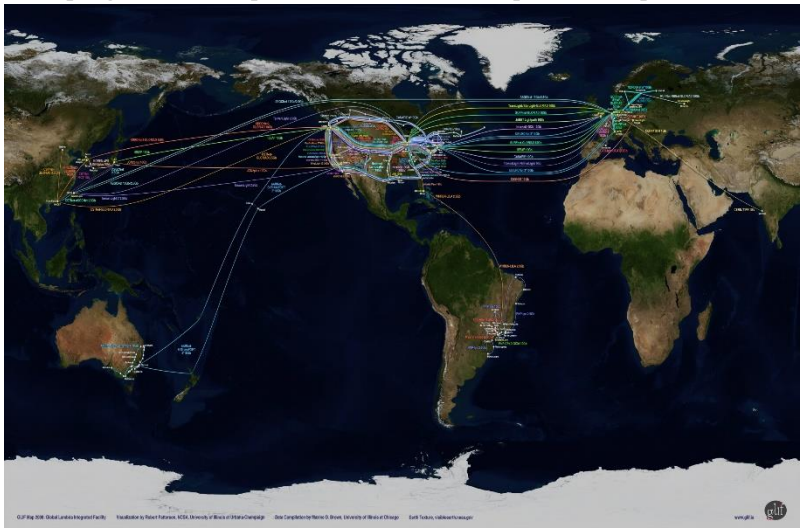


Light Path & Optical Networking



Global Lambda Integrated Facility

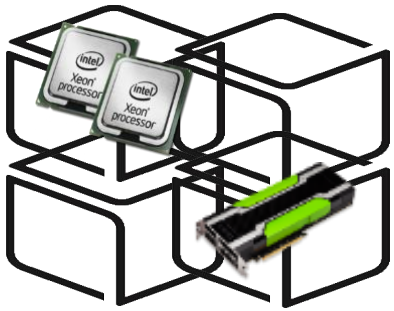
http://generic.wordpress.soton.ac.uk/ses/wp-content/uploads/sites/79

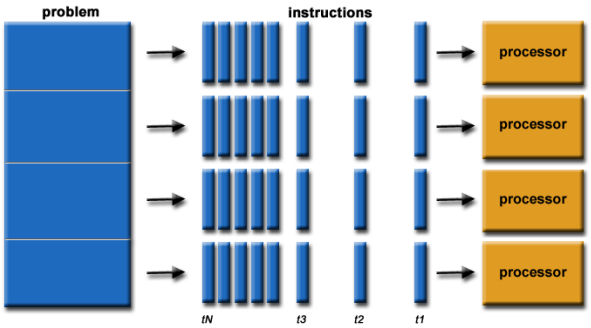


Computer Systems:

HPC (High Performance Computing) Clustering

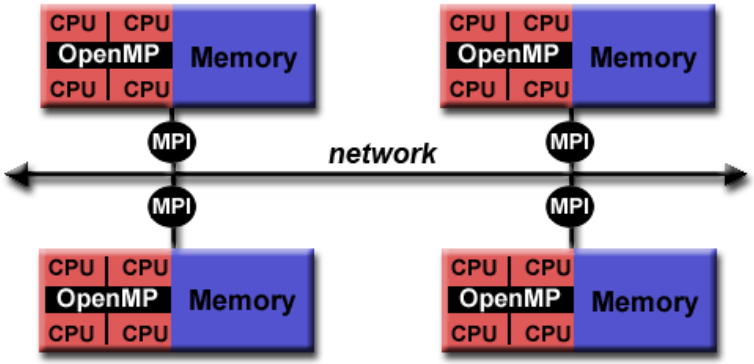
https://eds-uga.github.io/cbio4835-fa18/slides/Lecture5.slides.pdf

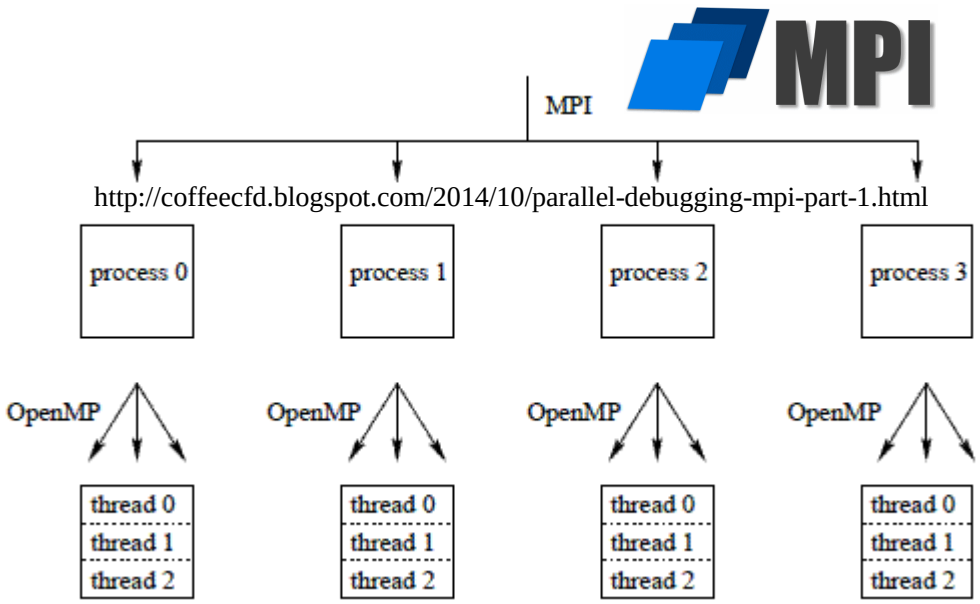




HPC with Parallel Computing

https://events.prace-ri.eu/event/729/contribution/3/material/slides/0.pdf

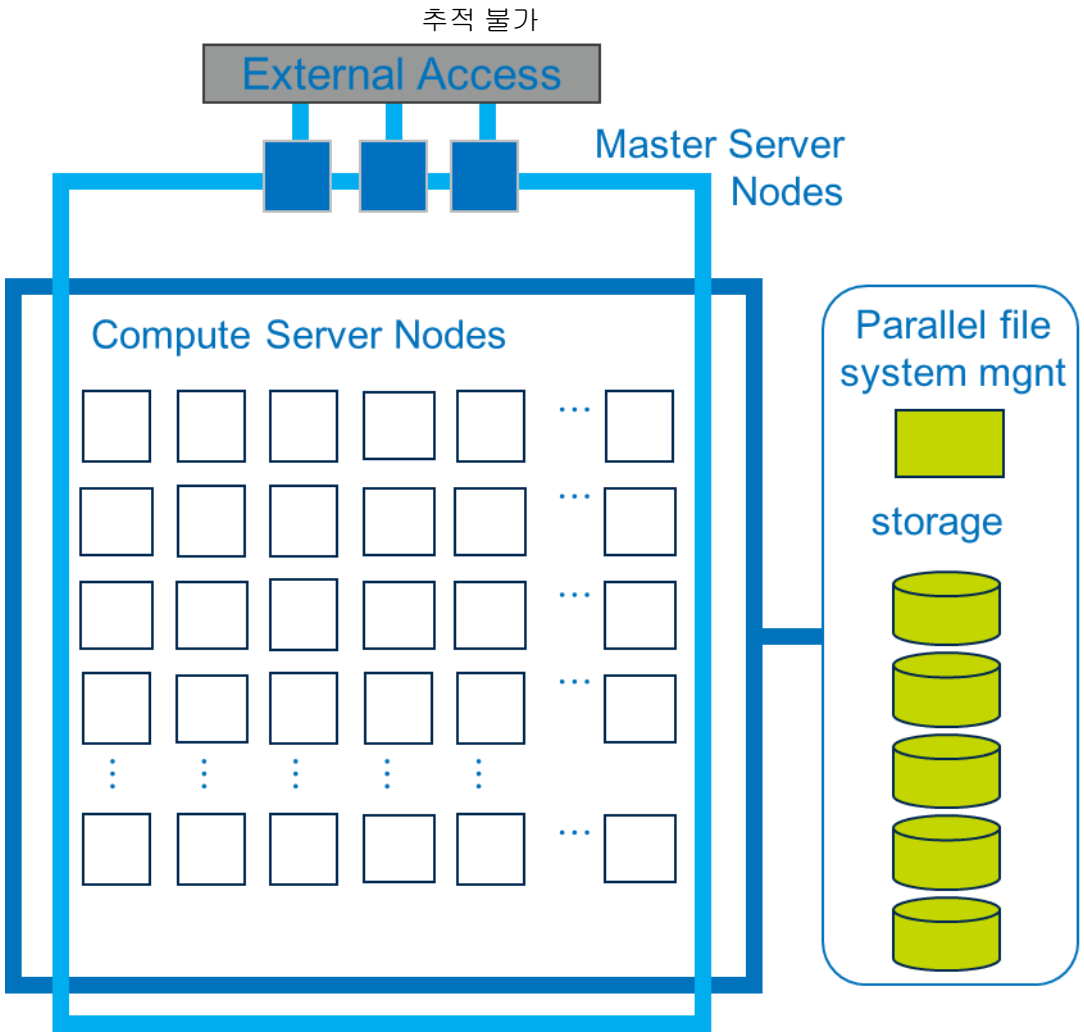




OpenMP

Parallel computing: MPI & OpenMP

Computer Systems: HPC Clustering Requirement



Powerful **master nodes**
- -manage the compute nodes
- -optimize overall capacity

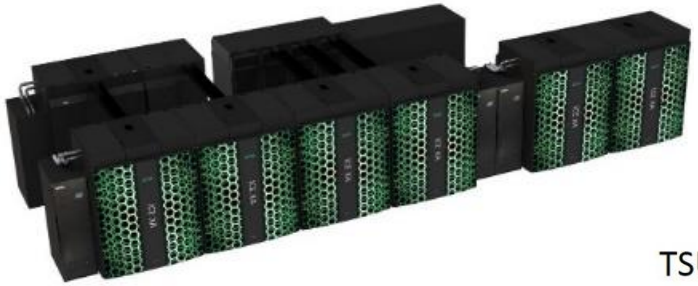
Many fast **compute nodes**
- -number crunching, rendering, compiling, or other manipulation

Low latency / high BW **fabric**
- -master to compute node comms
- -inter-compute node communications

Fast storage access
- -high performance data network
- -high performance **parallel file system**
- -mix of HDD and SSD (more SSDs with Big Data)

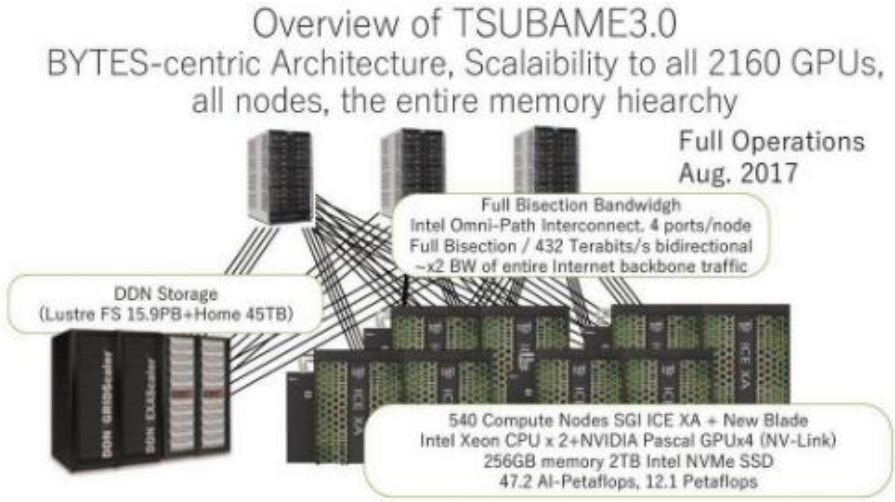
AND…easy to deploy, manage, and use (e.g. apps compatibility)

Computer Systems: HPC Clustering for Super Computer



TSUBAME3.0

400Gbps / Box
(with Intel Omni Path Adapter)



https://www.forbes.com/sites/marcochiappetta/2017/02/20/nvidias-accelerated-computing-platform-to-power-japans-fastest-ai-supercomputer/#112589b97708

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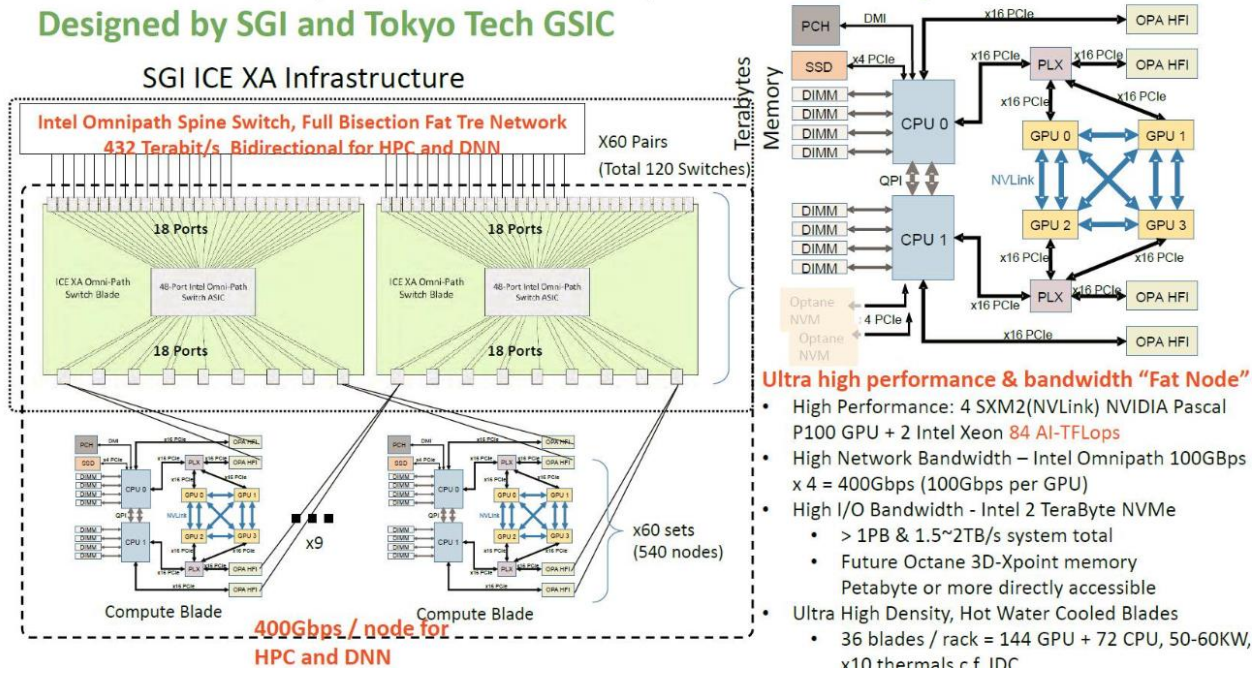
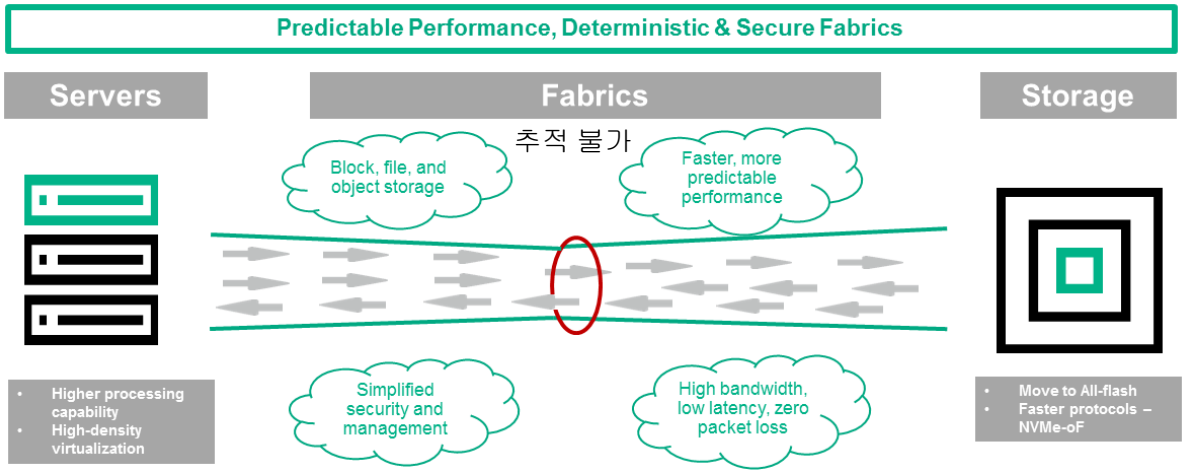
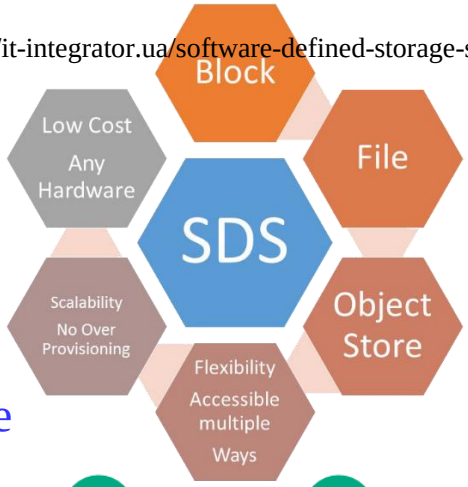


Storage Challenges: Latency & Cost

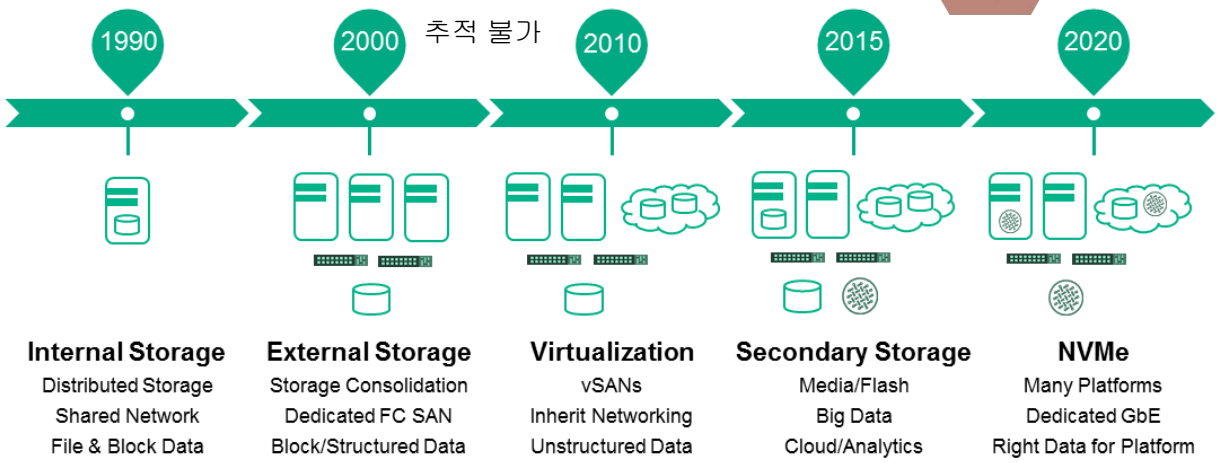
Data Storage Challenges



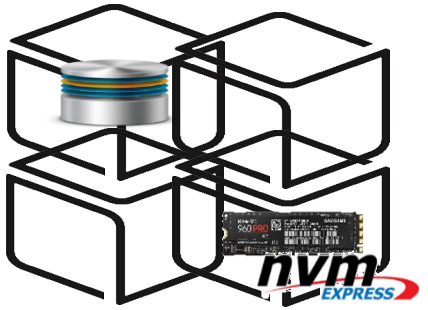
https://it-integrator.ua/software-defined-storage-sd



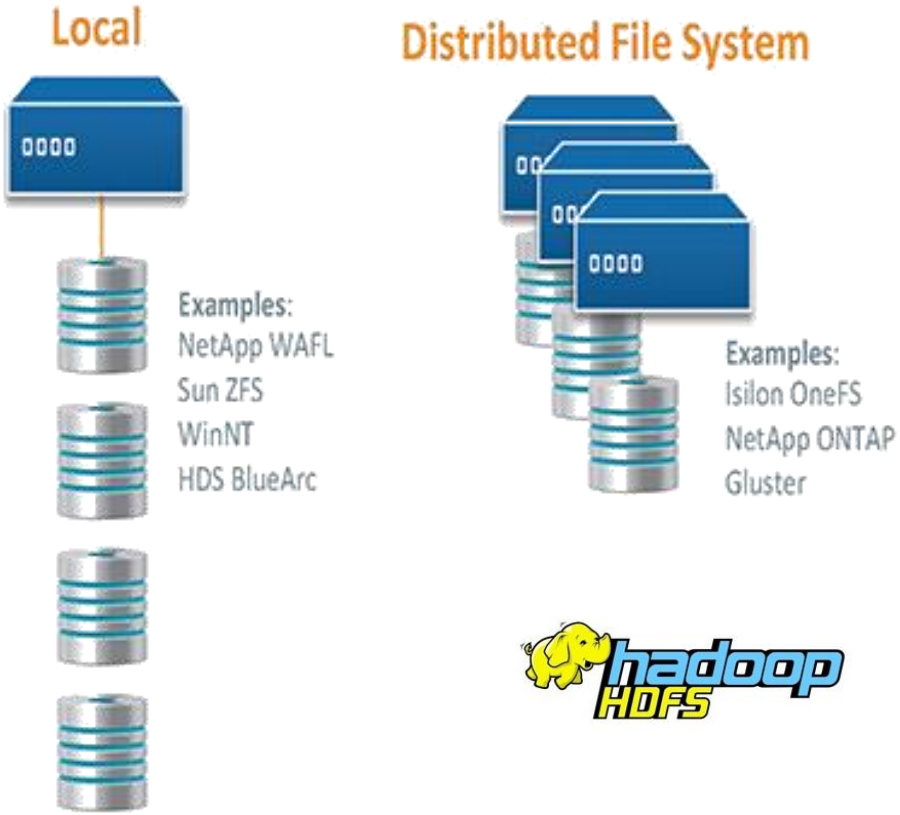
Data Storage Technology Evolution & Software-Defined Storage

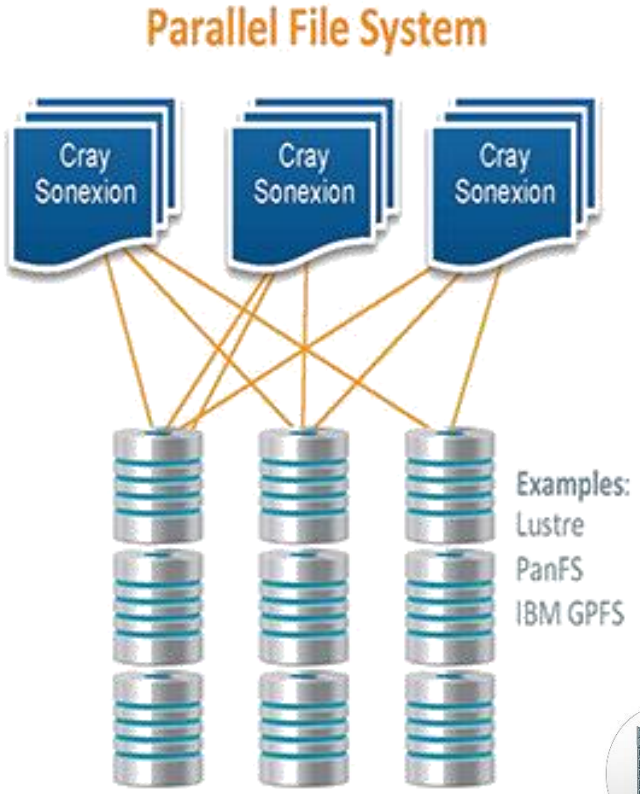


Storage Clusters & Distributed/Parallel File Systems



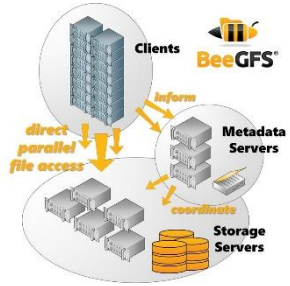
Storage Clustering





https://www.cray.com/sites/default/files/SB-Cray-Storage-Hedge-Funds.pdf

https://de.wikipedia.o
eegfs-architecture-

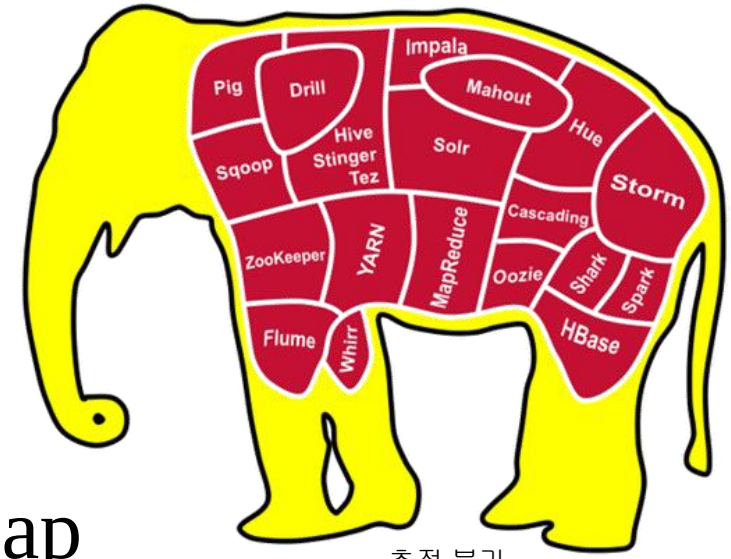


IBM GPFS Lustre®

Open-Source BigData Platform

THE APACHE SOFTWARE FOUNDATION

Hadoop: Distributed Computing Framework



추적 불가

ODPi

Flink

Spark

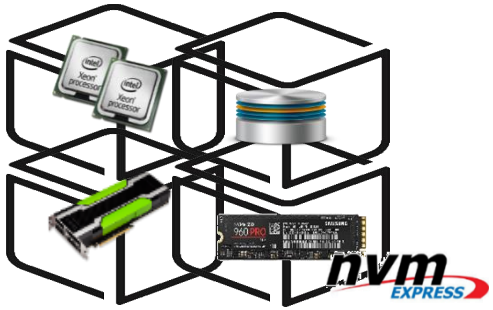
kafka

Map
Reduce

MESOS

hadoop HDFS

hadoop YARN

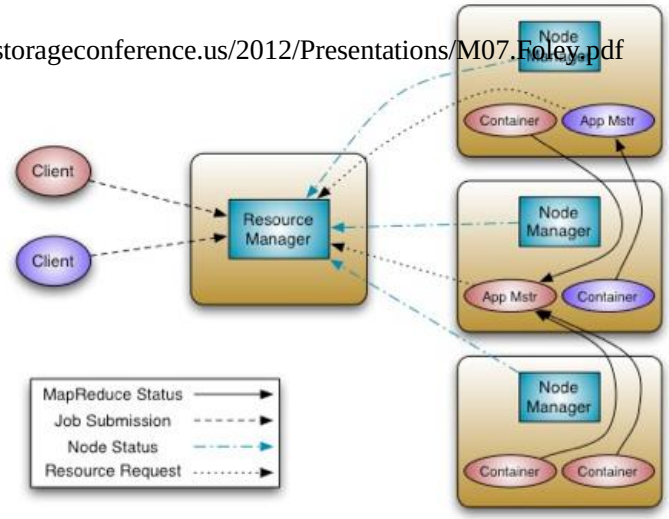


Storage + Compute Clustering

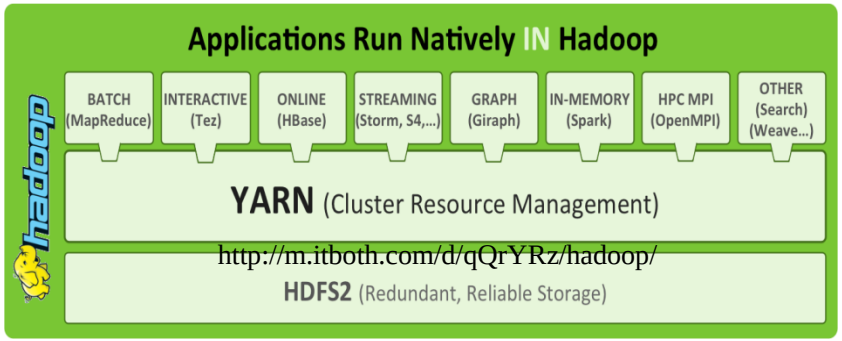
BigData (HPDA) Cluster Management

HPDA (High Performance Data Analytics)

http://storageconference.us/2012/Presentations/M07.Foley.pdf

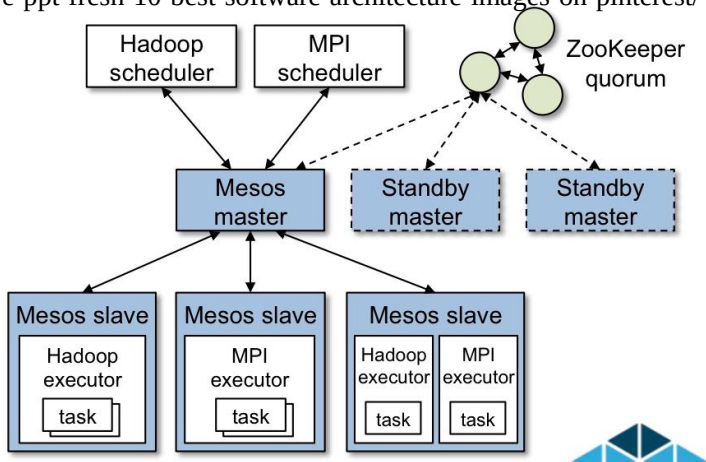


Apache Hadoop YARN

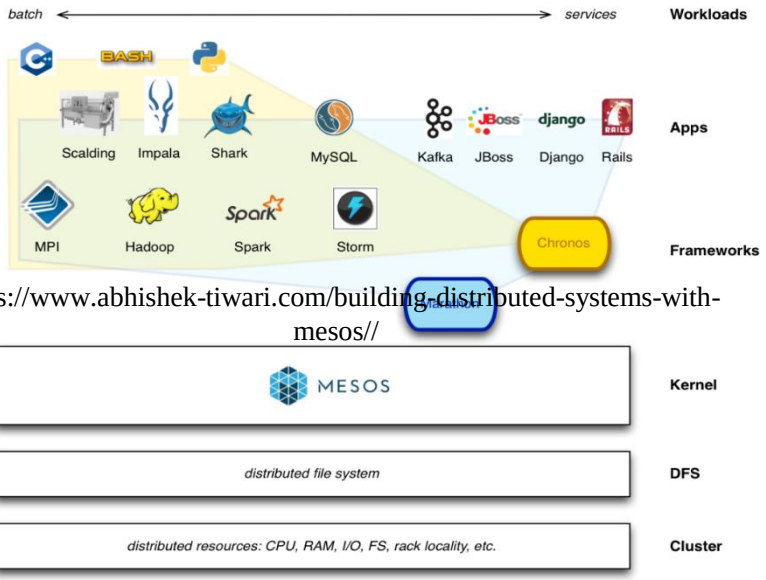


http://m.itboth.com/d/qQrYRz/hadoop/

https://portlandbathrepair.com/hadoop-architecture-ppt/hadoop-architecture-ppt-fresh-10-best-software-architecture-images-on-pinterest/

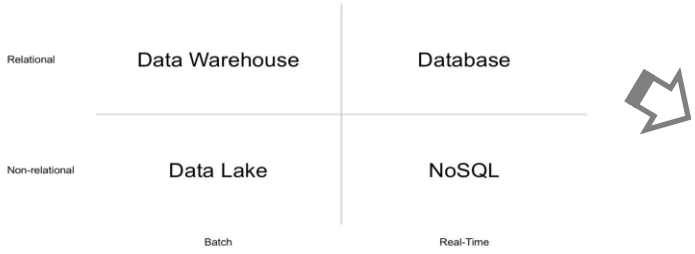


Apache Mesos

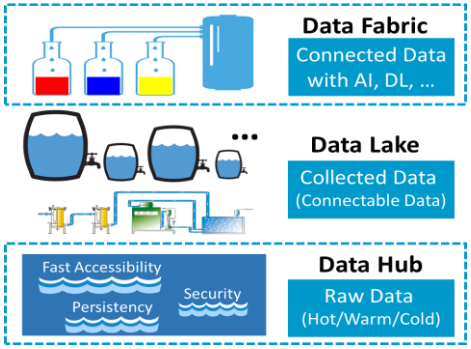


https://www.abhishek-tiwari.com/building-distributed-systems-with-mesos//

‘New’ Open Data Landscape:
Data Fabric vs Data Lake vs Data Hub



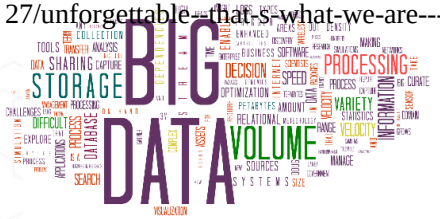
https://www.datanami.com/2017/06/19/carts-horses-need-focus-data-first/



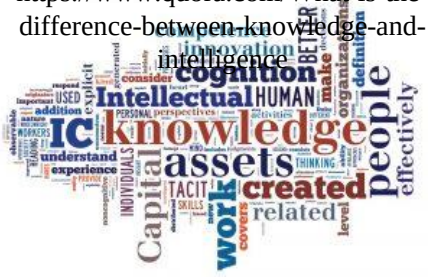
➔➔ Intelligence (Learning & Inference)

(Raw) Data ➔ Information ➔ Knowledge

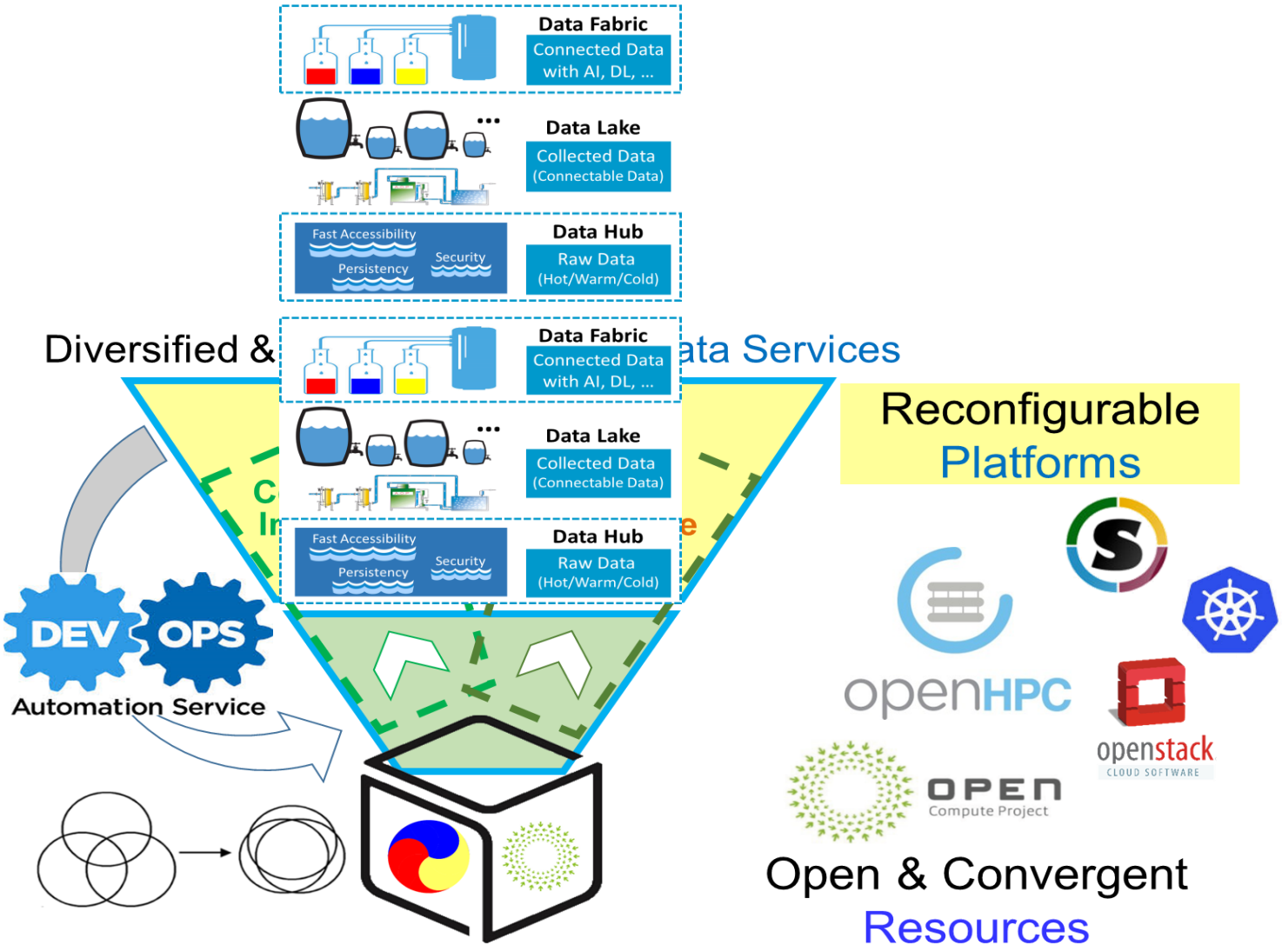
https://activerain.com/blogsview/4931027/unforgettable-that-s-what-we-are---



https://www.quora.com/What-is-the-difference-between-knowledge-and-intelligence



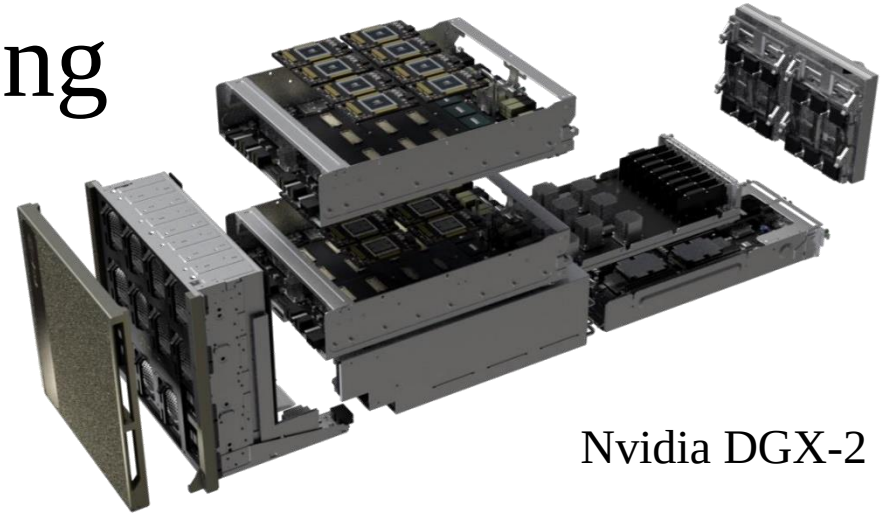
Configurable Clustering for AI-inspired HPC/BigData (HPDA)



Cluster for AI Computing

HPC + HPDA (BigData)

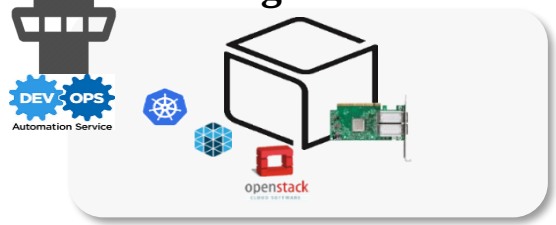
➔ AI (ML/DL)



Nvidia DGX-2

https://www.anandtech.com/show/12587/nvidias-dgx2-sixteen-v100-gpus-30-tb-of-nvme-only-400k

Intelligence Center



Multi-node AI Computing Cluster with Optimized DL Tools

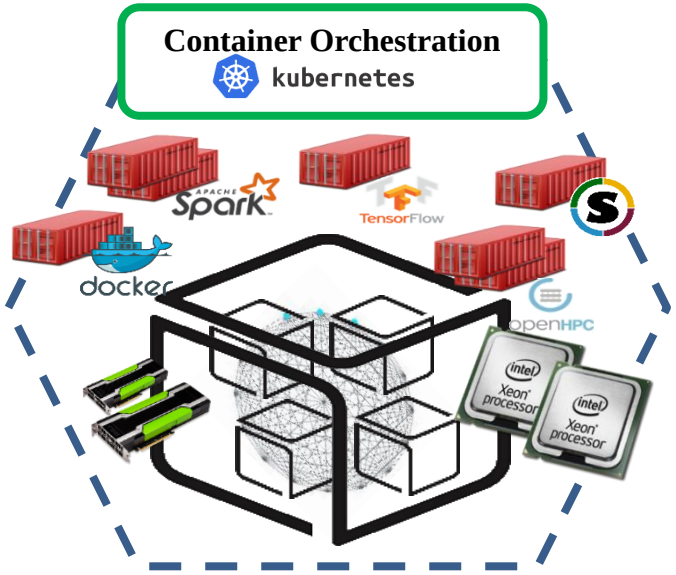
GPU Acceleration

GPU Cards

NVIDIA

Container Orchestration

kubernetes



Cloud Storage Cluster

Parallel File System

NVMe SSDs

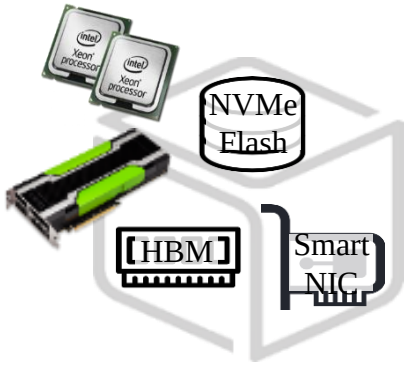
BeeGFS
developed by Fraunhofer

Cloud Storage

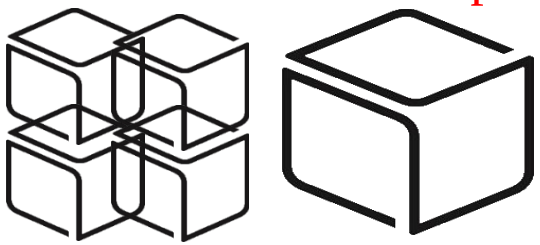
Smart NICs

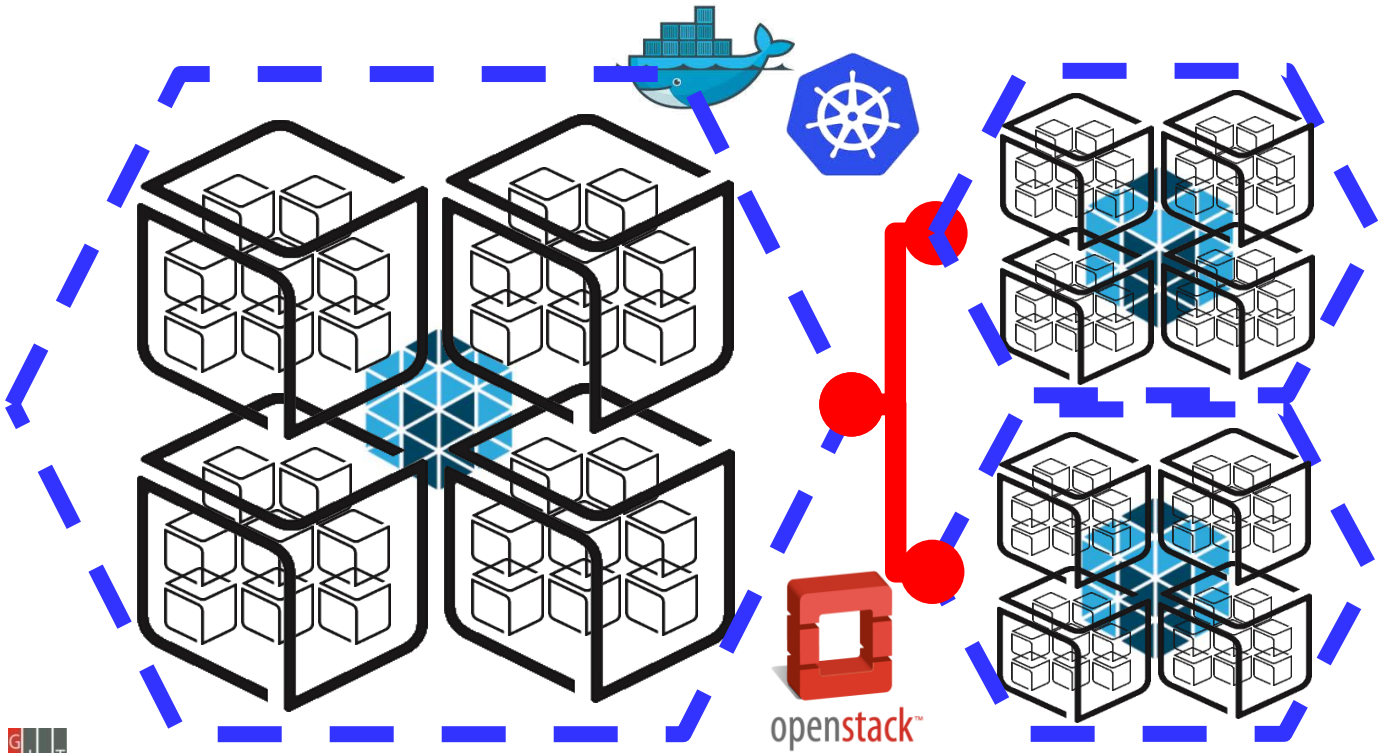
ceph

Computer System: Resource Scaling/Pooling with Clustering



Scale Out Scale Up





HPC +
HPDA (BigData)

➔ AI (ML/DL)

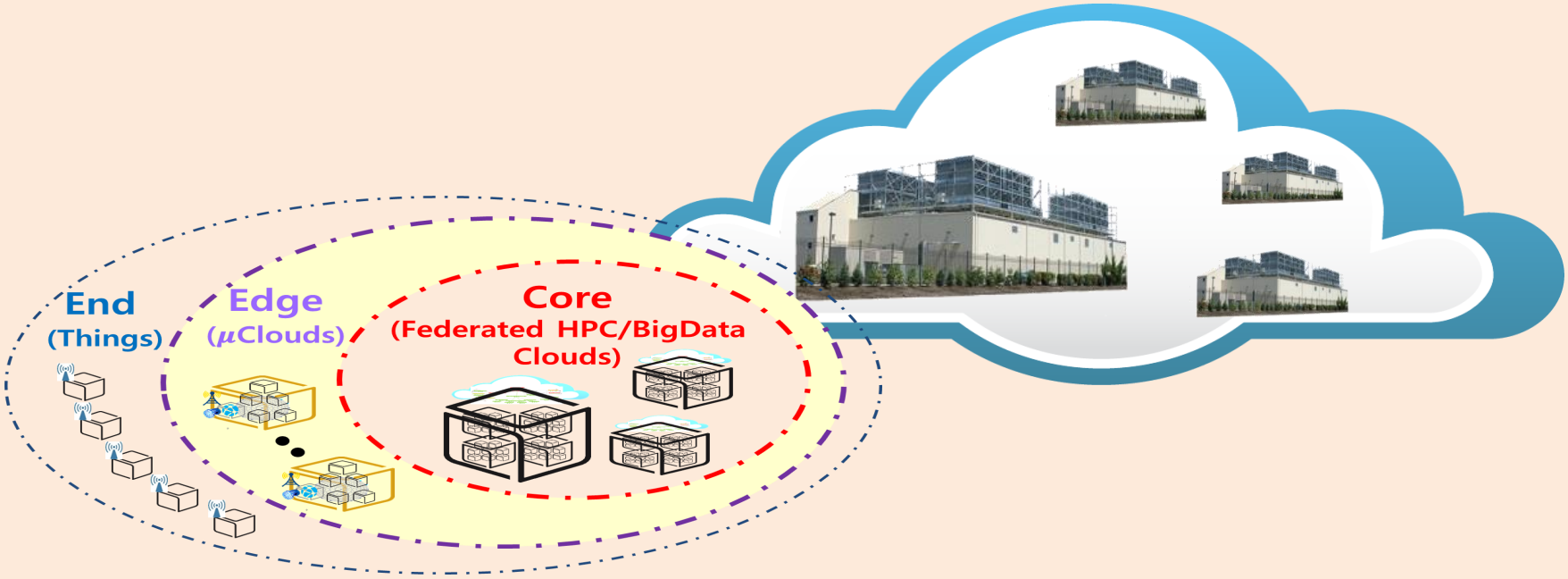
Gwangju Institute of
Science & Technology

Thank you!

Send Inquiry to jongwon@gist.ac.kr

http://nm.gist.ac.kr

Chapter 6: Computer Systems for Cloud Data Center and SDI



SDI (Software-Defined Infrastructure)

Chapter Keywords

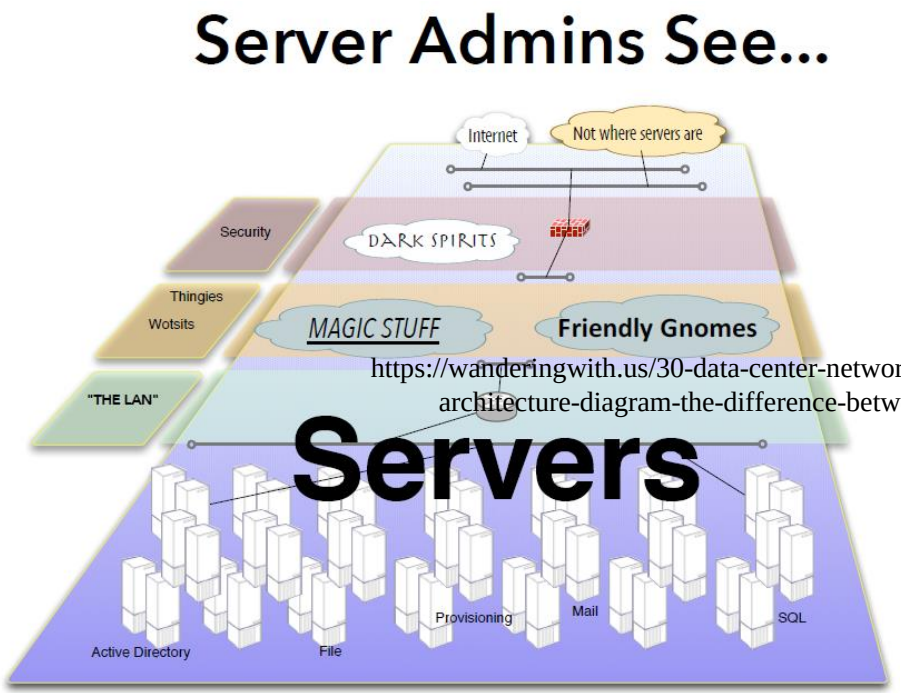
Data Center Networking

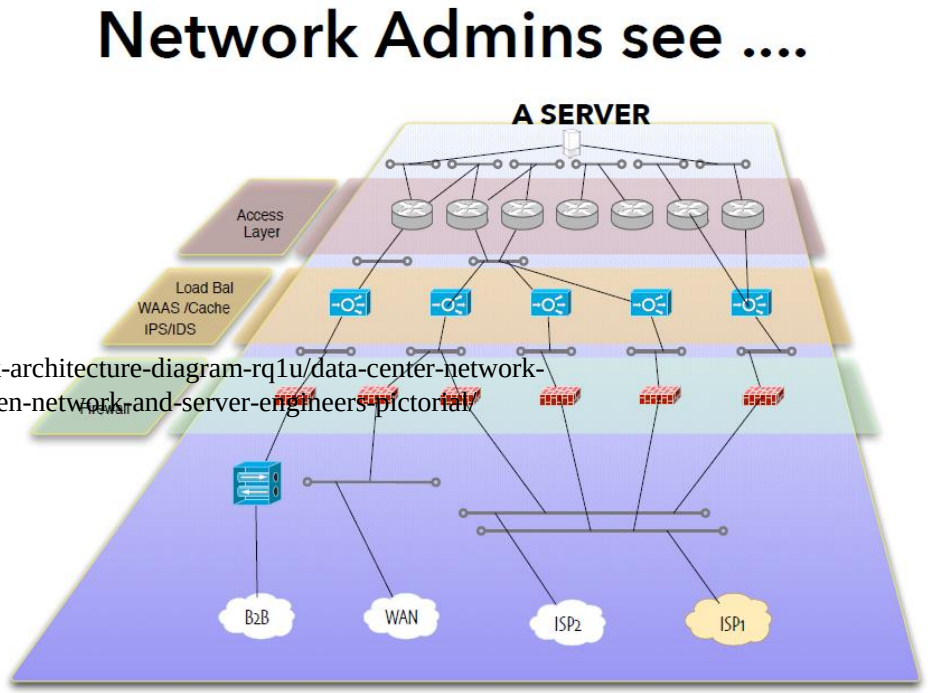
Data Center as a Big Computer

Cloud Computing

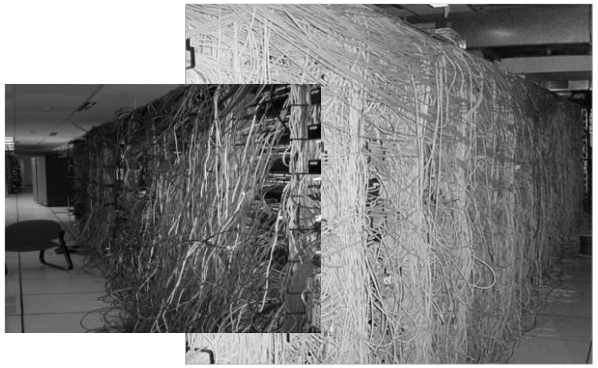
Software-Defined Infrastructure

Data Center: Separated Operation for Compute (Servers) and Networking





https://wanderingwith.us/30-data-center-network-architecture-diagram-rq1u/data-center-network-architecture-diagram-the-difference-between-network-and-server-engineers-pictorial/



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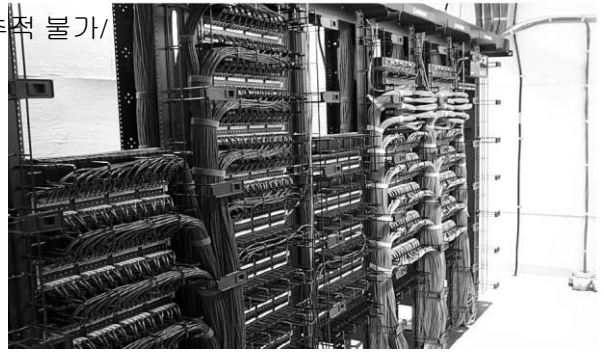
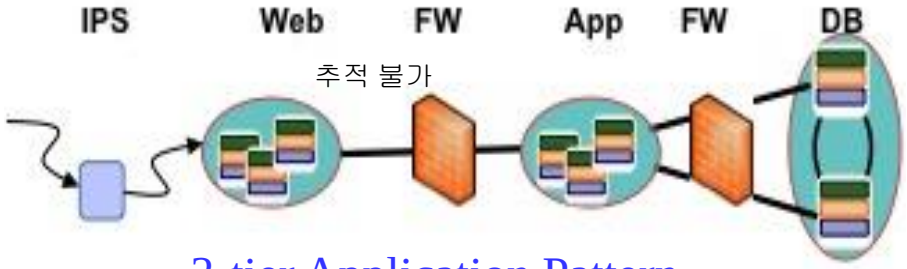
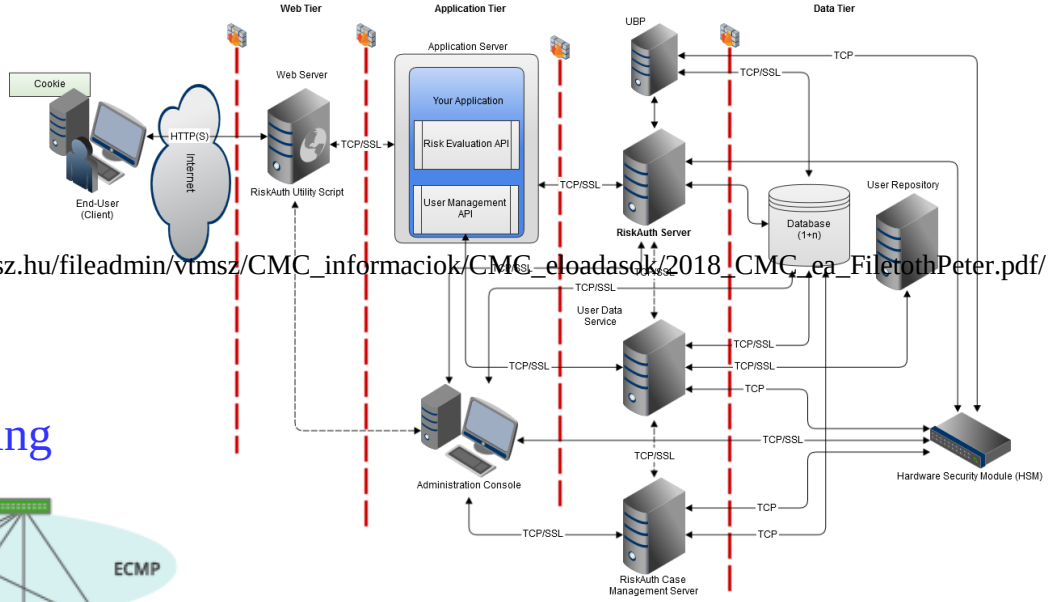


Ethereal Mind

Data Center 3-Tier Application Pattern & Networking

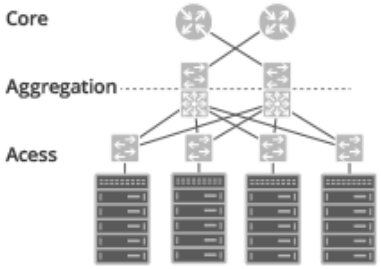


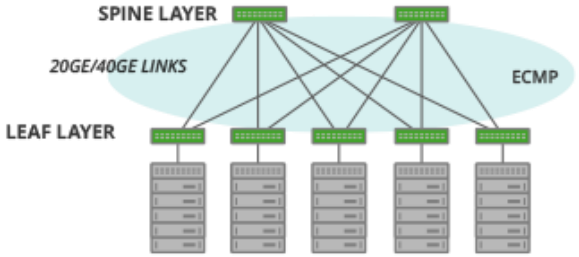
3-tier Application Pattern



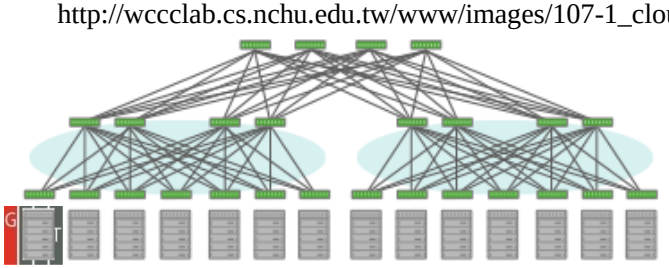
http://vtmsz.hu/fileadmin/vtmsz/CMC_informaciok/CMC_eloadasok/2018_CMC_ea_FiletothPeter.pdf/

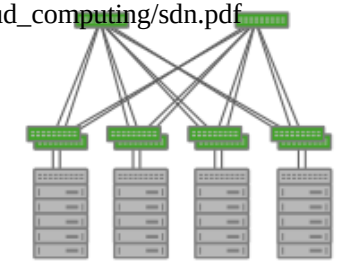
Multiple options for Data Center Networking

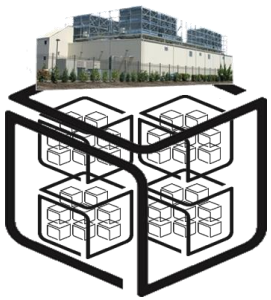




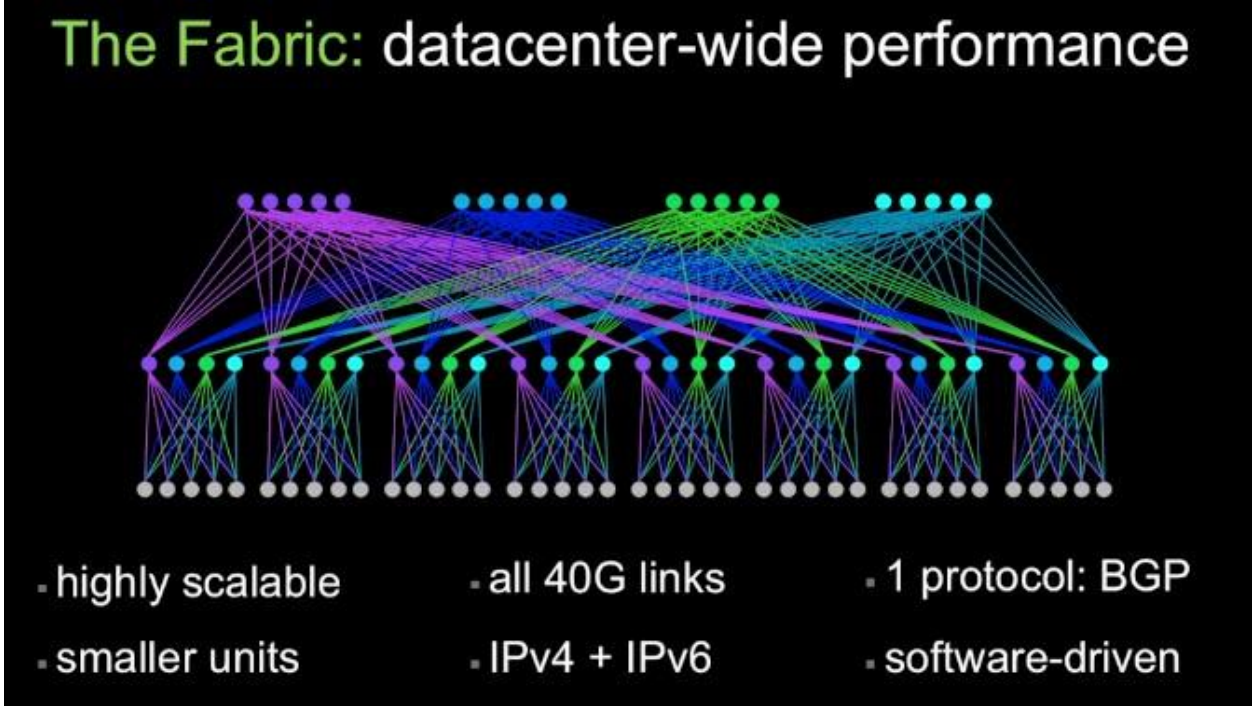
http://wccclab.cs.nchu.edu.tw/www/images/107-1_cloud_computing/sdn.pdf





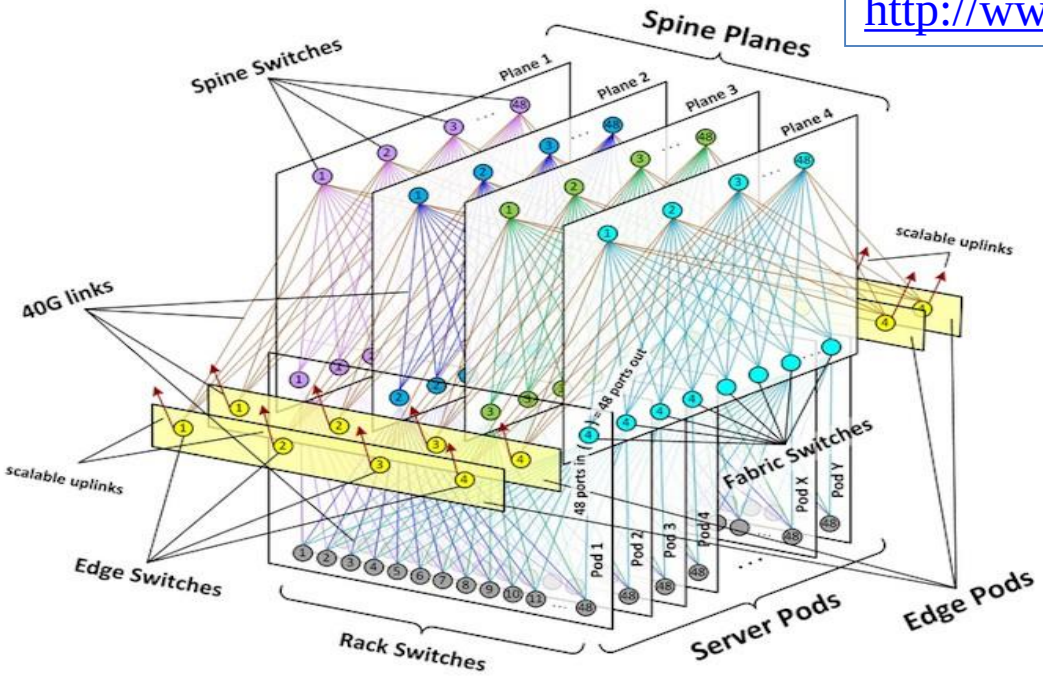


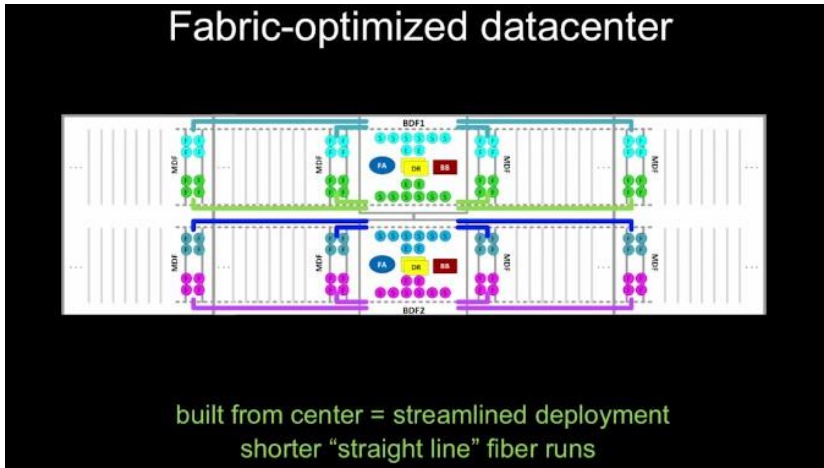
Data Center Networking: Facebook Fabric

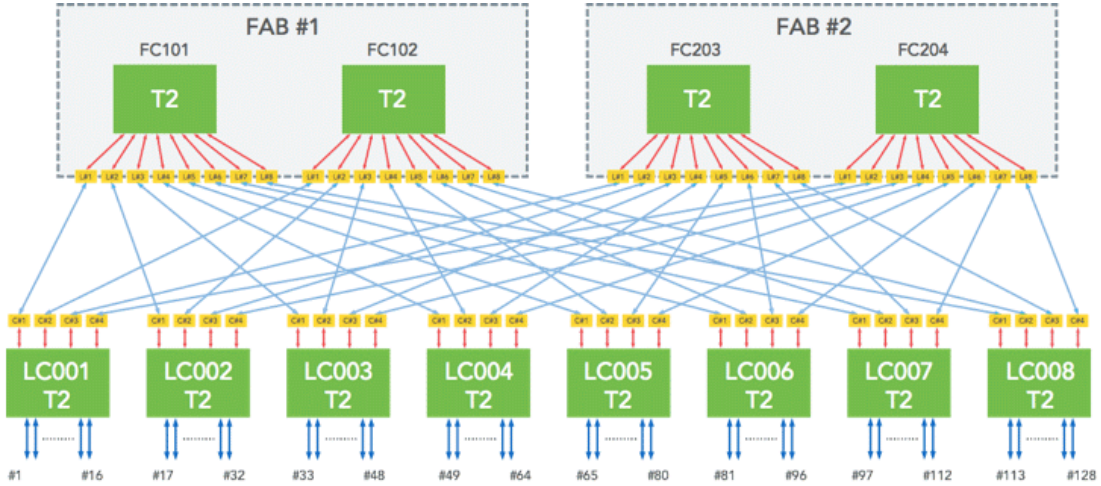


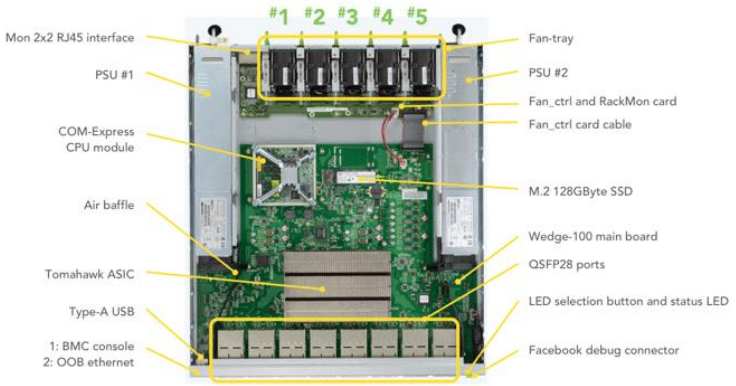
OPEN Compute Project

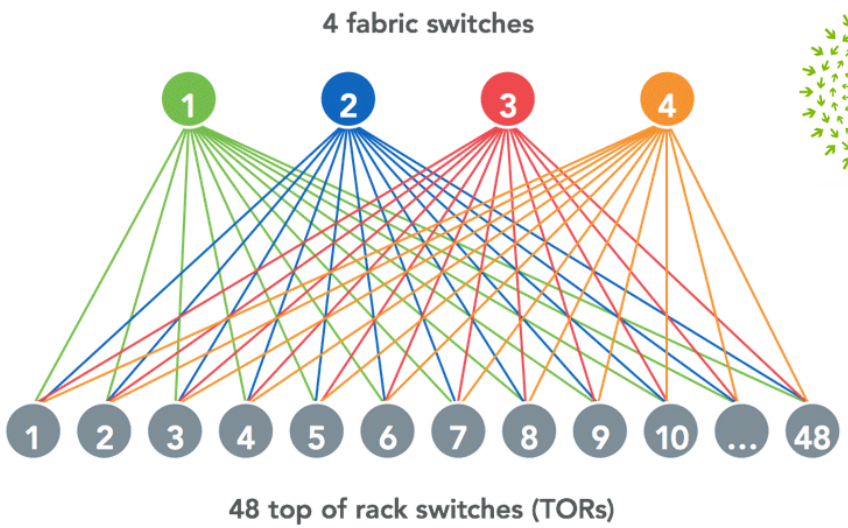
http://www.youtube.com/watch?v=mLEawo6OzFM

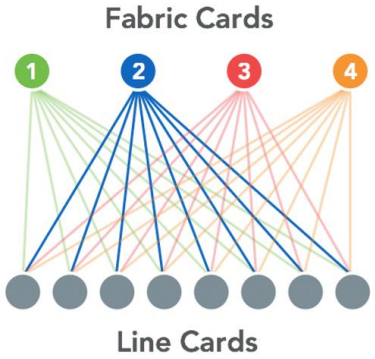


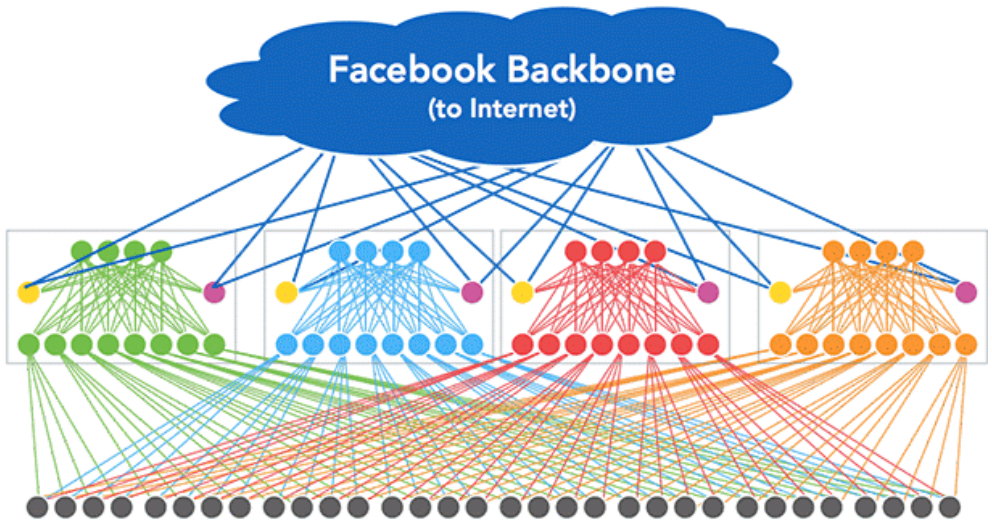










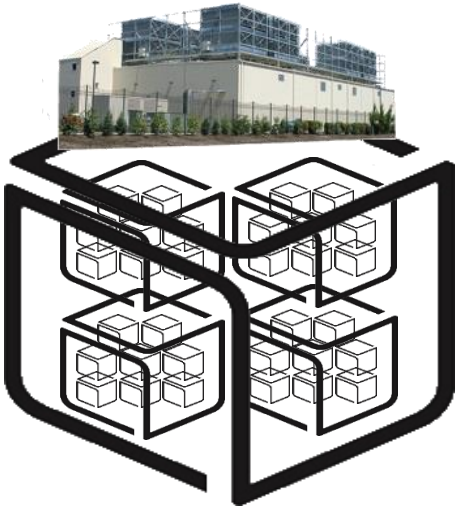


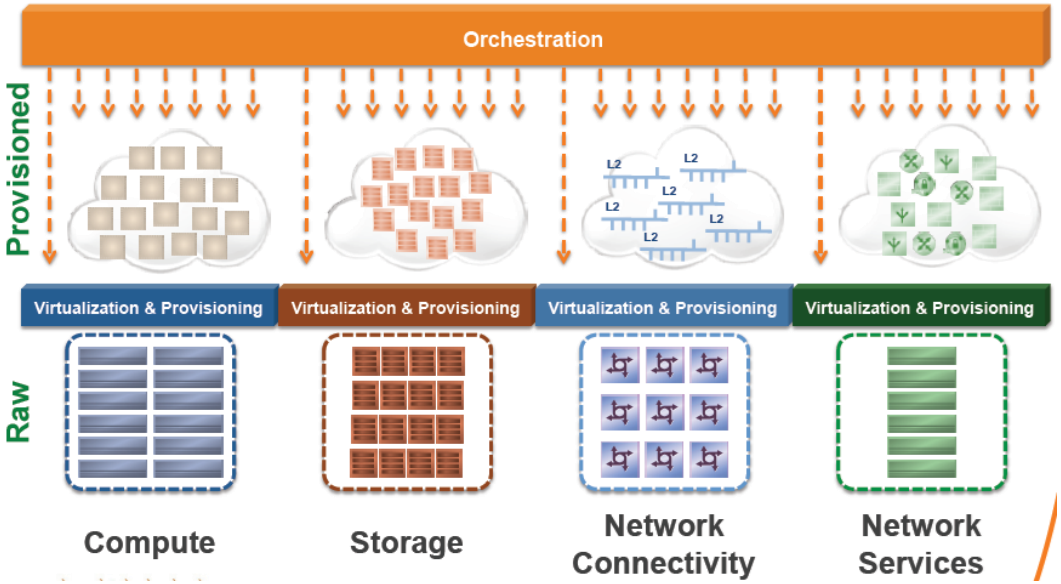
Data Center Networking: Facebook (Cont.)

https://code.fb.com/data-center-engineering/opening-designs-for-6-pack-and-wedge-100/

Software-Defined Data Centers

Unified, Programmable & Virtualized Resources





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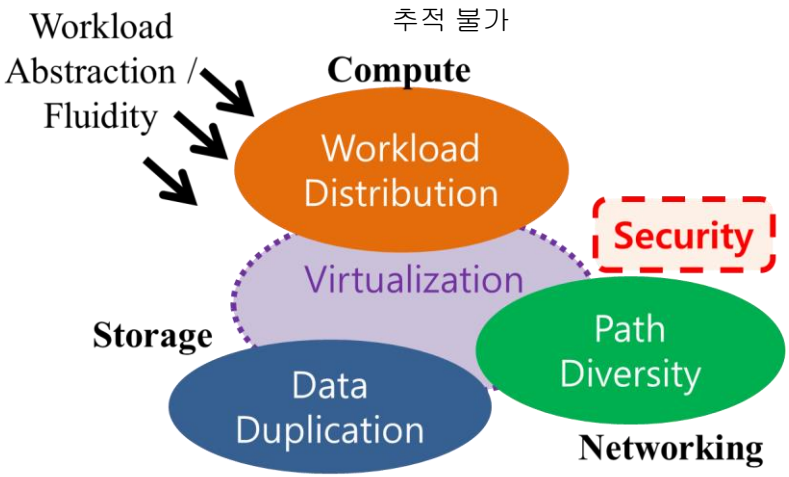
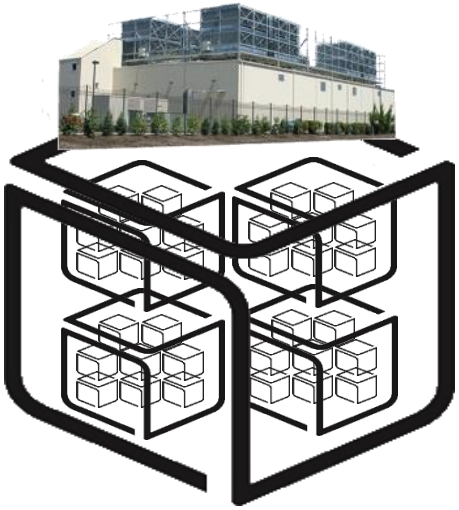
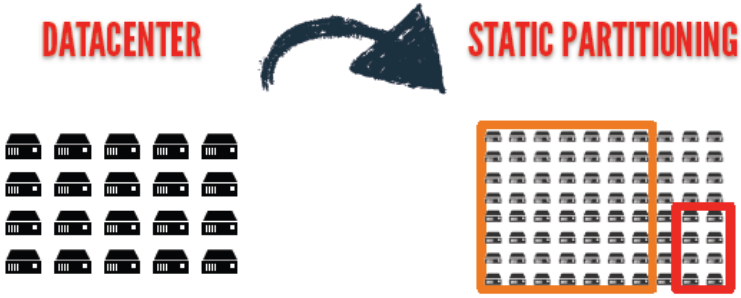


Data Center as a BIG Computer



The Datacenter as a Computer: An Introduction to the Design of Warehouse-Scale Machines

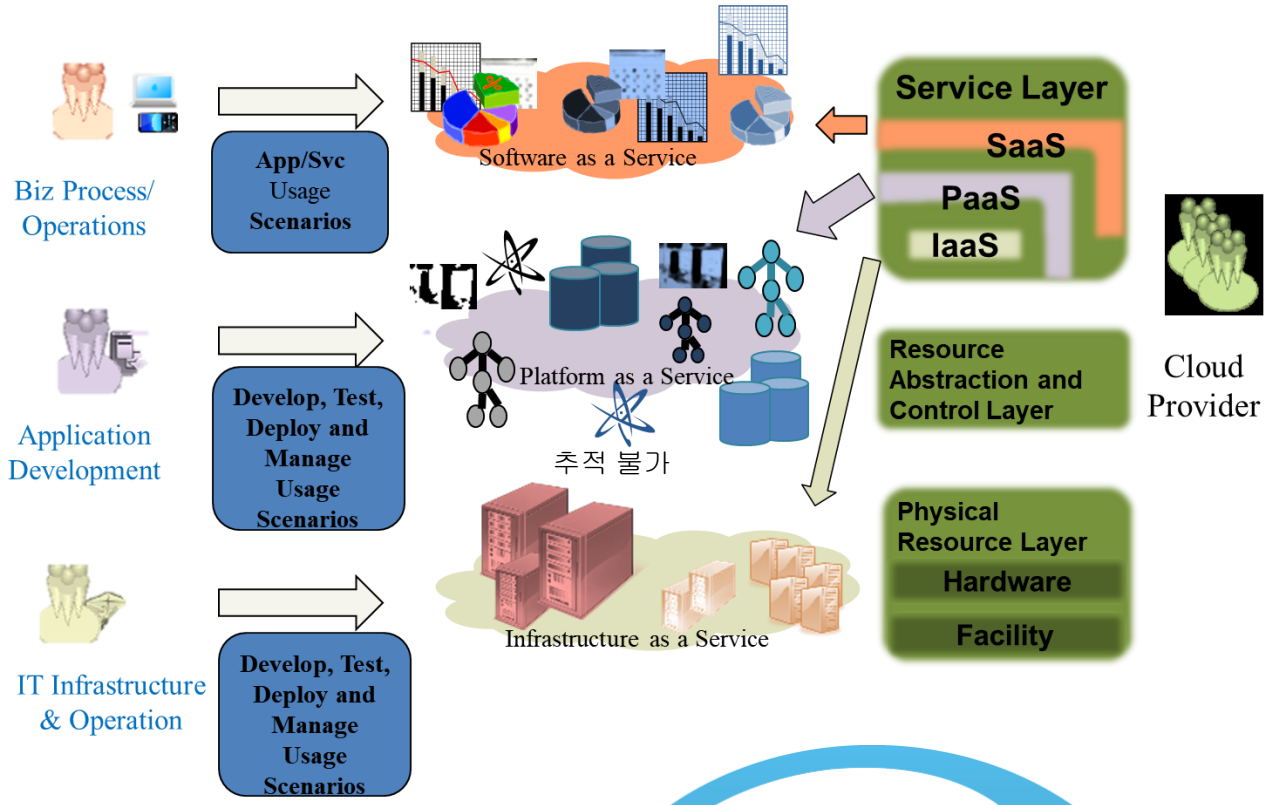
https://www.pinterest.co.uk/pin/386042999278706849/



ps://www.slideshare.net/robdthomas/ibm-big-data-references?next_slideshow=1

Google Omega:
flexible, scalable schedulers for large compute clusters;
Treat a data center like a single machine

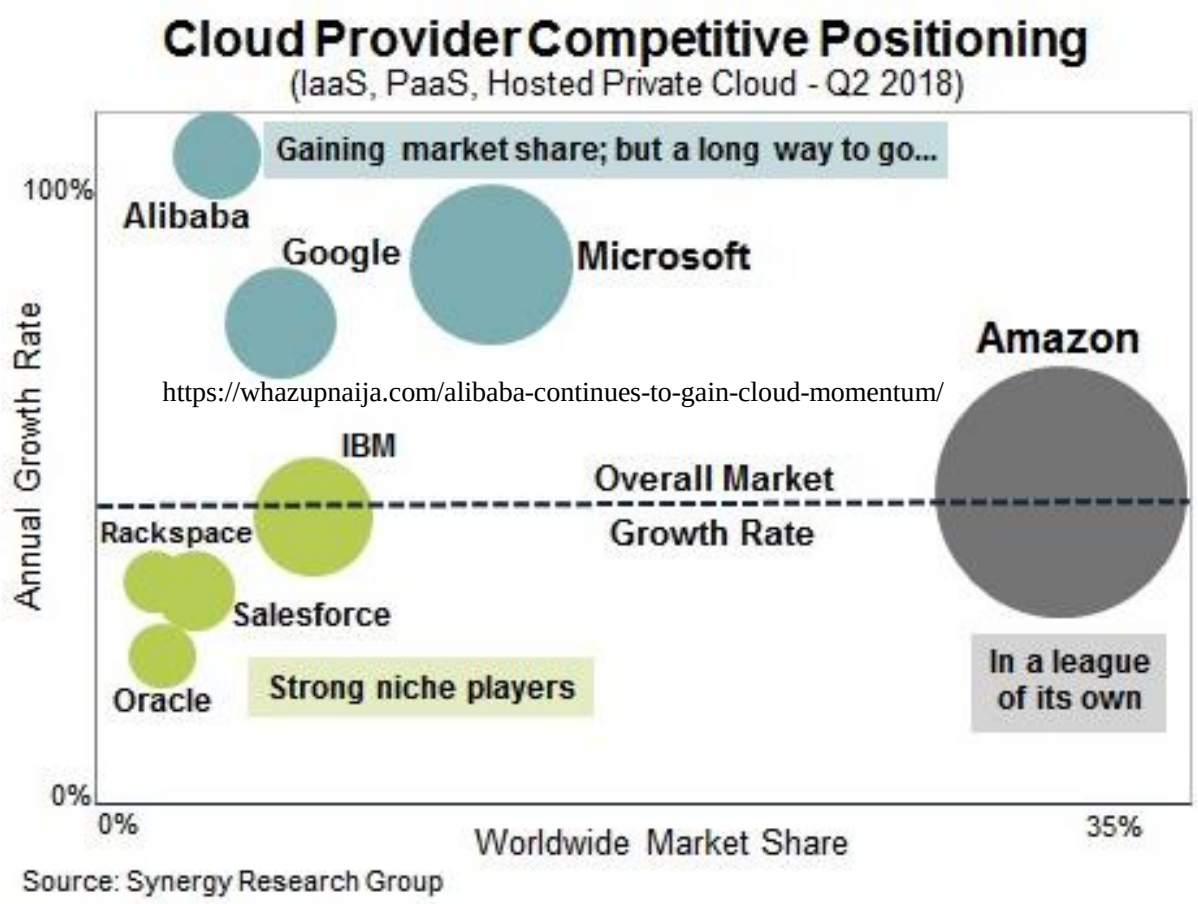
Cloud Computing: Service Orchestration



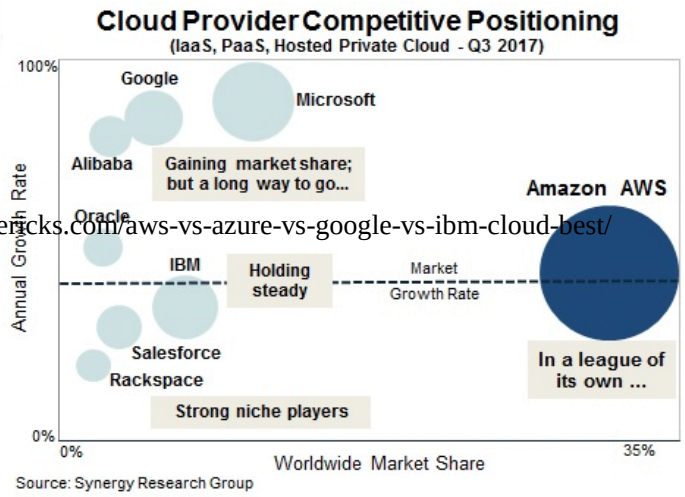
Infrastructure
➔
Platform
➔
Software

Utilization & Energy

Market Capacity: Cloud Providers



https://whazupnaija.com/alibaba-continues-to-gain-cloud-momentum/



https://www.nodericks.com/aws-vs-azure-vs-google-vs-ibm-cloud-best/

Market Capacity: Cloud/IT Infrastructure

https://outpost24.com/blog/7-tips-to-secure-your-hybrid-Cloud

IDC 2018

IDC Cloud Infra IT Spending (Public+Private): 57.2bn 2018

icveal.com/blog/connect2-me-facilitando-iot/

Gartner Public Cloud Revenue 186.4bn / 2018

Gartner Public Cloud Revenue 302.5bn / 2021

Hyper-Converged Product Market 6n Year 2018

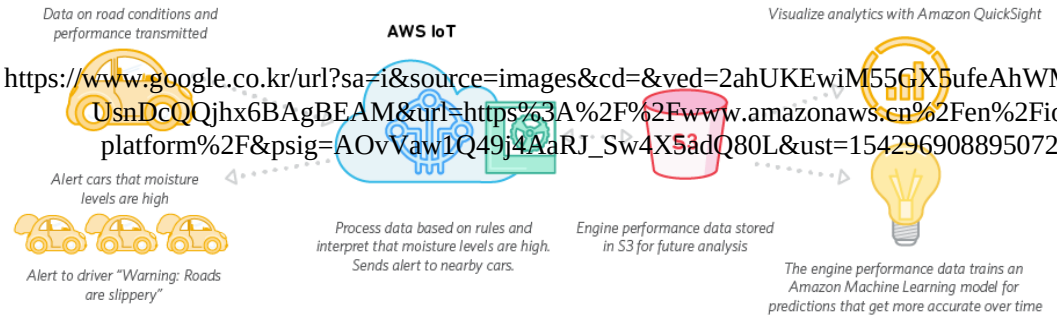
AWS Revenue 25bn Year 2018

DC+Cloud Infra IT Spending 124bn Year 2018

Worldwide IT spending 2.4 Trillion Year 2017 2.65 Trillion Year 2020

IoT/HPC/BigData Services from Hyper-scale Cloud (AWS)

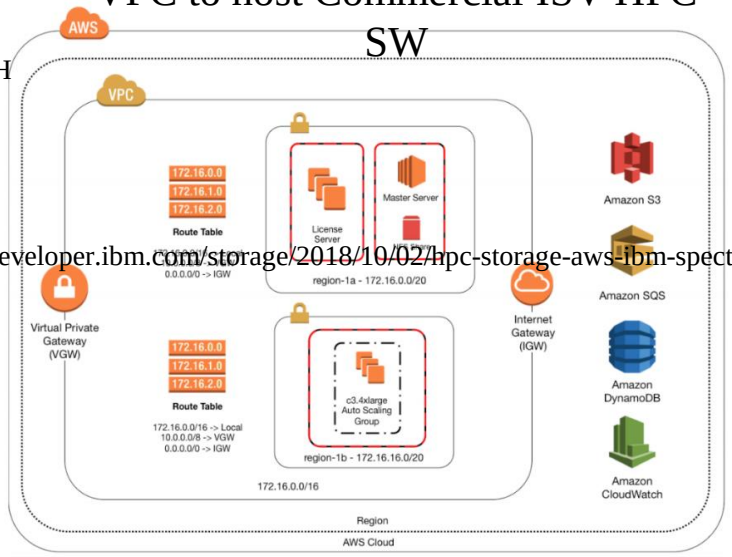
https://www.google.co.kr/url?sa=i&source=images&cd=&ved=2ahUKEwiM55GX5ufeAhWMWrwKHUsnDcQQjhx6BAgBEAM&url=https%3A%2F%2Fwww.amazonaws.cn%2Fen%2Fiot-platform%2F&psig=AOvVaw1Q49j4AaRJ_Sw4X5adQ80L&ust=1542969088950725



AWS-IoT

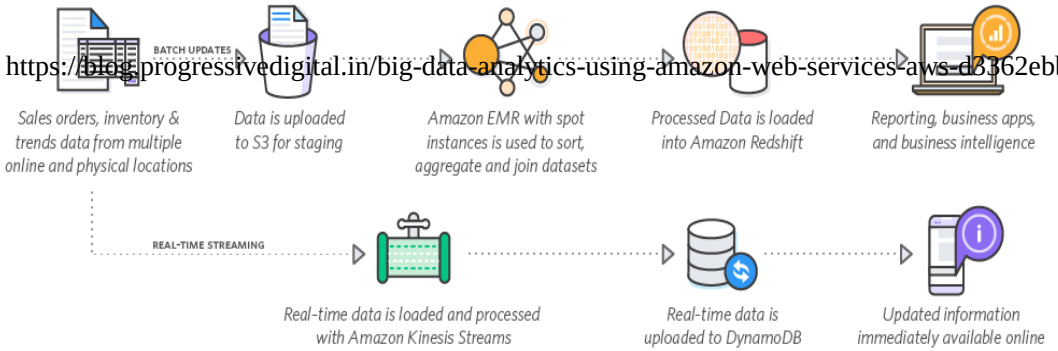
VPC to host Commercial ISV HPC SW

https://developer.ibm.com/storage/2018/10/02/hpc-storage-aws-ibm-spect



AWS-HPC

https://blog.progressivedigital.in/big-data-analytics-using-amazon-web-services-aws-d3362ebbc339



AWS-BigData

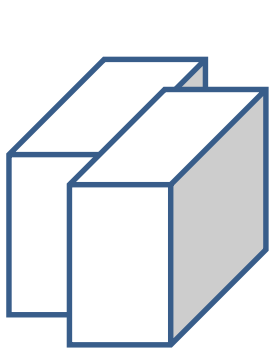
추적 불가

P3 EC2 instance: Nvidia Tesla V100

AWS-DL

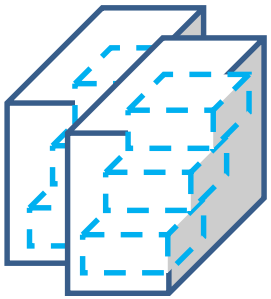
Recap: From Baremetal to Containers / Serverless

Monolithic Apps N-tier Apps Micro-services Nano-services



Baremetal Boxes

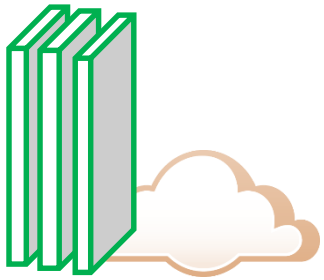
Cloud (VMs, BM, …)



Virtual Machines

Cloud-native

Serverless (functions)

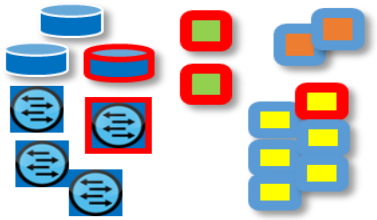


Containers (Docker, Singularity, LXD, …)

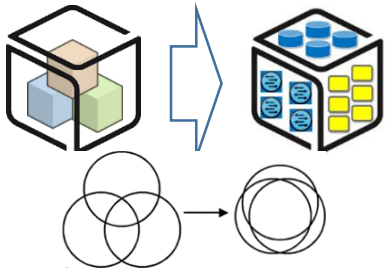
unikernel

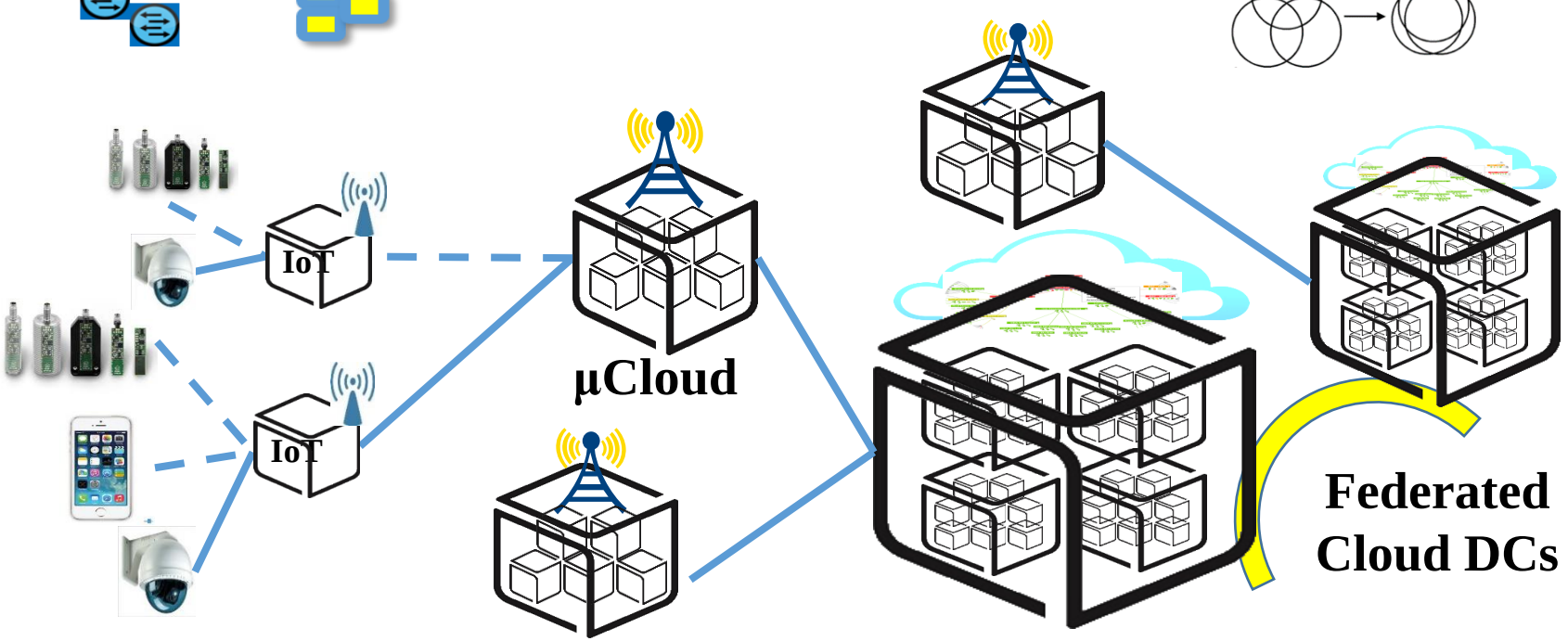
Convergent SDI for Diversified Services

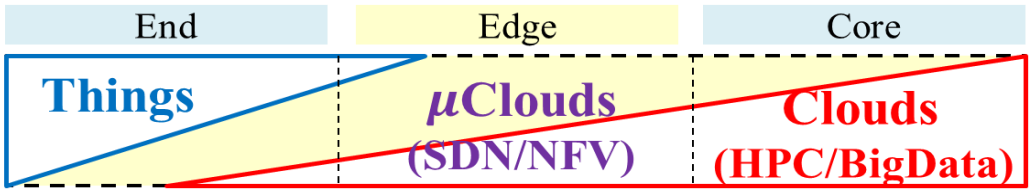
Diversified MicroServices Architecture Applications



Resources in Hyper-Converged Boxes





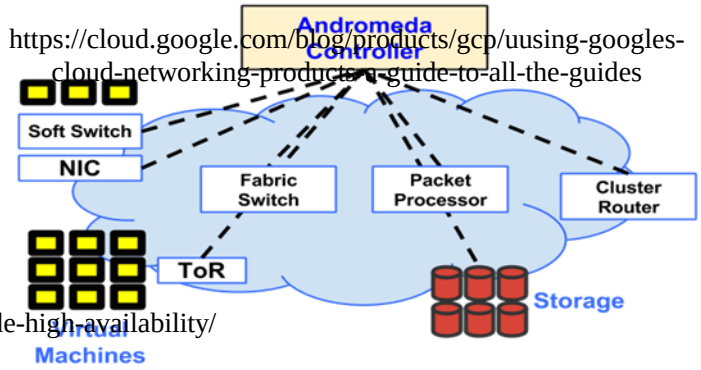


Converged SDI @ Hyper-scale Cloud

https://cloud.google.com/blog/products/gcp/uusing-googles-cloud-networking-products-a-guide-to-all-the-guides

https://www.oss.kr/oss_case/show/c2daddca-7bb9-4227-837c-98108f180a89

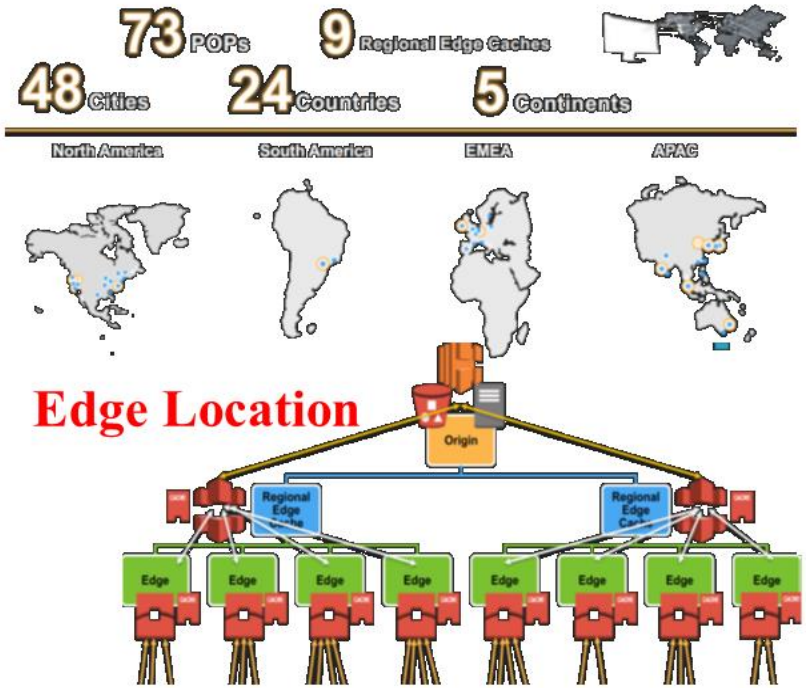
https://www.capside.com/labs/amazon-s3-outage-provide-high-availability/



Andromeda SDN/NFV

Regions

amazon web services

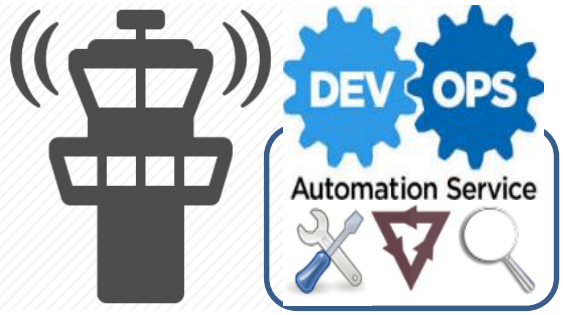


B4 Global SD-WAN

5G-leveraged Converged SDI

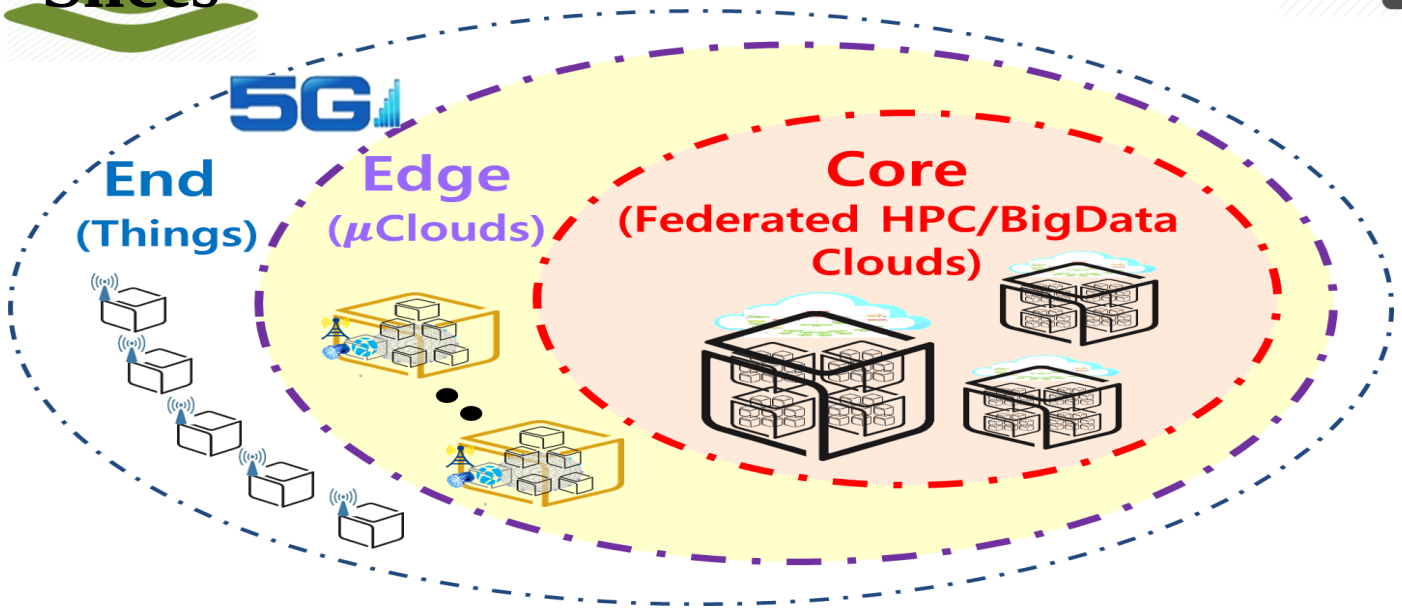
(SDN/NFV/Cloud Integrated)

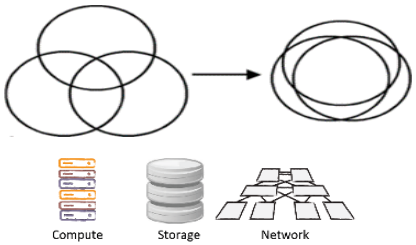
DevOps Tower



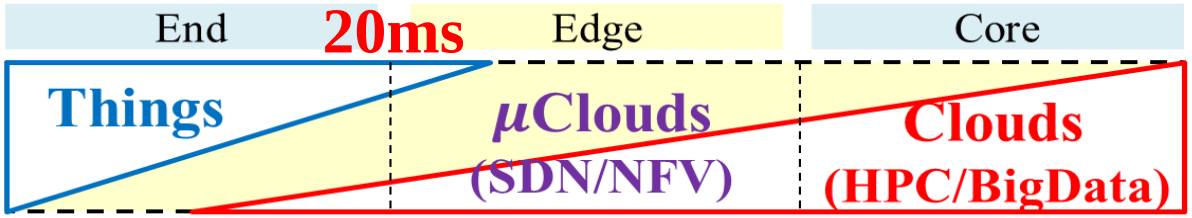
CLOUD NATIVE COMPUTING FOUNDATION

Slices





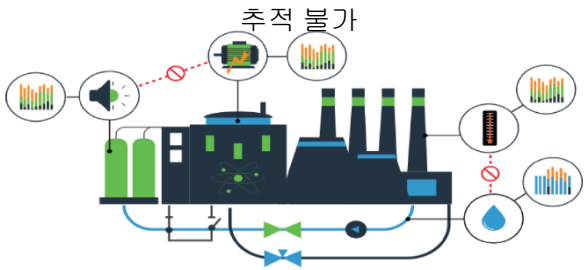
Hyper-Converged

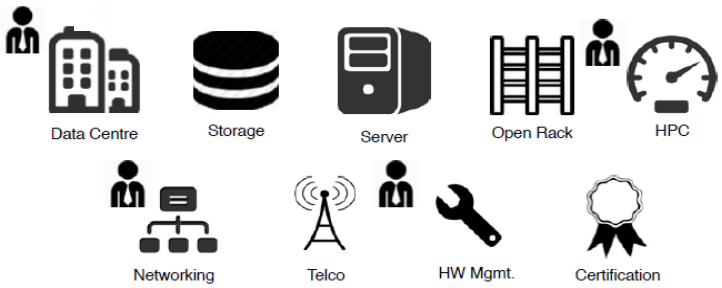


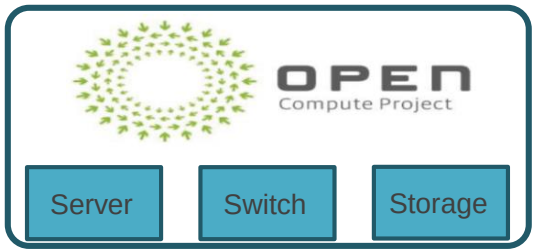
LINUX FOUNDATION

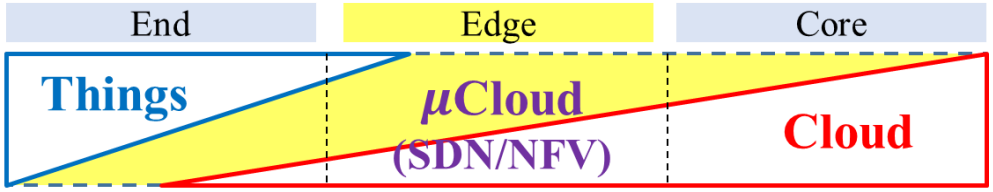
Open-Source Software/Hardware for Converged SDI

http://www.apnoms.org/2017/apnoms2017/ppt/tutorial4.pdf



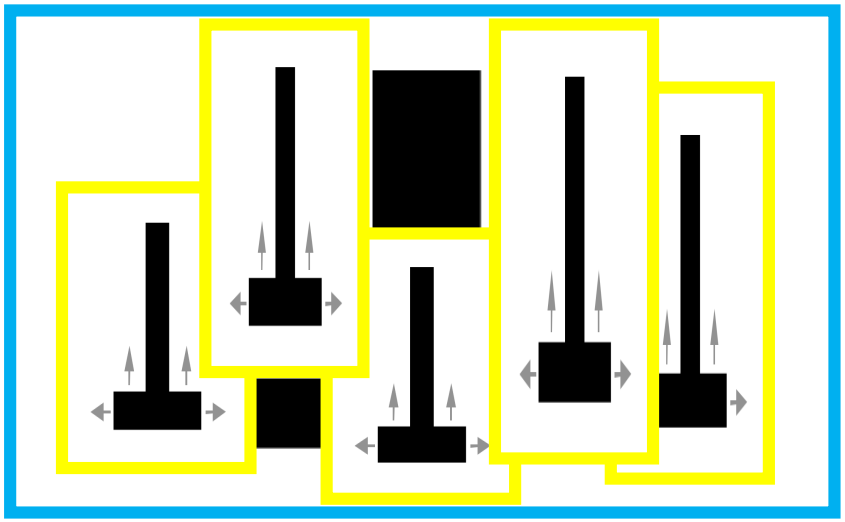


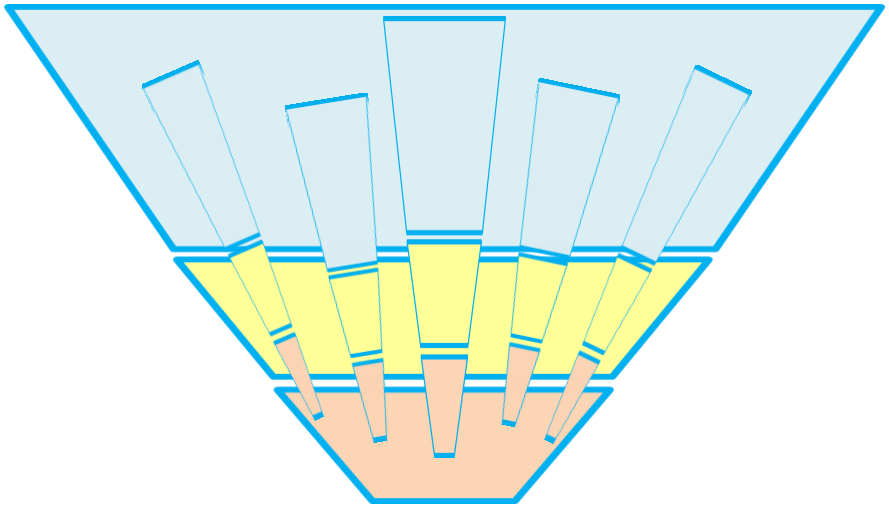


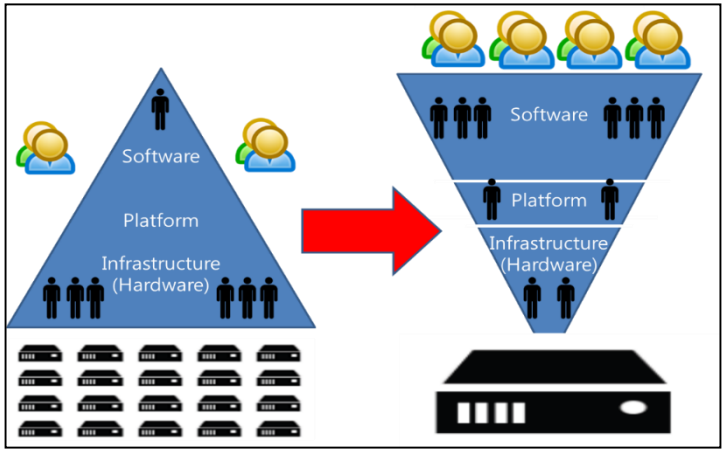


Infrastructure vs Platform vs Services

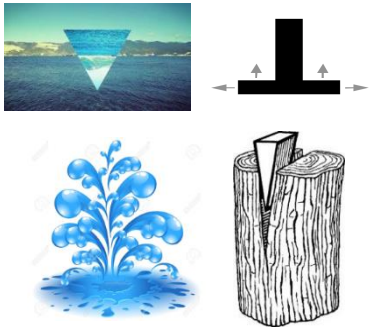
Toward Razor-thin Platform that becomes "Composable"

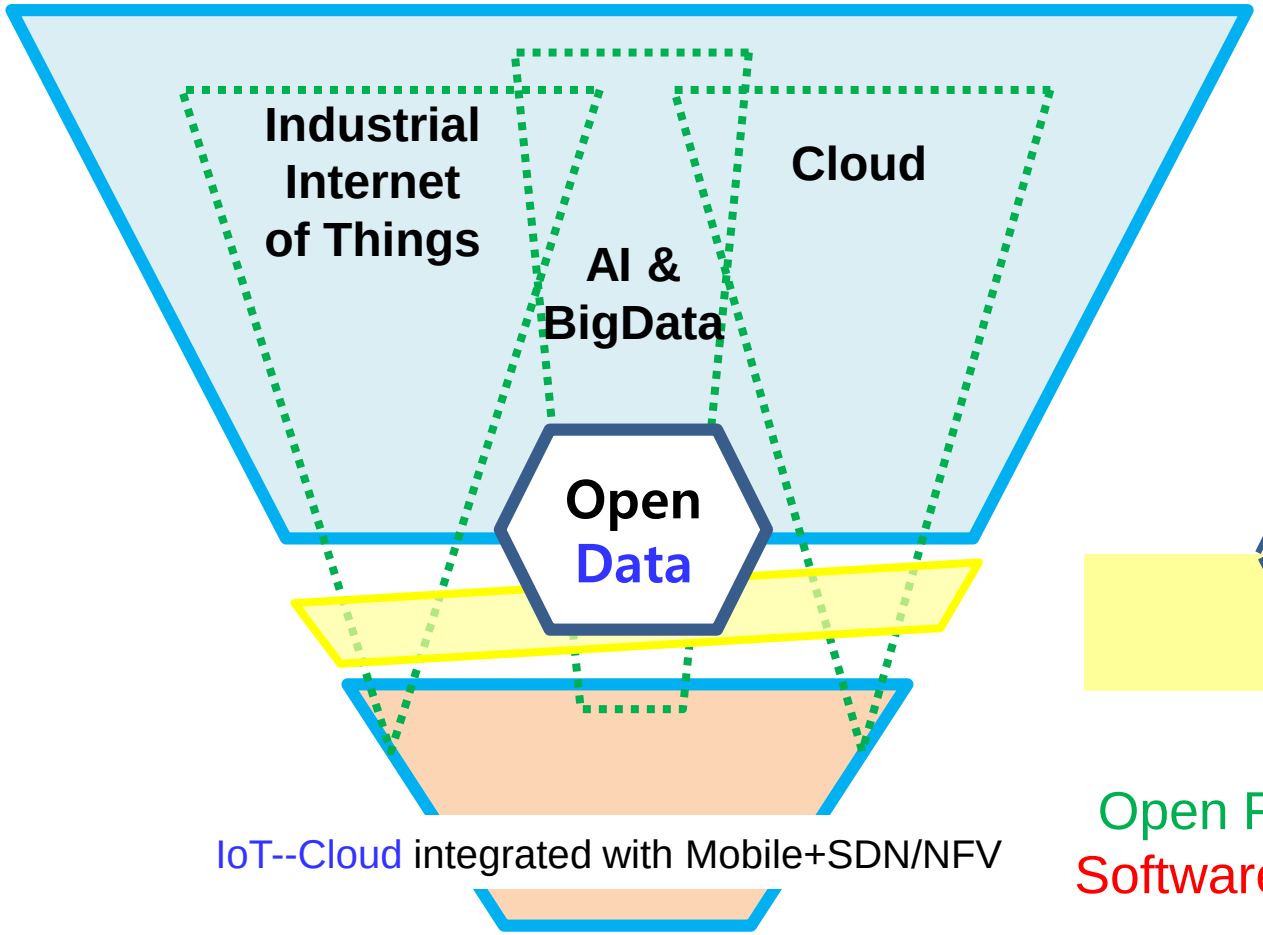






Diversified Services over Software-Defined Infrastructure





Container-leveraged
Software as a Service

Open APIs
Open Platforms (Tools)

Open Federated, Composable
Software-Defined Infrastructure
(Resources)

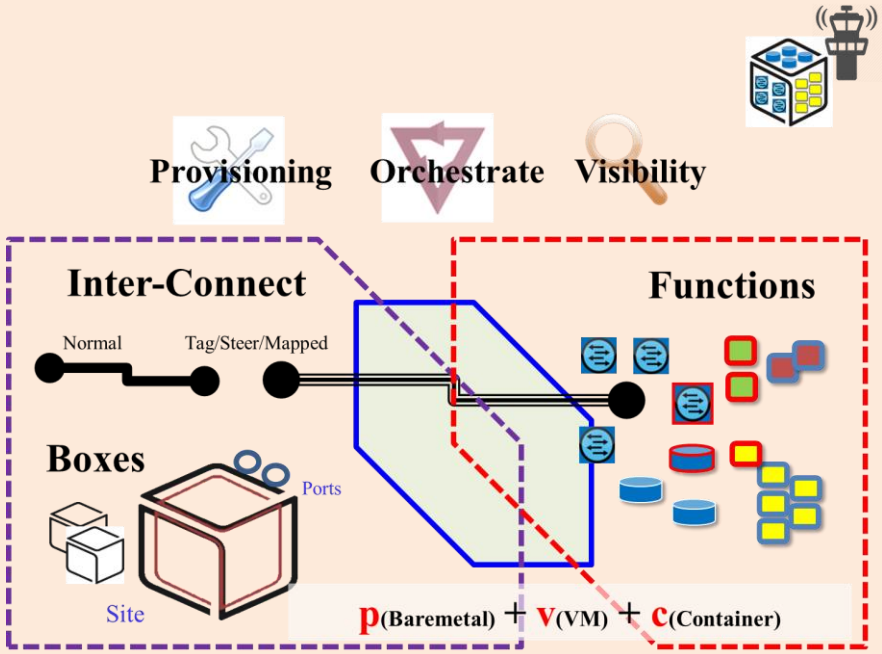
Gwangju Institute of
Science & Technology

Thank you!

Send Inquiry to jongwon@gist.ac.kr

http://nm.gist.ac.kr

Chapter 7: Computer System SmartX Abstraction



Chapter Keywords

Inter-Connect

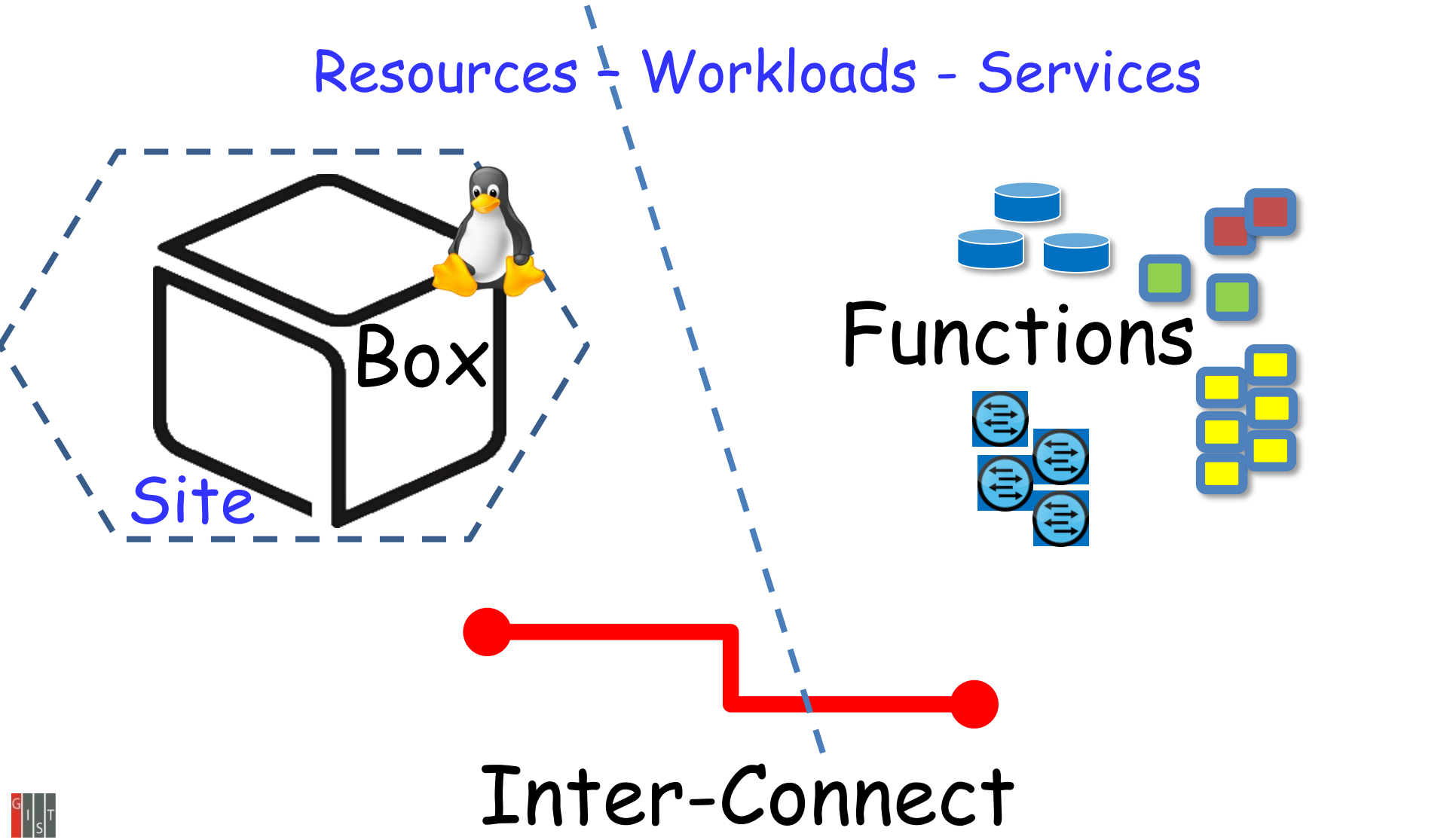
Box

Functions

SmartX Automation

SmartX Playground

Computer System: Inter-Connected Functions inside/across Boxes/Sites



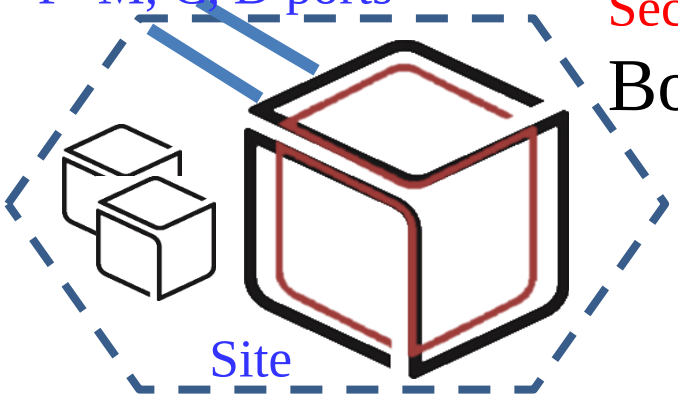
Computer System: Inter-Connected Functions inside/across Boxes/Sites

Configuration

Control

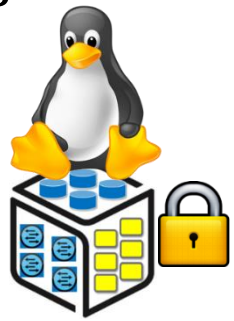
Visibility

P+M, C, D ports



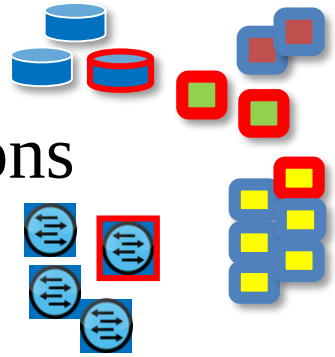
Secured

Boxes

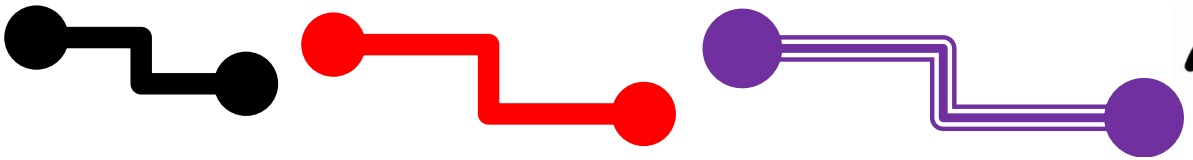


Secured BM/Container/VM Functions

Functions



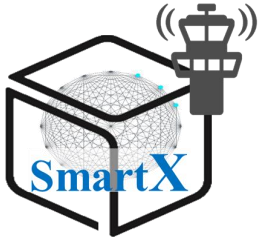
Inter-Connect



Discover & Connect

Normal → Secured → Tag/Steer/Mapped

Computer System: Inter-Connected Functions inside/across Boxes/Sites



Provisioning

Orchestrate

Visibility

Inter-Connect

Normal

Tag/Steer/Mapped

Functions

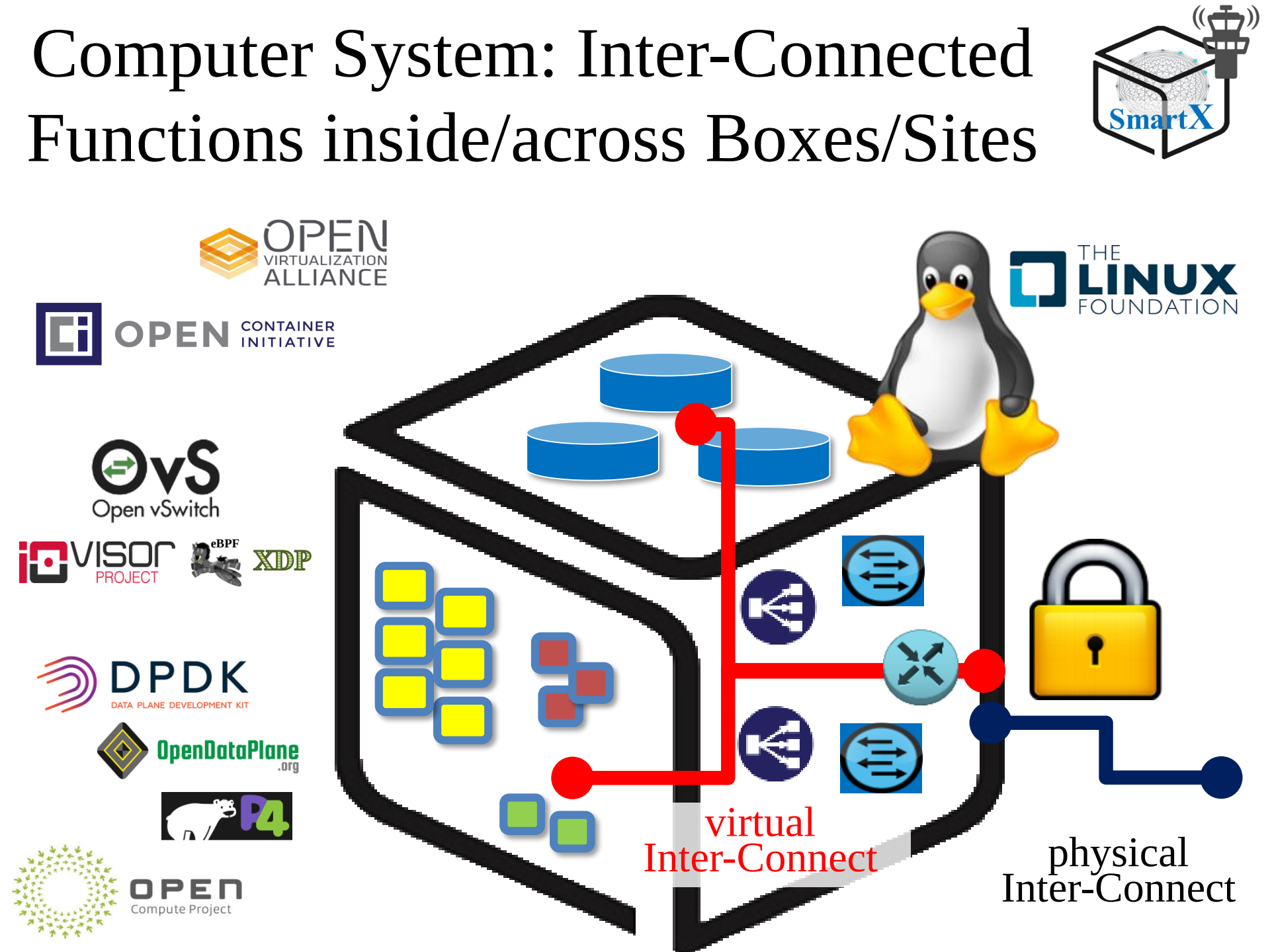
Boxes

Ports

Site

p(Baremetal) + **V**(VM) + **C**(Container)

Computer System: Inter-Connected Functions inside/across Boxes/Sites

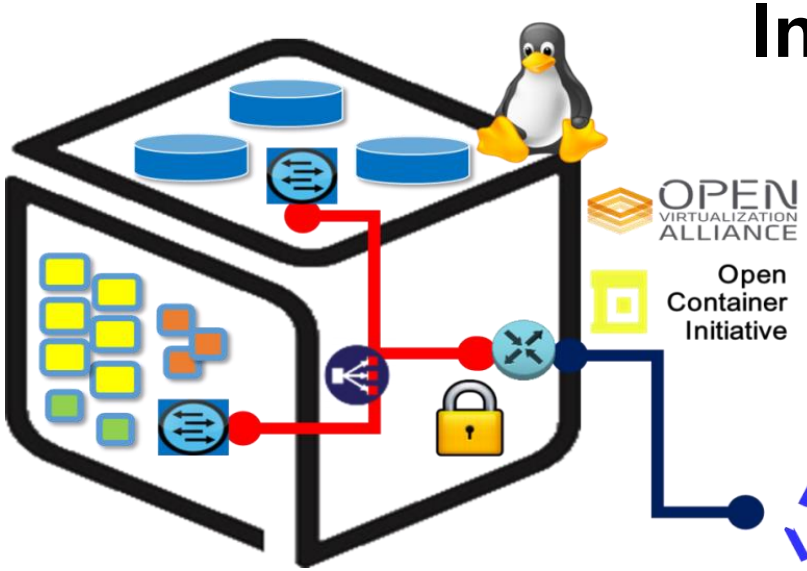


Computer System: Inter-Connected Functions inside/across Boxes/Sites

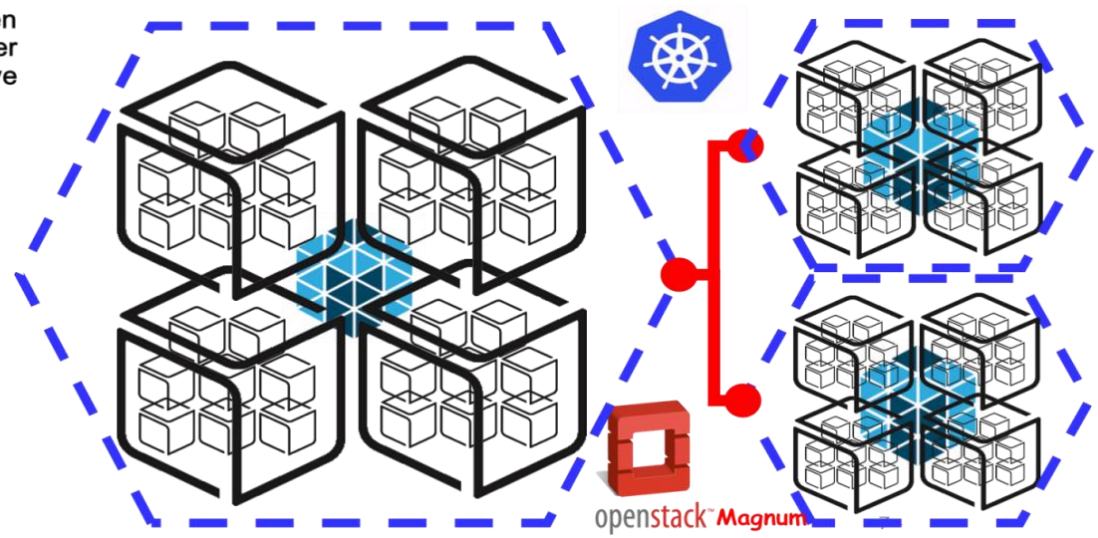
p+v+c Harmonization Challenge:

p(Baremetal) + v(VM) + c(Container)

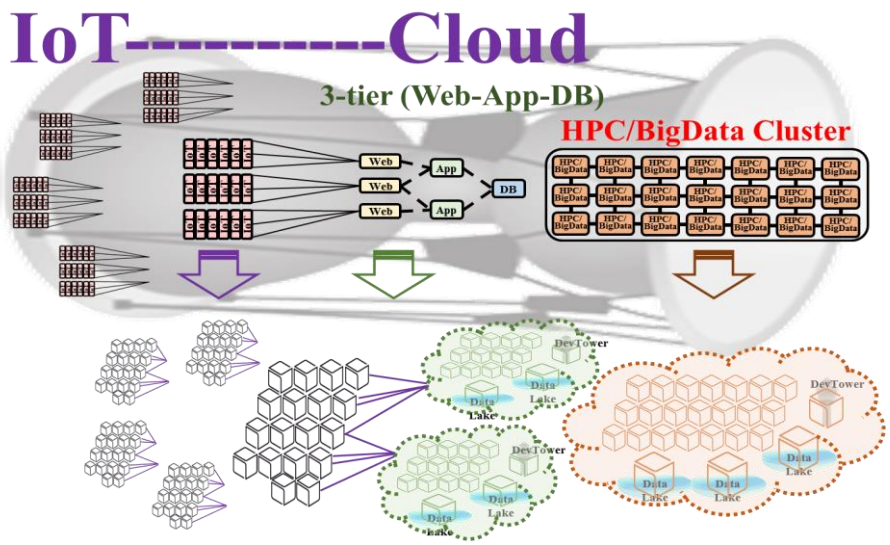
Inside a Box



Across Clusters



SmartX IoT-Cloud Services with Micoservices-based SaaS Applications



p(Baremetal)
+ c(Container)
+ v(VM)

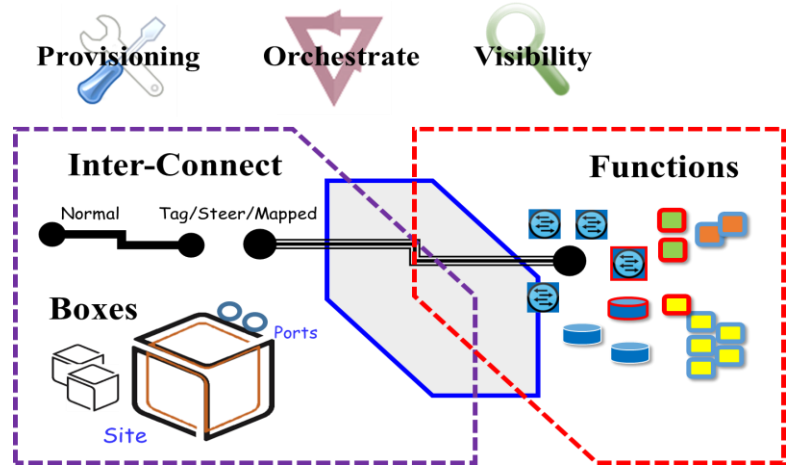
Process containers

application containers

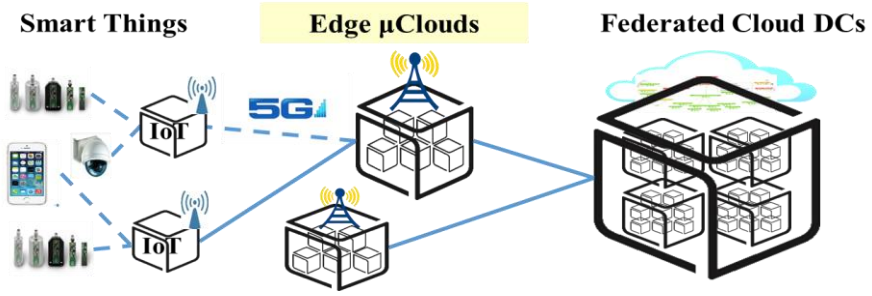
(Monster containers)

Machine containers

VM hypervisors

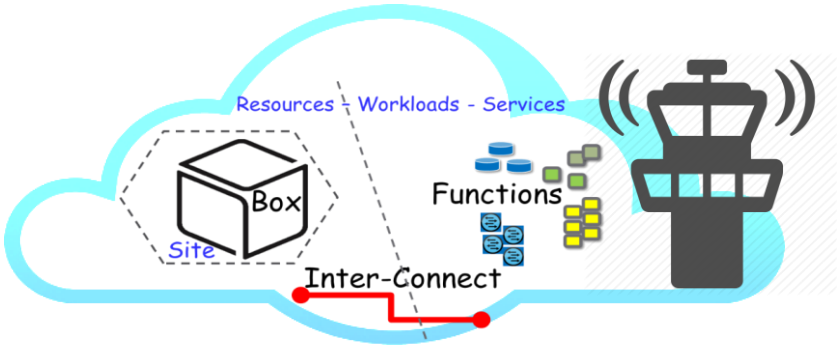


Realize SmartX Services with Open APIs enabled by SmartX Boxes

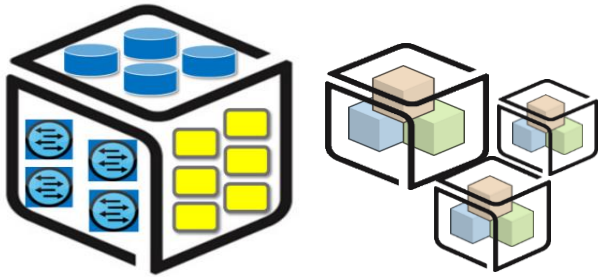


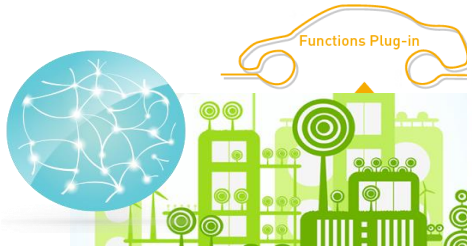
Open Platform: Prepare **Open APIs** by Placing and Tuning Inter-connected Functions

Software-Defined Infrastructure: Build Programmable & Virtualized Resource Pools with Hyper-converged **SmartX Boxes**

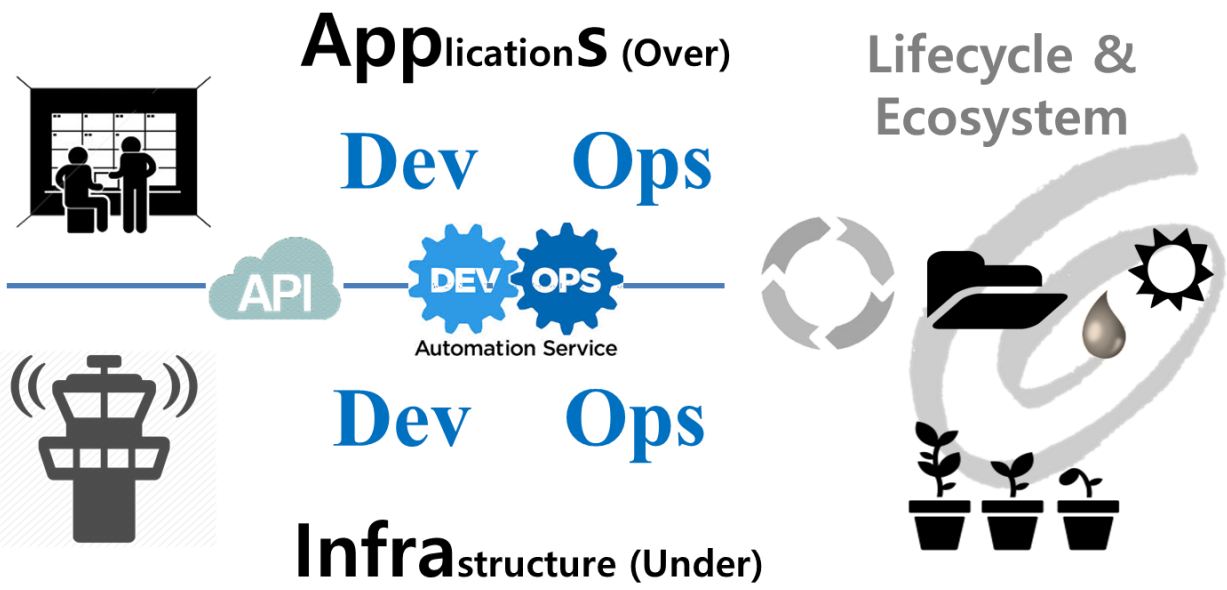


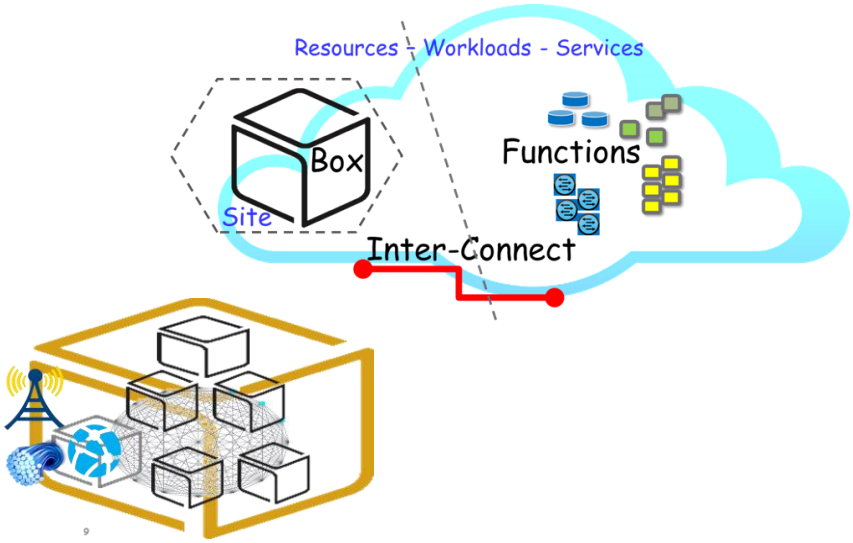
User-Defined Services: Create and Orchestrate Smart IoT-Cloud Services with Domain-specific **Open Data**

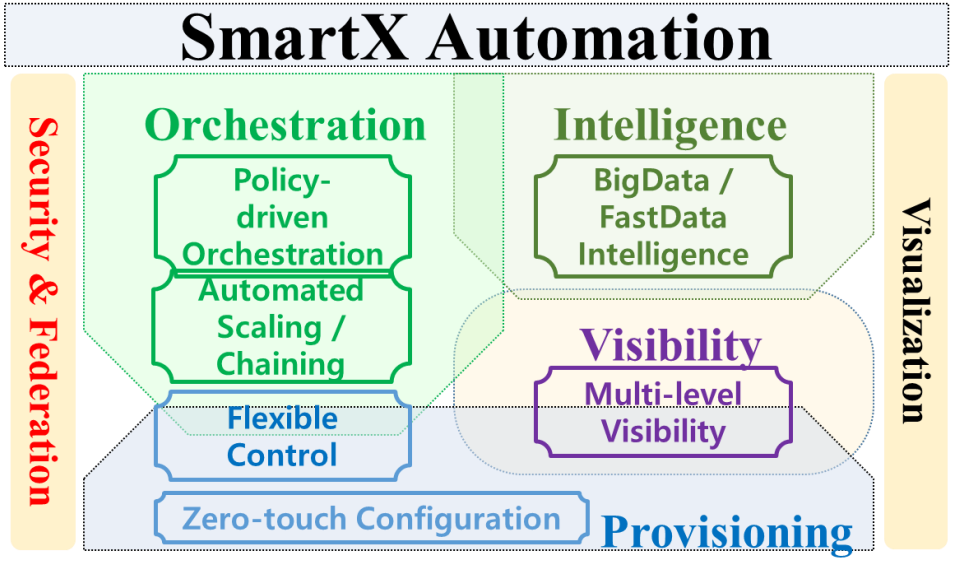




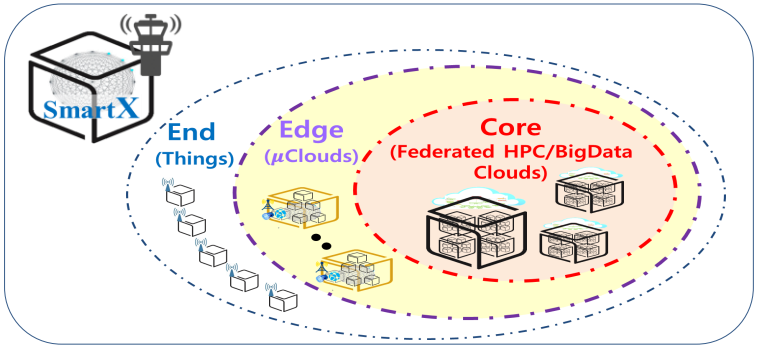
SmartX Automation Framework







SmartX Composable Playground & Boxes



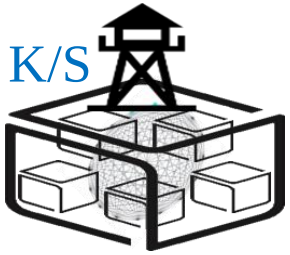
Type B/C

SmartX
Cloud Box

Type O

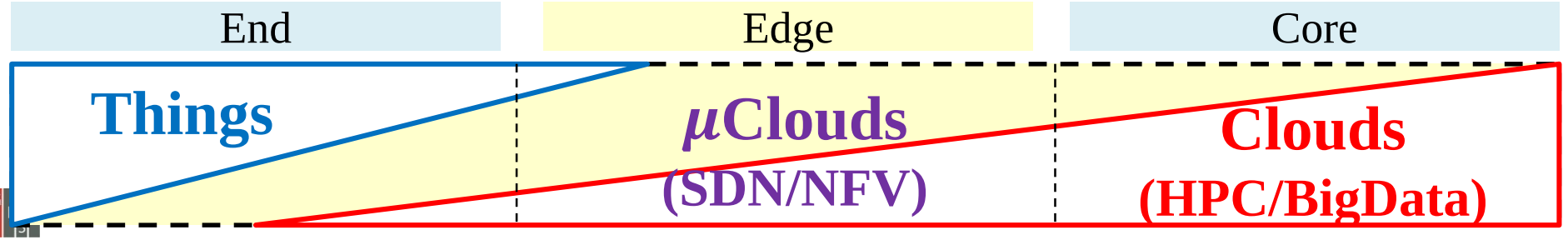
SmartX
Edge μBoxes

Type K/S



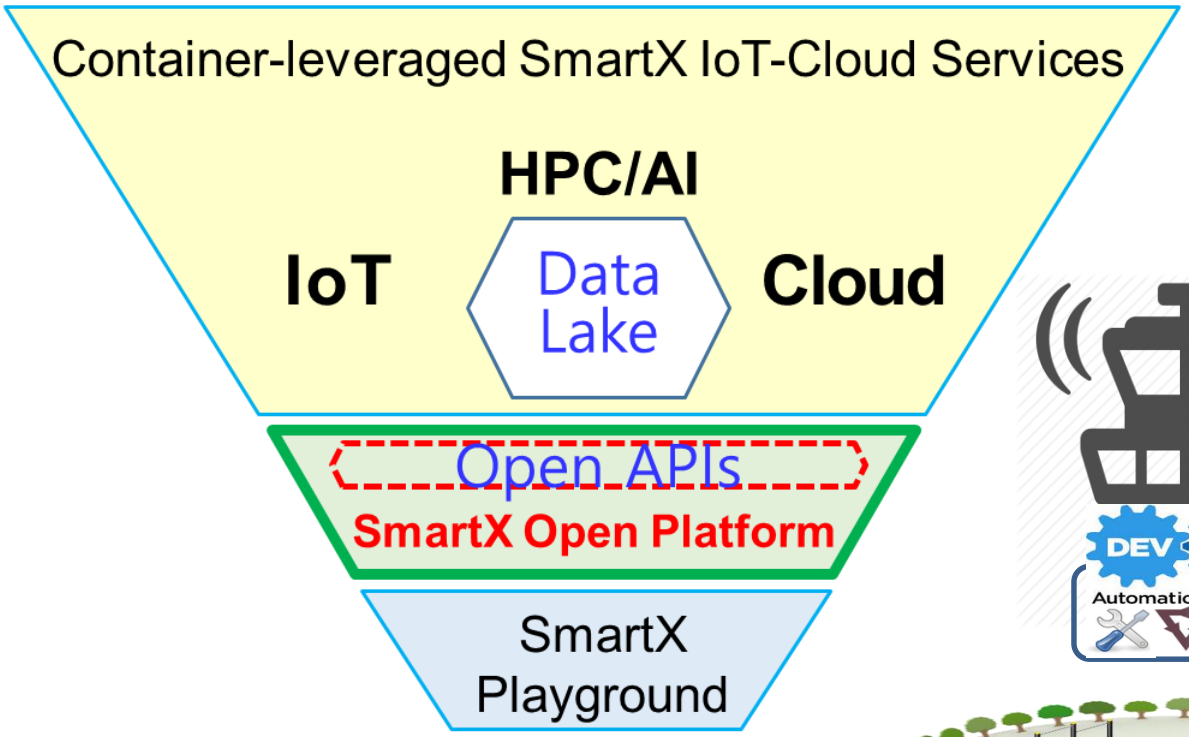
SmartX
Edge Cluster

SmartX
DevOps Tower
Cloud
with DataLake

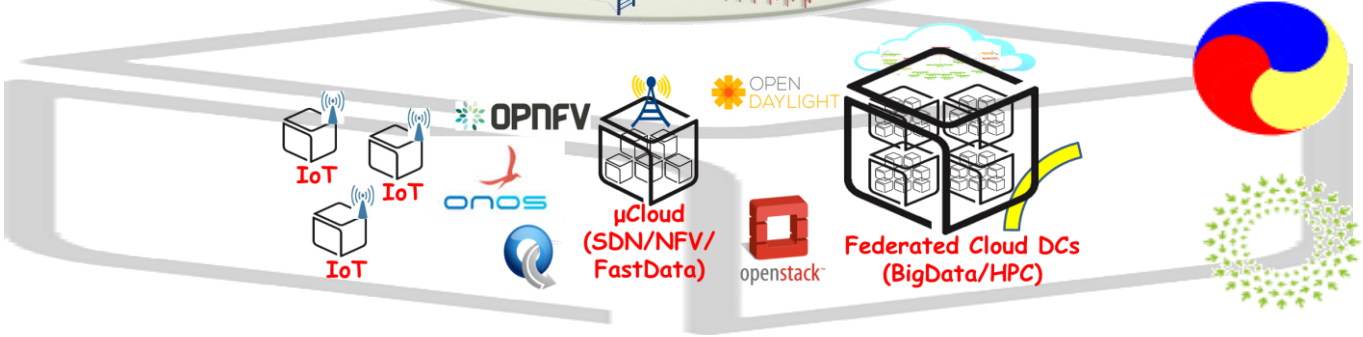


Open-Source-leveraged **Open Playgrounds**

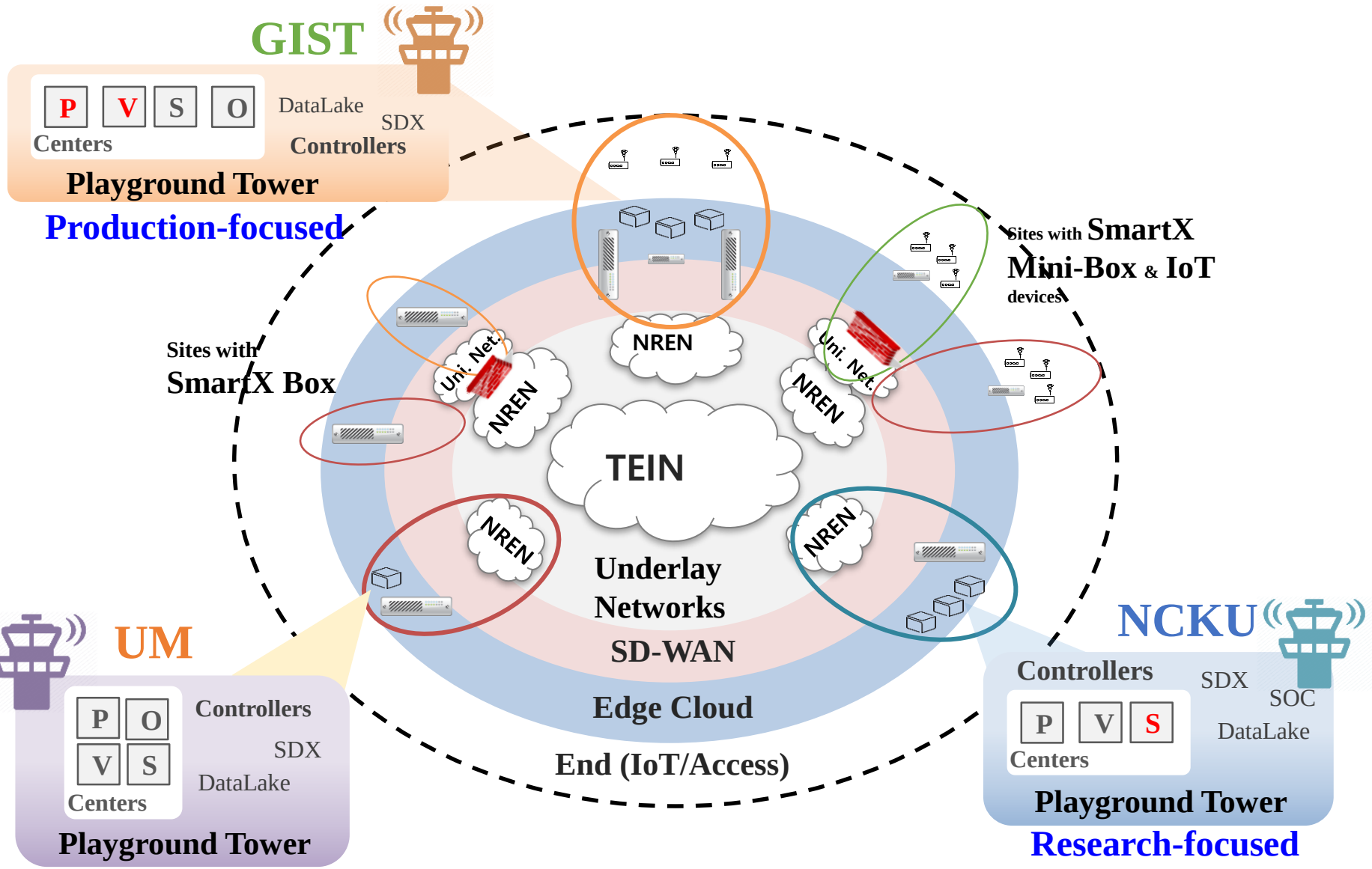
(IoT-SDN/NFV-Cloud (HPC/BigData) Ready)



SmartX Open Playgrounds



Federated OF@TEIN+ SmartX Playground

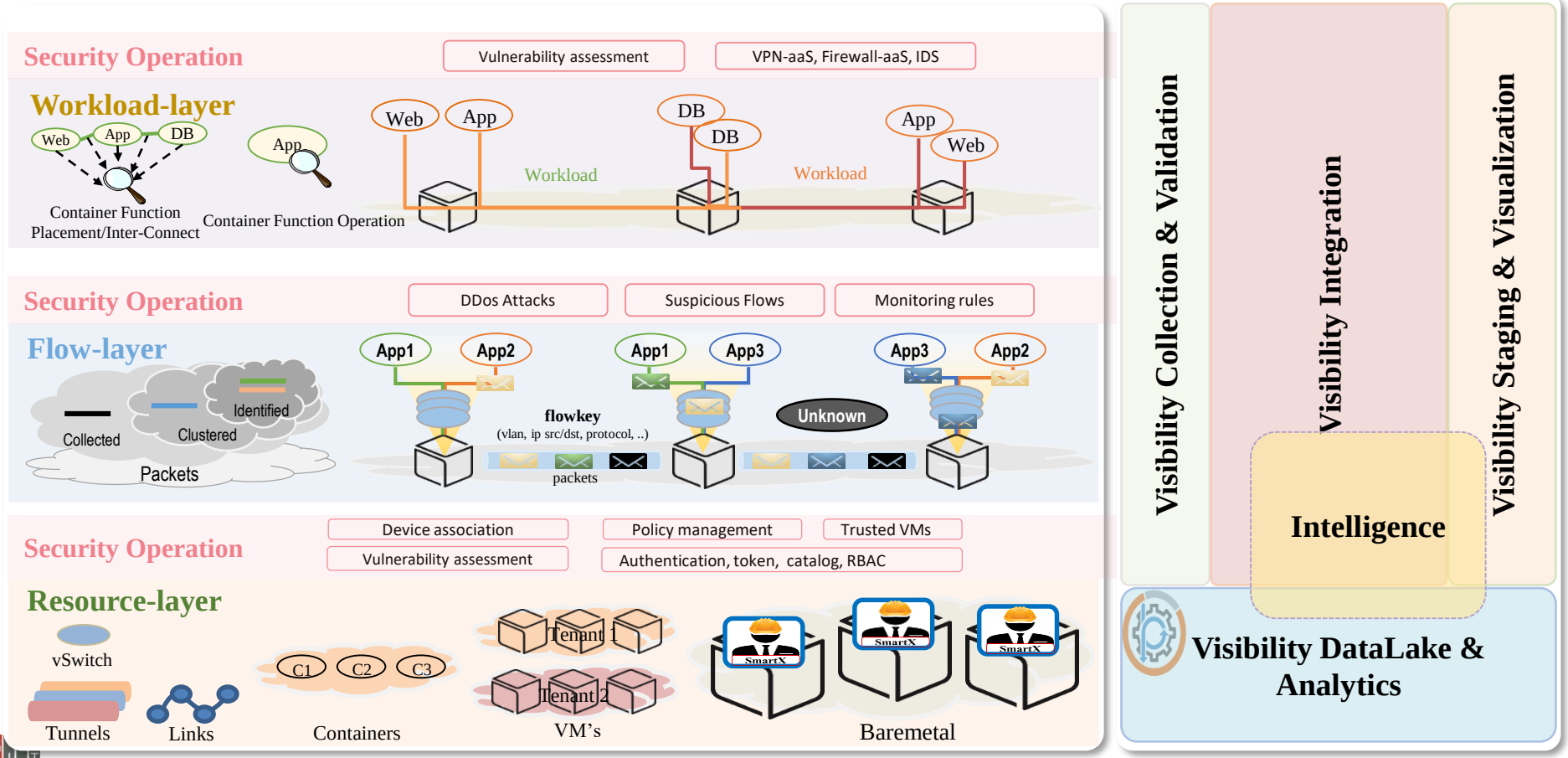


Visibility & Security Operation for SmartX Playgrounds

SmartX-MultiView

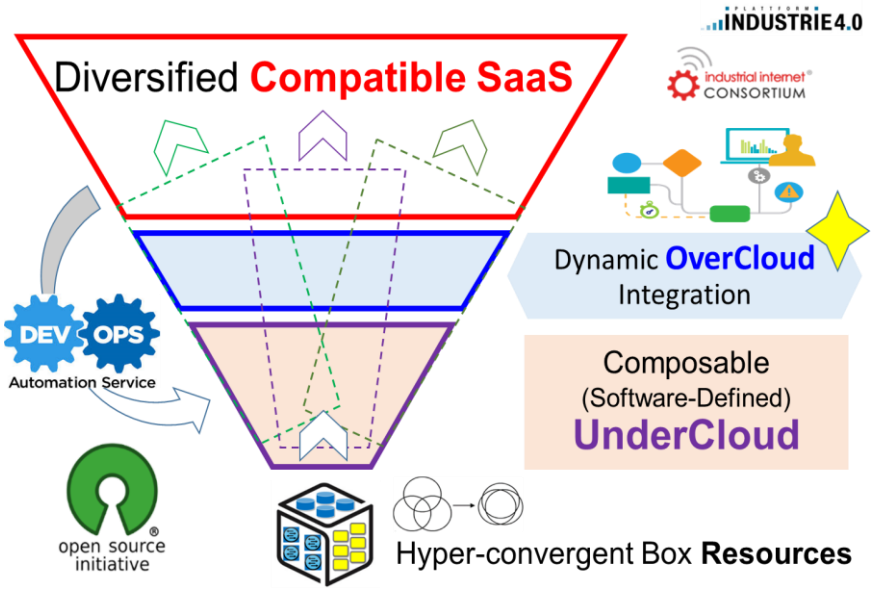
SmartX-MultiSec

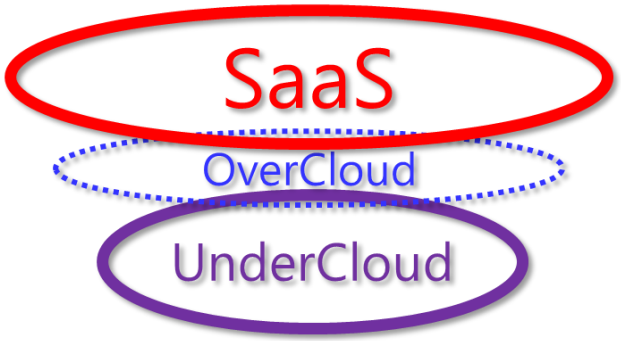
SmartX MultiView/MultiSec Framework

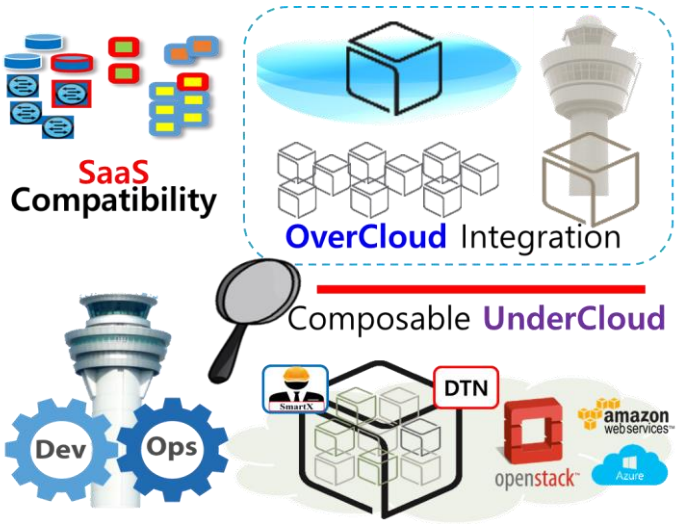


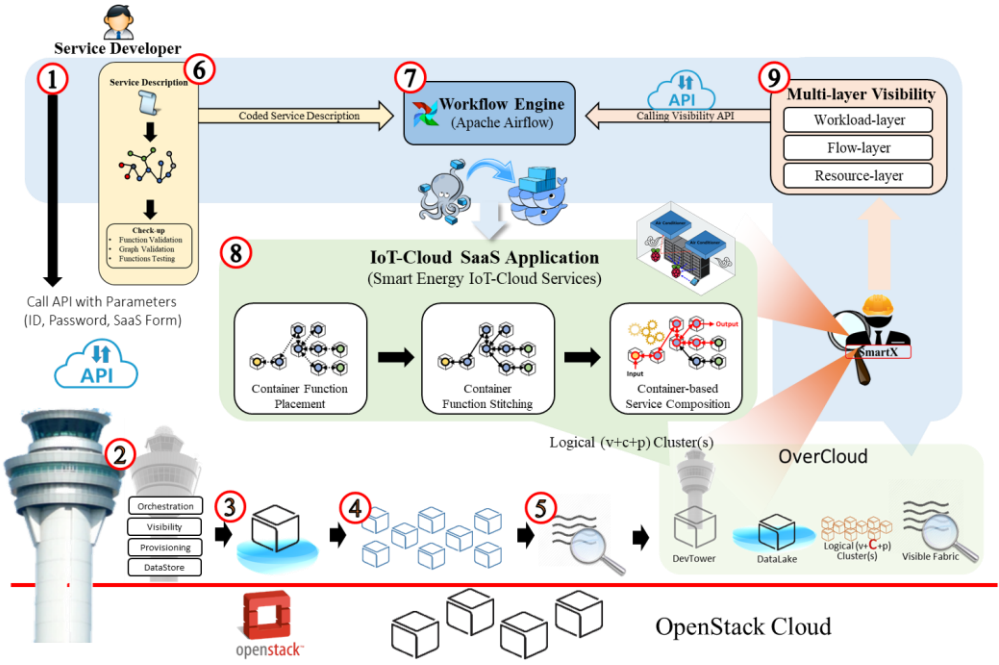
Dynamic Cloud-native OverCloud

leveraging Infrastructure Slicing over Converged SDI



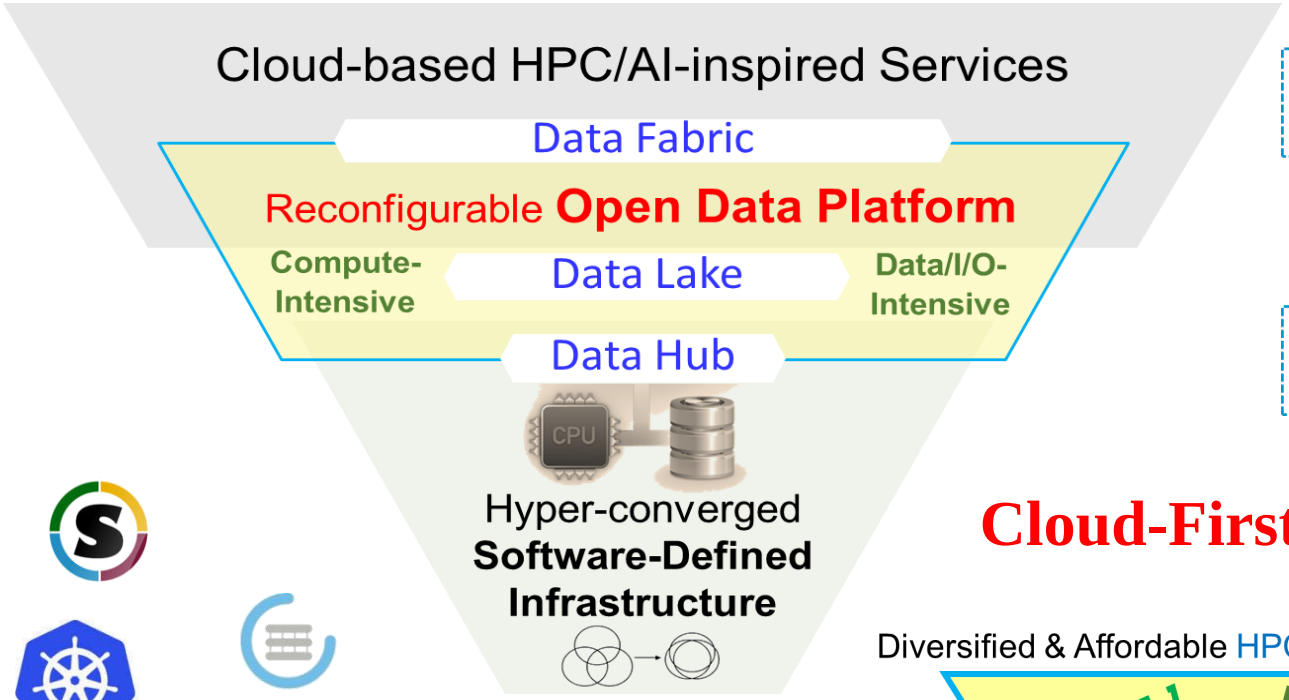


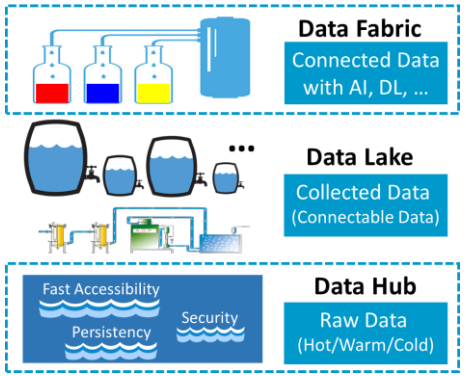




Open/Reconfigurable Data-Centric Cloud

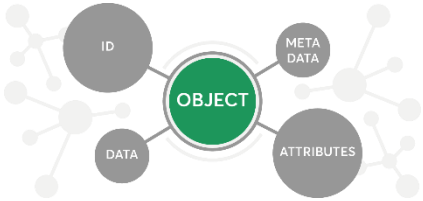
Cloud-leveraged HPC/AI-inspired Services over Hyper-converged SDI



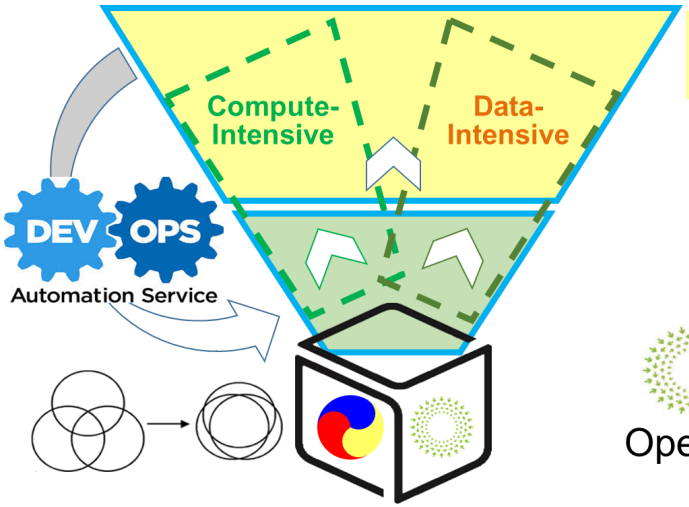


openHPC

openstack CLOUD SOFTWARE



Cloud-First Integration



Reconfigurable Platforms

openHPC

openstack CLOUD SOFTWARE

OPEN Compute Project

Open & Convergent Resources

Flexible HPC/HPDA

HPC/AI-inspired Services with Open S&T Ecosystem

PLATTFORM INDUSTRIE4.0

HPC/AI-inspired services

DataLake

Cloud-leveraged Platform

Software-Defined Infrastructure

Developers

Operators

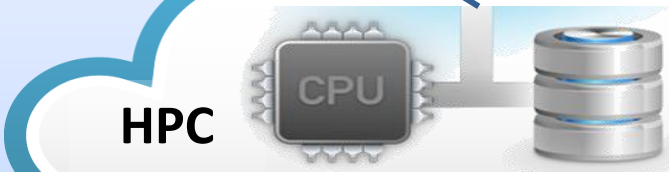
One-Stop Portal

Collaboration

User Communities

Workflows

Network (SDN)



HPC

DataHub

Gwangju Institute of
Science & Technology

Thank you!

Send Inquiry to jongwon@gist.ac.kr

http://nm.gist.ac.kr