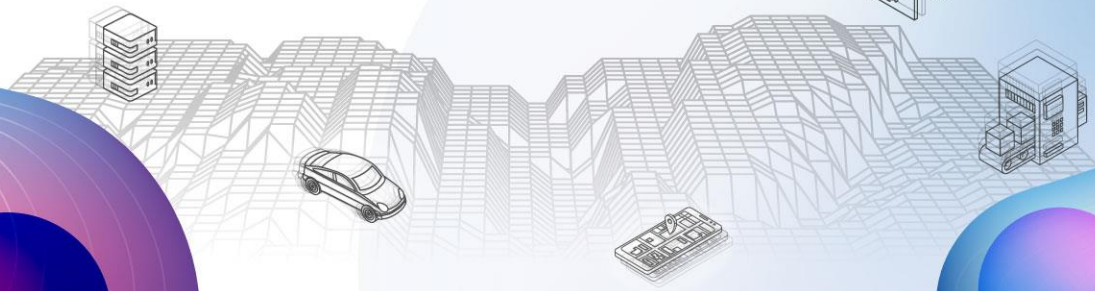
RESHAPING THE FUTURE
The Power Behind Digital Transformation

QCT | intel

新世代靈活性基礎架構優化 HPC&AI 應用服務轉型

雲達科技 | 張文祥 (Stephen Chang)



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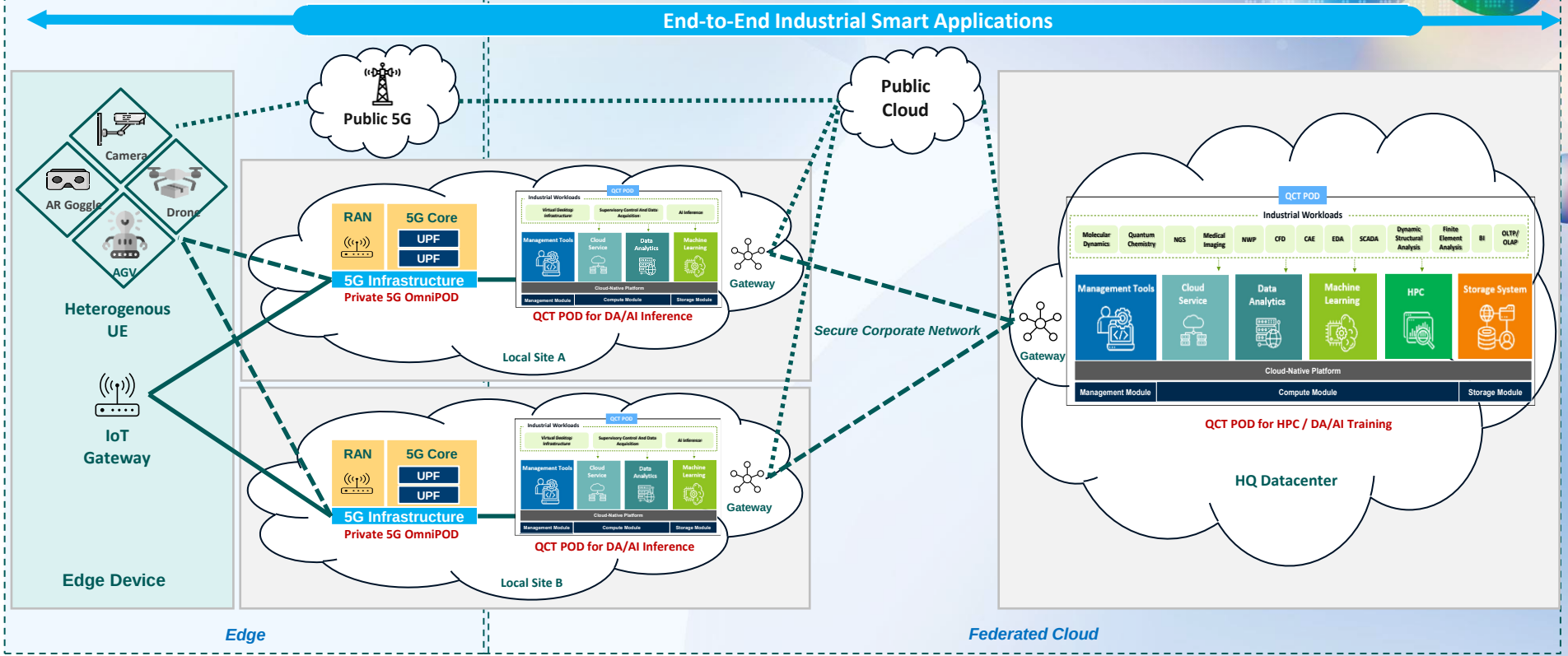
新世代靈活性基礎架構優化 HPC&AI 應用服務轉型

- 企業應用服務模式發展趨勢
- 新世代HPC/AI資訊服務架構
- 打造新世代HPC/AI應用服務的最佳實踐
- QCT HPC/AI解決方案

企業5G x AI x Cloud應用服務



企業"雲端"應用服務

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Enterprise Edge

Real-time Compute + short-term data *at location X*

AI Inference | SCADA | Real-time Messaging | VDI | Data Streaming

Location X

Secure Corporate Network

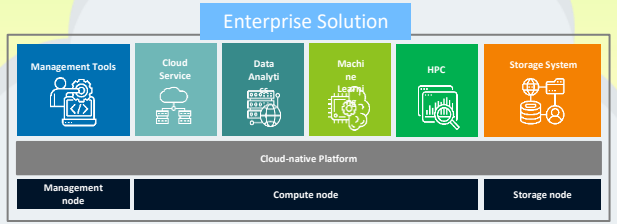
Gateway — Gateway

Enterprise Cloud

Mid/long-term Data *in the HQ Data center*

Massive Compute *either in location X or HQ data center*

AI Training | HPC | Data Analytics | BI | Data Warehouse



HQ Data Center

Federated Cloud

工作負載導向推動應用服務轉型

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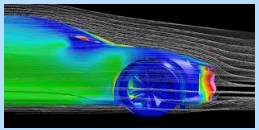
智慧製造

電腦輔助設計與製造
CAD / CAM Simulation

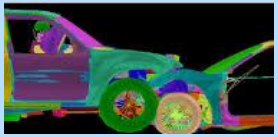
自動化生產
Peripheral Equipment Automation

自動化品質檢測
Automated Quality Inspection

智慧交通



汽車風流設計
Fluid Mechanics

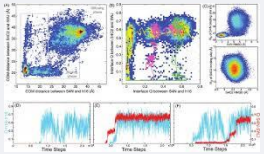


汽車碰撞測試
Crash Test Simulation

道路物件偵測
Object Detection

智慧醫療

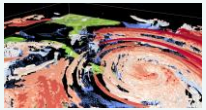
次世代基因定序
Next Generation Sequencing



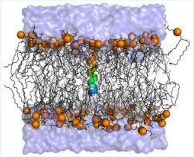
藥物開發
Molecular Dynamics

醫療影像辨識
Image Recognition

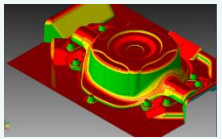
科技研究



氣候模擬
WRF



分子結構模擬
Molecular Dynamics



結構設計
CAD Simulation

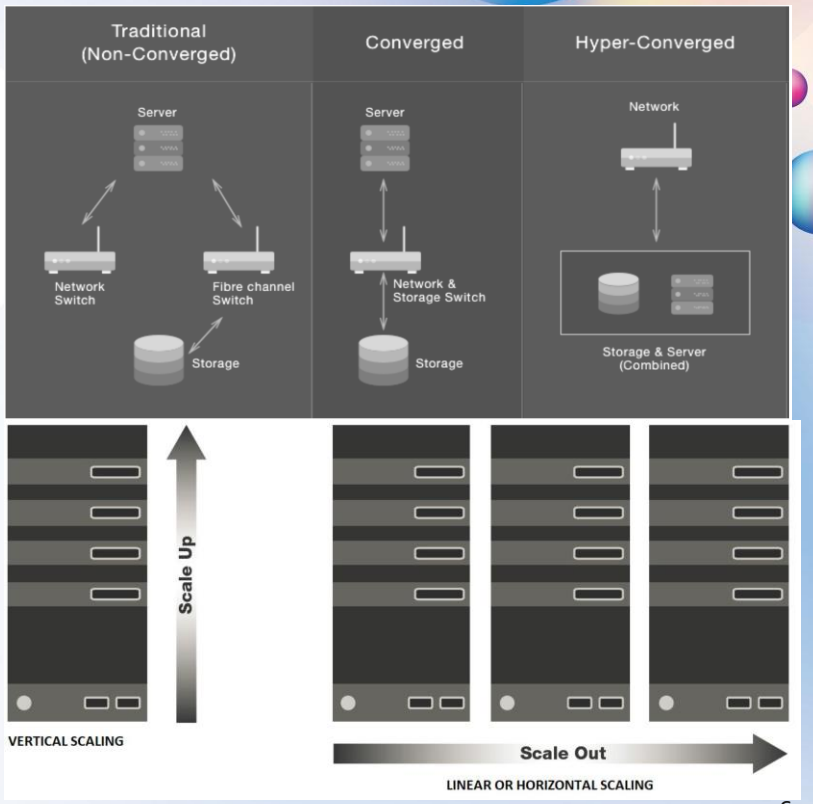
智慧金融

風險控管
Risk Management

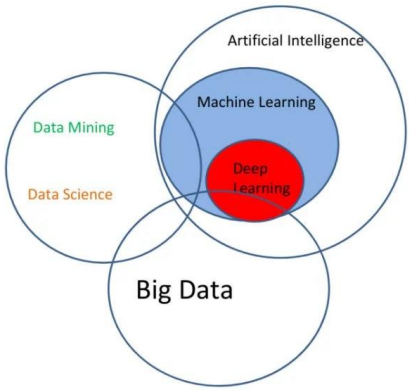
高頻交易
Trading

資訊基礎架構演進

- **傳統架構(Traditional) – 獨立資訊基礎架構**
  - Physical workload
  - Silos and static
  - Complex process
- **融合式架構(Converged) – 整合資訊基礎架構管理**
  - Pre-configured systems
  - Hardware defined solution
  - Minimized compatibility issues
- **超融合架構(Hyper-converged) – 簡化部署**
  - Software defined storage
  - Virtual workloads
  - Scale-out architecture
- **組合式架構(Composable) – 簡化基礎架構即服務**
  - Software defined everything
  - One infrastructure for any workload
  - Flexible hardware & software integrated as one



邁向應用情境整合



產業應用 Domain Scenarios	高效能運算 HPC (e.g. MPI, OpenMP)	資料分析 Data Analytics (e.g. Spark)	機器學習 AI/ML/DL (e.g. Tensorflow)
資源管理 Resource Management	多重資源管理 Multi-domain Resource Manager (e.g. SLURM, Kubernetes)		
資源部署 Resource Provisioning	裸機部署 Bare-metal Provisioning (e.g. xCAT, Warewulf, Ironic)	雲端服務 Cloud-based Provisioning (e.g. Azure, AWS, Google, Containers)	
基礎架構 Infrastructure	運算 Compute (e.g. CPU/FPGA/GPU)	儲存 Storage (e.g. File, Block, Object, PFS, NAS, All flash)	網路 Network (e.g. Ethernet, InfiniBand)

https://whatsthebigdata.com/2016/10/17/visually-linking-ai-machine-learning-deep-learning-big-data-and-data-science/

不同工作負載的特性分析

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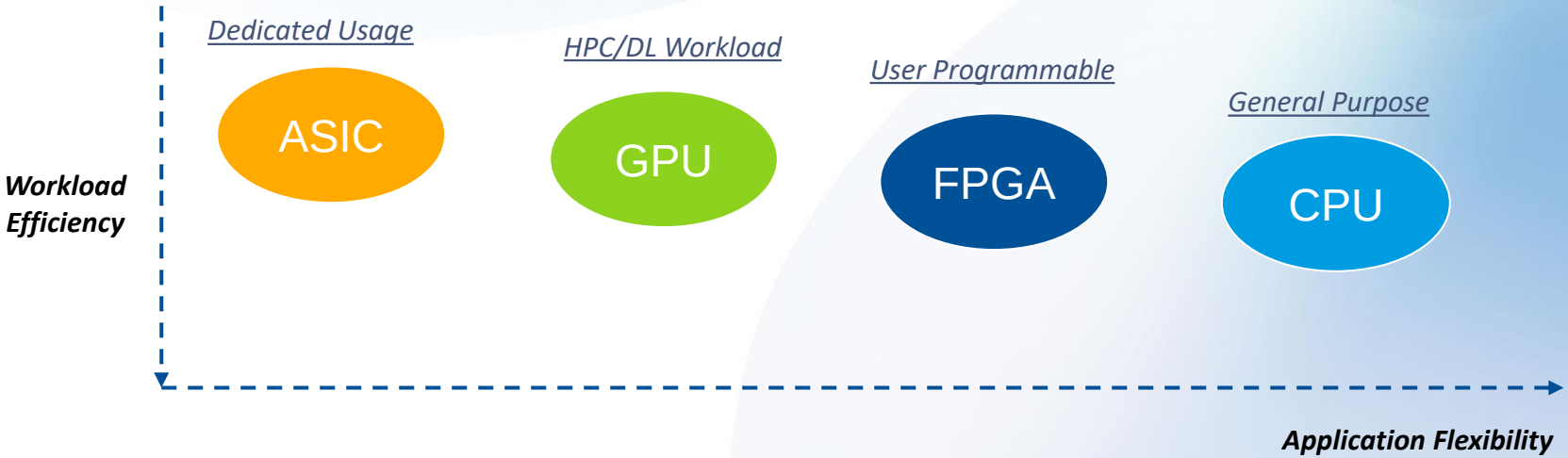
Workloads		Artificial Intelligence		Data Analytics		High Performance Computing							
						Life Science		*Utility*		*FSI*		*Manufacturing*	
Category	Type	Training	Inference	Real Time	Batch	DNA Sequencing	Molecular Dynamics	Seismic Processing	Reservoir Engineering	Trading	Risk Mgmt.	EDA	CAE
Compute-bound	INT8 / INT16 / INT32		+	++	++					+	+		
	FP16 (HP)	++	+++	+	+								
	FP32 (SP)	+++	++	++	+++	++	+++			++	++		
	FP64 (DP)	+	+		+	+	+	+++	+++	+	+	+++	+++
Memory-bound	Shared	+++	+	++	+	+++	++	+++	++	+++	++	+	+++
	Distributed	+		+	++	+	+++	+	++	+	++	+++	+++
I/O-bound	Network	+++	++	+++	++	+	++	+	++	+++	+	+++	++
	Storage	+++		+	+++	+++	+	+	++	+	+++	+++	+

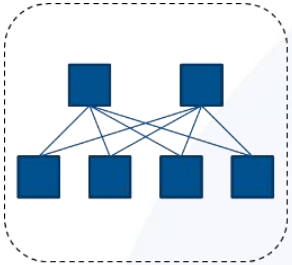
應用於不同工作負載的資料運算

- CPU適用於通用型工作負載但針對特定應用有效能瓶頸
- ASIC是針對特用工作負載優化效能的專用晶片，但相對其應用有其侷限性
- GPU廣泛應用於深度學習及高效能運算但需要額外撰寫修改應用程式
- FPGA易在效能與成本上取得平衡，但其導入應用進入門檻較高

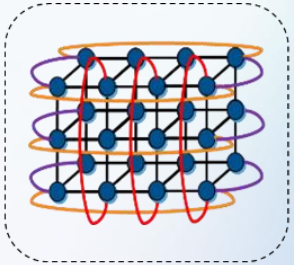


應用於不同工作負載的資料網路

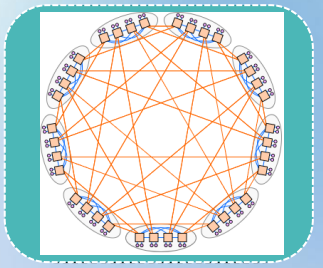
- 資料網路指標
  - 延遲時間(Latency) : 從來源端(source)傳送資料封包至目的端(destination)所花費的時間
  - 頻寬(Bandwidth) : 透過網路連線在單位時間的傳輸資料量 (bps)
  - 傳輸量(Throughput) : 在網路通道上單位時間能成功傳遞的平均資料量
- 資料網路架構
  - Fat Tree/CLOS
  - Torus
  - Dragonfly
- 資料網路技術
  - Ethernet
  - InfiniBand



Fat Tree



Torus



Dragonfly

應用於不同工作負載的資料儲存

- 資料儲存指標
  - 效能 (Performance) (IOPS/Throughput/Latency)
  - 容量 (Capacity) (Thin Provisioning/Duplication)
  - 保存 (Persistence) (Temporary/ Permanent)
- 資料儲存型別
  - 檔案儲存 (File) (NFS/CIFS)
  - 區塊儲存 (Block) (Fibre channel/ iSCSI)
  - 物件儲存 (Object) (S3)
- 資料儲存技術
  - SAS/SATA/Fibre Channel
  - HDD / SSD
  - NVMe / NVMe-oF

儲存型別	檔案儲存	區塊儲存	物件儲存
成本優勢	++	+	+++
性能導向	++	+++	+
可擴充性	++	++	+++

應用於不同工作負載的整體擁有成本

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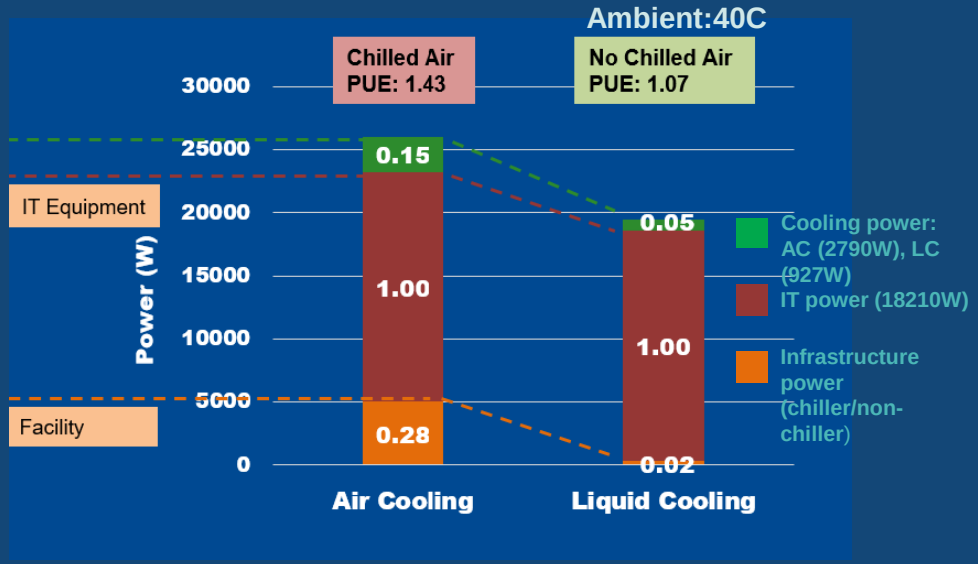
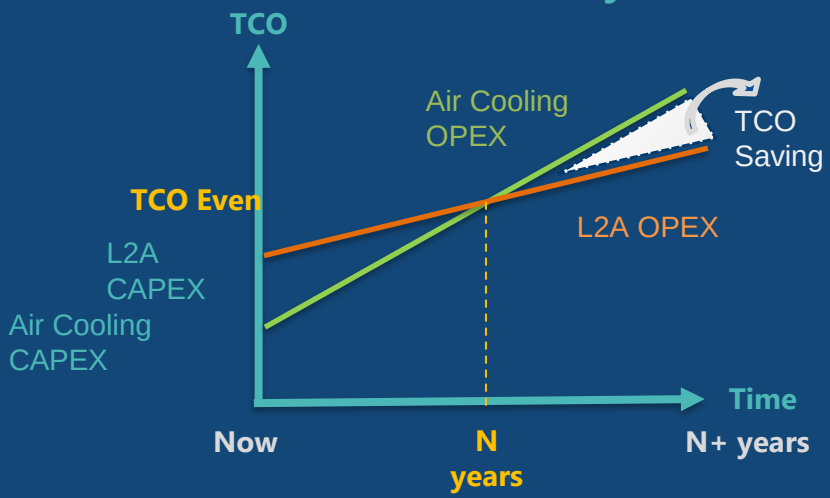
PUE Optimization:

The more power you save from HVAC, the more optimization you achieve on PUE & CFP.



TCO Analysis



應用於不同工作負載的機房規劃

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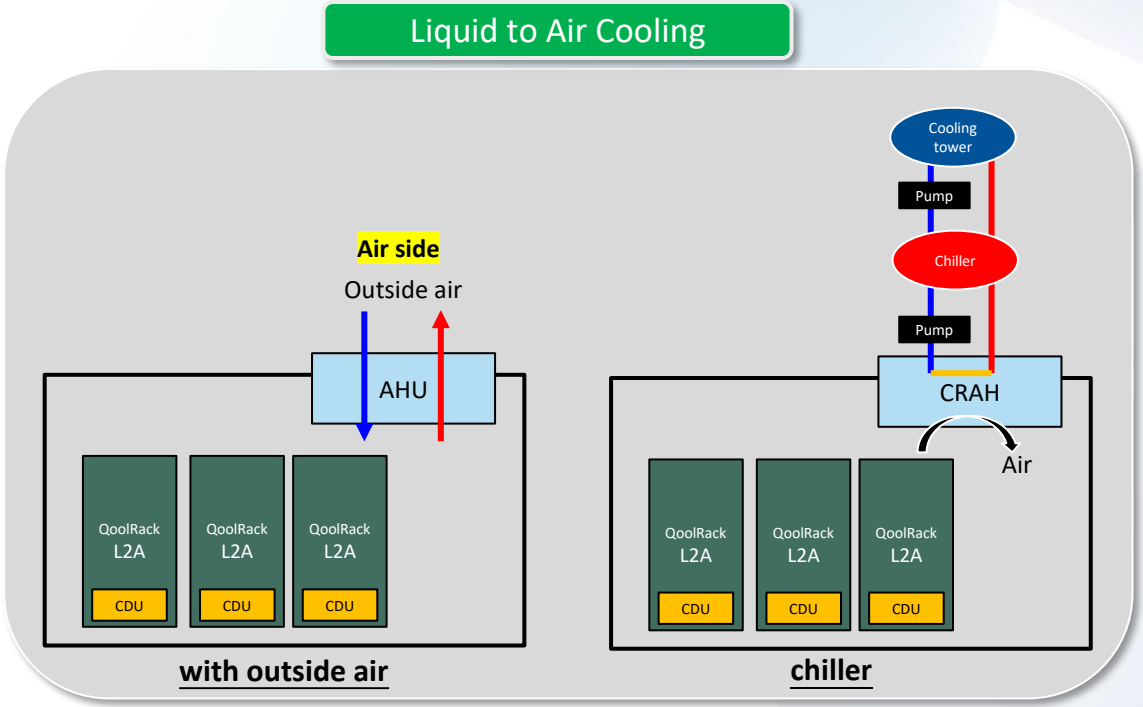
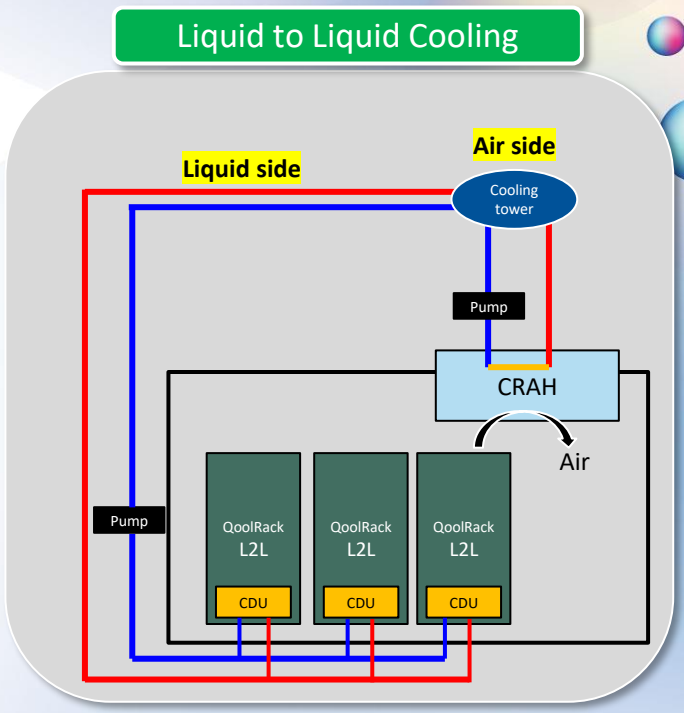
- Advanced Liquid Cooling Capability with Superior Power Efficiency





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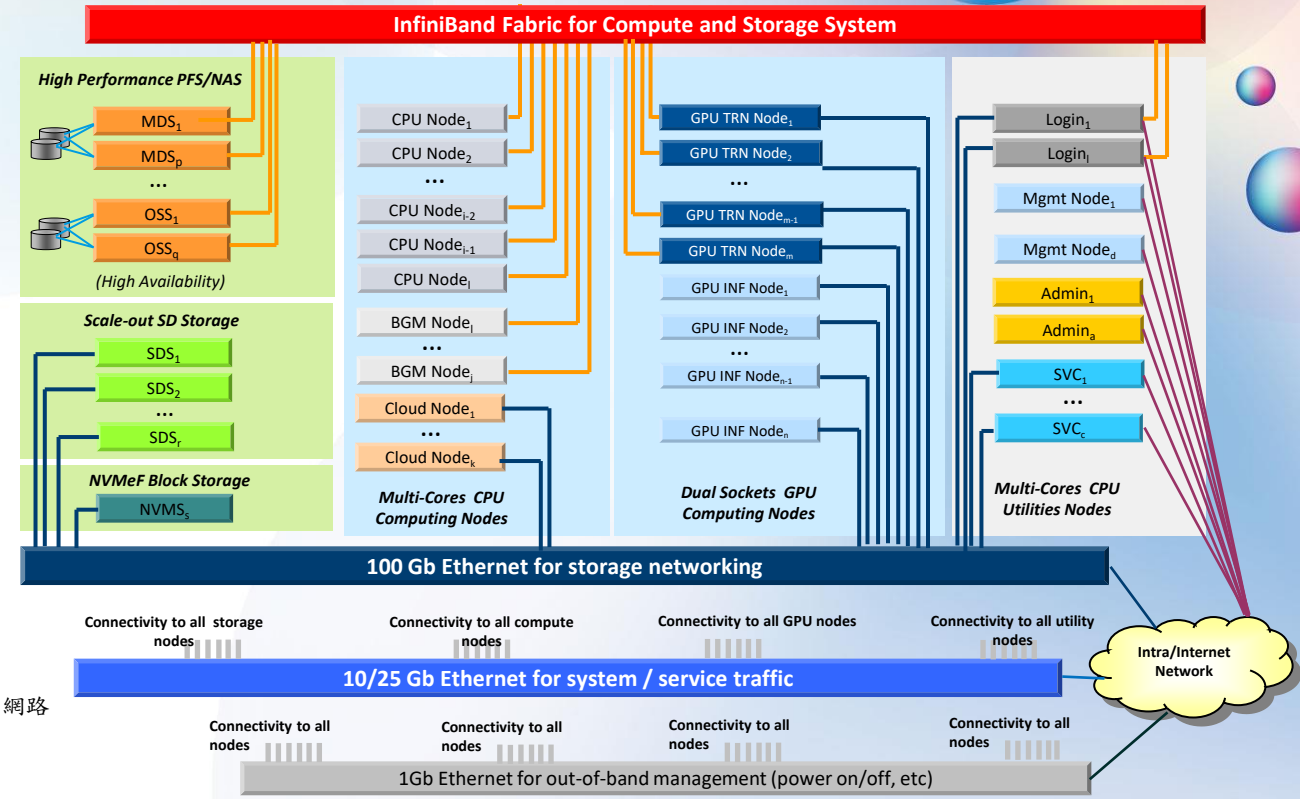
應用服務平台系統架構

- 計算與服務節點
  - L組登入服務節點(Login)
  - D組部署系統管理節點(Mgmt)
  - A組系統服務管理節點(Admin)
  - C組虛擬主機/容器服務節點(SVC)
  - I組CPU HPC計算節點(CPU)
  - J組CPU/BigMem計算節點(BGM)
  - K組Cloud Service計算節點(NGS)
  - M組GPU/AI Inference節點(GPU INF)
  - N組GPU/AI Training節點(GPU TRN)
- 高性能檔案儲存系統
  - P/Q組MDS/OSS儲存節點
- 網路區塊/物件/檔案儲存及備份系統
  - R組SDS儲存節點
  - S組NVMS儲存節點
- 管理與資料傳輸網路
  - 連接所有節點之1Gb BMC埠至管理網路
  - 連接所有節點之10/25GbE 網路埠至控制網路
  - 連接計算節點之高速網路埠(InfiniBand/Ethernet)至運算網路



新世代HPC/AI/DA系統軟體服務

Admin Portal

Software Service

- **User Portal**: Self-Service Portal; App Catalog
- **Web-based UI**: Jupyter Hub; Jupyter Lab; App UI
- **Fine-Tuned Workloads**: HPC Apps; AI Apps; DA Apps

CLI: SSH; X2Go; VNC

API Gateway

Management Pack

- System Deployment
- System Monitoring
- Cluster Management
- Identify and Access Management
- Network Security
- Service Level Management

Application Platform

- **Development Tools**: GitLab; oneAPI; NV HPC SDK; Jenkins; OpenVINO; CUDA SDK
- **HPC, IoT, Data Analytics and Machine Learning Application Frameworks**: MPI; TAO; RAPIDS; Keras; Kubeflow; Apache Kafka; BigDL; Horovod; CUDA-X; DOCA; TensorFlow; PyTorch; Apache Spark; PostgreSQL

Cloud Infrastructure

- **Resource and Job Management**: SLURM / OpenPBS
- **Open Cloud Management**: Apache CloudStack
- **Cloud Native Management**: Kubernetes; Volcano; Helm; KubeEdge
- **Bare Metal**: Red Hat Enterprise Linux / Rocky Linux
- **Virtual Machine**: KVM
- **Containerization**: Podman; CRI-O; Containerd; Singularity

Adaptive Server: Utility Node; CPU Node; Accelerator Node

Heterogeneous Network: Service; Management; Data

Software-Defined Storage: Block; Object; File

高效能應用程式容器化管理的挑戰

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kubernetes Kubernetes Blog

Kubernetes Meets High-Performance Computing

Tuesday, August 22, 2017

Editor's note: today's post is by Robert Lalonde, general manager at Univa, on supporting mixed HPC and containerized applications

Anyone who has worked with Docker can appreciate the enormous gains in efficiency achievable with containers. While Kubernetes excels at orchestrating containers, high-performance computing (HPC) applications can be tricky to deploy on Kubernetes.

https://kubernetes.io/blog/2017/08/kubernetes-meets-high-performance/

Traditional HPC vs. Containerized Jobs

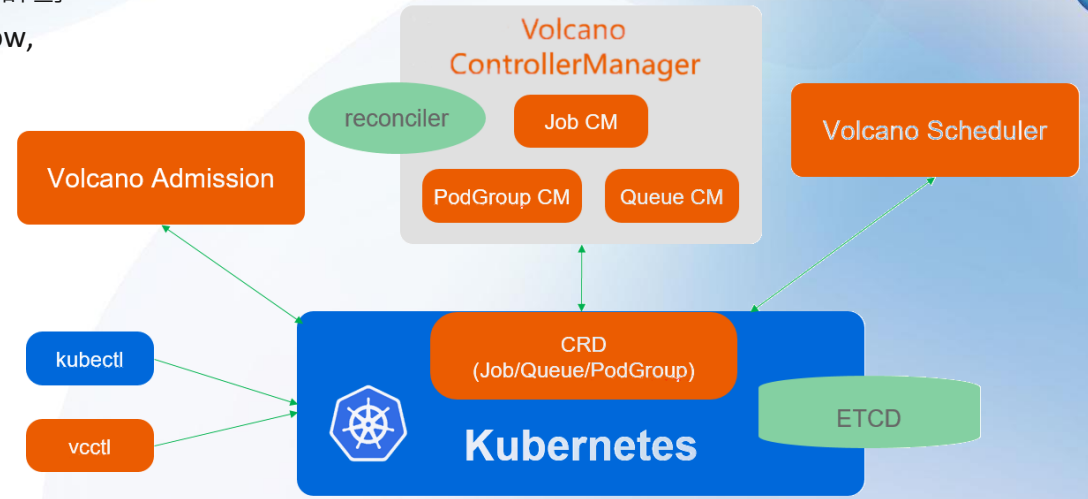
Workload Characteristics	• Possible 10K+ short-running tasks low-latency, high throughouput • Potential cross-node parallelism & sync. • Specific HW needs (GPU, etc) • HW policy enforcement	• Container based • Typically used for long-running services • Dynamic • Resources limits/requets handled by K8s scheduler.
Job Submission	Run with traditional HPC cli tools: `srun job-script.sh`	1. Package workload into container 2. Push to registry 3. Submit YAML manifest.

可能解決方法

- 獨立建置基礎架構
  - Siloed clusters
  - Increased infra cost and mgmt overhead
- 透過既有HPC工作排程工具執行容器化應用程式
  - Minimal disruption
  - Lack native K8s features
- 採用K8s-native工作排程管理工具
  - Impractical for many HPC users
  - Negative impact on latency

容器資源自動化管理的最佳助手

- **Volcano**
  - 針於K8s環境所運行高效能工作負載應用程式之開放原始碼原生批次工作排程管理工具
  - 具備高效能工作負載應用程式所需但K8s所不足之強大批次工作排程管理功能
  - CNCF官方所支持的容器批次工作管理開發計劃
  - 支援常用的應用程式框架 (Spark, TensorFlow, PyTorch, OpenMPI, etc…)
  - 採用K8s-native程式庫
- **Customized K8s Scheduler**
  - 延伸強化K8s工作排程管理政策
    - Gang, fair-share, queue, preemption, toplogy, reclaim, backfill, etc.
  - 優化排程時間
  - 豐富插件支援
  - GPU共享支援能力



Volcano的應用限制

- 使用者需要對Kubernetes的操作環境有一定的知識
  - 如何新建及交付YAML設定檔案
  - 以YAML型式之工作腳本製作
  - 熟悉取得資源需求格式宣告
- 無法直接使用輸入BASH或是CLI命令作為工作腳本
- 複雜的 CLI命令選項
  - 大量的命令選項
  - 繁複的特定指令操作
- 缺乏指定資料來源處理
- 缺乏工作記錄檢視管理
- 缺乏永久性工作記錄資料庫支援

```
apiVersion: batch.volcano.sh/v1alpha1
kind: Job
metadata:
  name: lm-mpi-job
spec:
  minAvailable: 3
  schedulerName: volcano
  plugins:
    ssh: []
    svc: []
  tasks:
    - replicas: 1
      name: mpimaster
      policies:
        - event: TaskCompleted
          action: CompleteJob
      template:
        spec:
          containers:
            - command:
                /bin/sh
              - -c
              - |
                MPI_HOST=`cat /etc/volcano/mpiworker.host | tr "\n" ","`;
                mkdir -p /var/run/sshd; /usr/sbin/sshd;
                mpiexec --allow-run-as-root --host ${MPI_HOST} -np 2 mpi_hello_world;
              image: volcanosh/example-mpi:0.0.1
              name: mpimaster
              ports:
                - containerPort: 22
                  name: mpijob-port
              workingDir: /home
          restartPolicy: OnFailure
```

```
~/github/proglog/internal/server master
❯ vcctl job run -N JOB_NAME -i nvidia/tensorflow:1 \
  --requests "cpu=1000m,memory=256Mi" -f job-file.yaml
```

For comparison, using Slurm:

```
$ sbatch job-script.sh
$ sbatch -c 1 -mem=256 job-script.sh
```

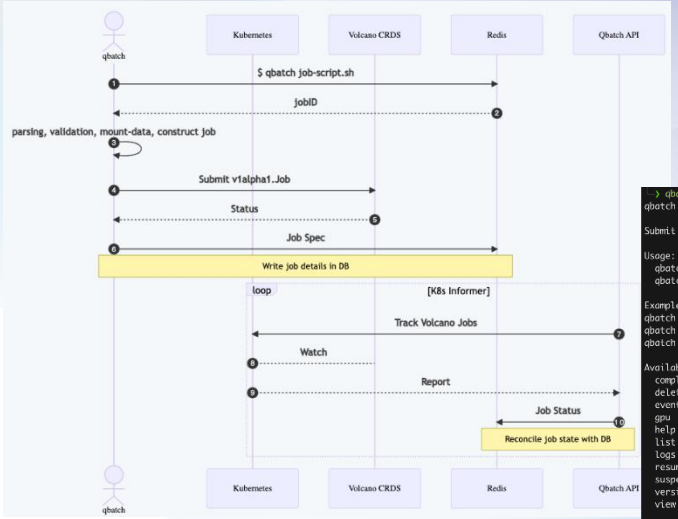
Or PBS

```
$ qsub job-script.sh
```

QBatch – 簡約之美

- **Qbatch**
  - QCT自行開發的CLI工具，提供HPC使用者如qsub/qrun等類似CLI界面在Kubernetes環境下交付執行批次工作
- **功能特色**
  - 可支援BASH、CLI或是YAML交付工作腳本
  - 可透過RESTful API交付工作
  - 可方便指定者自定資源來源
  - 簡化CLI命令輸入選項
  - 可支援In-script 資源指定處理

    ex: #QBATCH –-cpu=3
  - 提供工作記錄輸出
  - 將工作記錄儲存於資料庫中以利後續管理運用




```
❯ qbatch help
qbatch - HPC job management with Volcano Job Scheduler.

Submit jobs defined in .sh, .yaml, or run commands directly.

Usage:
  qbatch [flags]
  qbatch [command]

Examples:
qbatch ( <job.sh> | <job.yaml> ) -i <image>
qbatch -c <Command> -i <image> -N <jobName> [--output]
qbatch ( view | logs | suspend | resume | delete ) <jobName>

Available Commands:
  completion  Generate the autocompletion script for the specified shell
  delete      Delete a job
  events      Display system events related to a job.
  gpu         List all available GPUs.
  help        Help about any command
  list        List all jobs
  logs        View or follow a job's logs
  resume      Resume a job that isn't running
  suspend     Stop a currently running job
  version     View qbatch version information
  view        View detailed information about a job

Flags:
  -c, --command string      the command to run
  -C, --cpu int             requested number of CPU cores.
  -d, --data strings        data dir(s) to mount, multiple dirs should be comma-separated
  -e, --entrypoint          use a container-defined entrypoint, instead of default '/bin/sh'
  -g, --gpu int             requested number of GPUs.
      --gpu-type string     type of nvidia gpu to use, this will take precedence over node-name
  -h, --help                help for qbatch
  -i, --image string        name of the container for the job runtime
  -k, --kubeconfig string   kubeconfig file
  -l, --label string        specify one or more node-labels
  -s, --master string       the address of apiserver
  -M, --mem int             requested amount of Mem (Mi).
  -m, --min int             the minimal available tasks of job (default 1)
  -N, --name string         the name of job
  -n, --namespace string    the namespace of job
      --node string         target node
  -o, --output              pipe the job pod's logs to stdout in realtime
  -r, --replicas int        the total tasks of job (default 1)
  -S, --scheduler string    the scheduler for this job (default "volcano")
  -t, --tolerate strings    allow job to bypass nodes' taint-toleration
```

應用程式效能優化歷程

RESHAPING THE FUTURE
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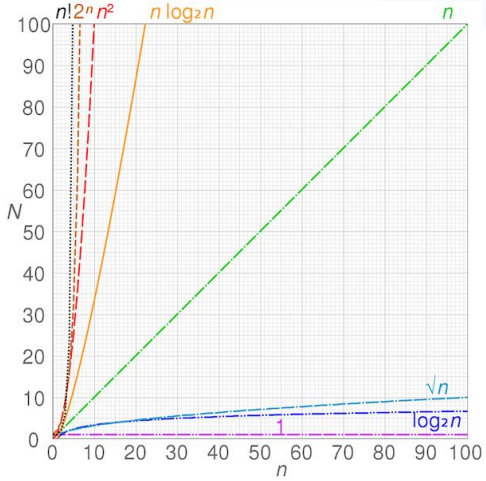
探索(Discover)
- 條件限制

設計(Design)
- 理論與基準測試

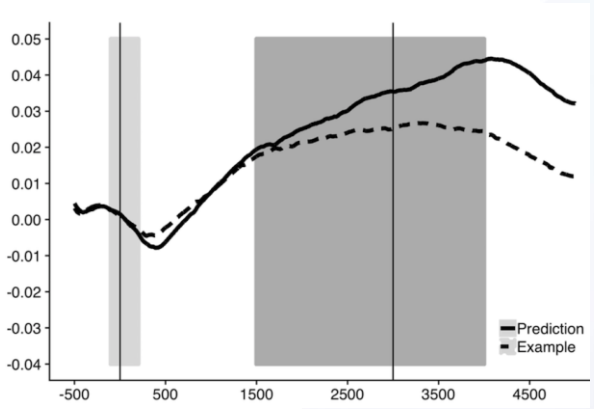
測量(Measure)
- 效能瓶頸為何

改善(Refine)
- 系統化實驗改進

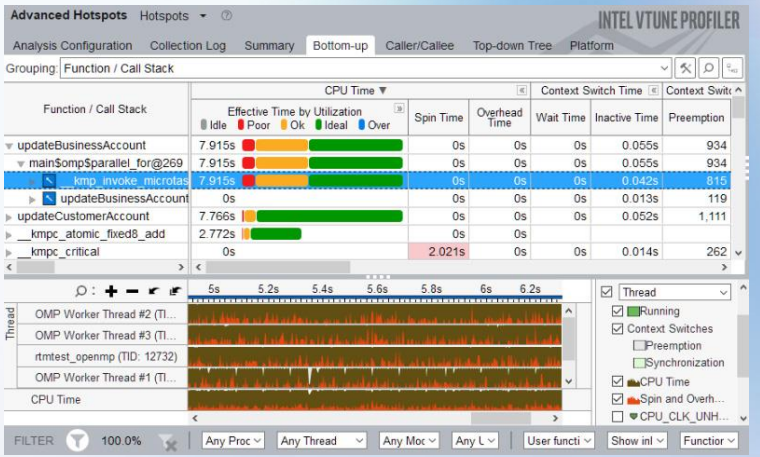
Theoretical Performance



Performance Baseline

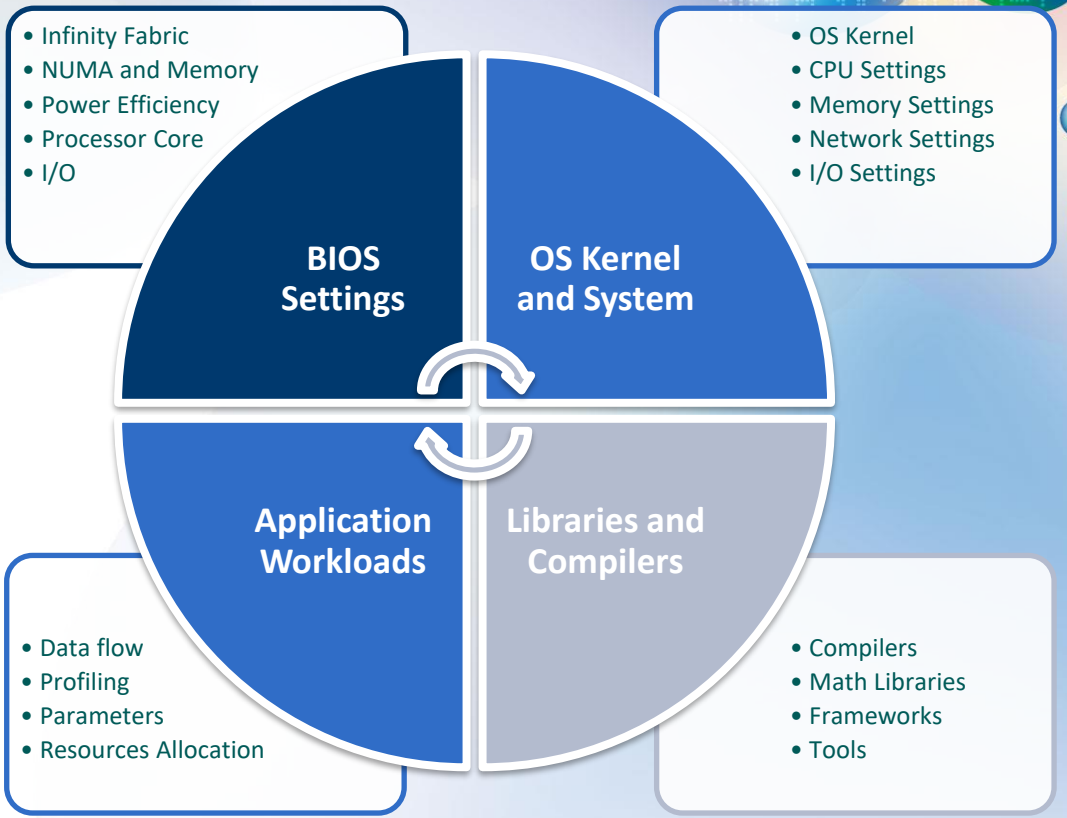


Workload Profiling



應用程式效能優化主要考量因素

- 工作負載分析 (AP Characteristics)
  - 運算導向 / 記憶體導向 / 資料存取導向
  - 資料特性及處理流程
- 系統架構 (System Architecture)
  - 單機 / 叢集架構
  - 高頻 / 高數量運算核心
  - 中央處理器與加速器混合運算
  - 跨節點網路連線(頻寬/延遲時間)
  - 資料型別與存取效能
- 軟體套件(Software Stack)
  - 編譯器種類
  - 軟體開發及編譯
  - 工作負載計算資源分配
- 最適化方案 (No one-fit-all solution)
  - 參考架構(RA)
  - 應用實務(Best Practices)

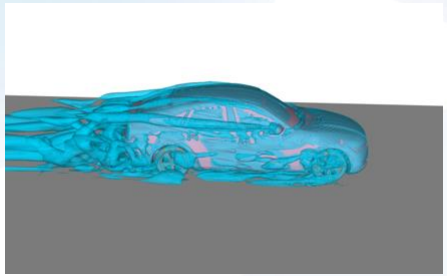


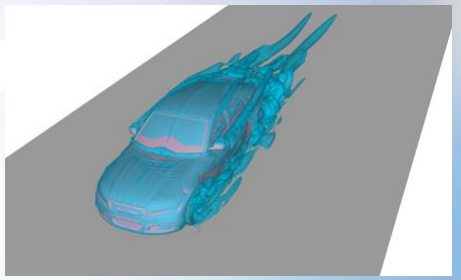
應用程式效能測試分析

OpenFOAM

OpenFOAM® is the leading free, open source software for computational fluid dynamics (CFD), owned by the OpenFOAM Foundation and distributed exclusively under the General Public License (GPL).

- Version: v10
- Release Date: 12th July 2022
- Web site : https://openfoam.org/
- Compile with : GCC-11.2, OpenMPI
- Test case : drivaerFastback

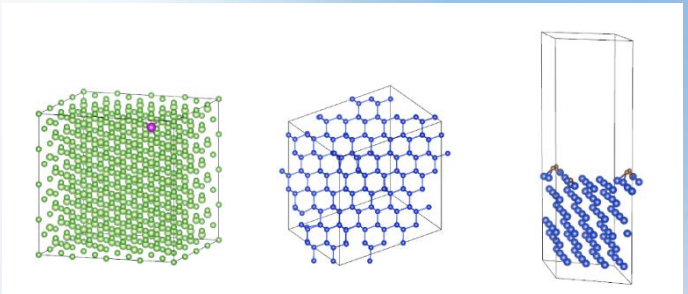




VASP

The Vienna Ab initio Simulation Package (VASP) is a computer program for atomic scale materials modelling based on the First principle.

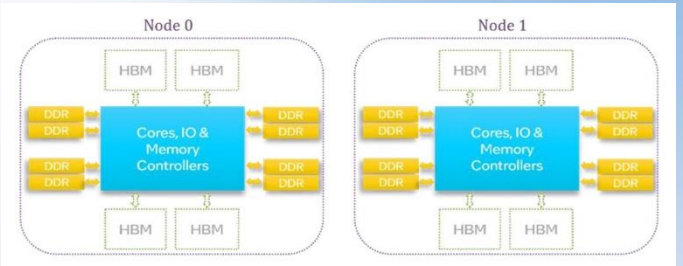
- Version: 6.3.2
- Release Date: 28th June 2022
- Web site : https://www.vasp.at/
- Compile with : Intel OneAPI Fortran, Intel OneMKL, OpenMPI
- Test case : CuC_vdw, GaAsBi-512 and Si256-VJT-HSE06
- VASP work support : Jyh-Pin Chou, Associate Professor, Dep. of Physics, NCUE



GaAsBi_512 Si256_VJT_HSE06 CuC_vdw

測試環境及組態

	ICX	SPR	HBM*
Server Model	D53XQ-2U	D54X-1U	D54Q-2U
CPU	Intel Xeon 8368 * 2	Intel Xeon 8458P * 2	Intel Xeon 9468 * 2
Memory	DDR4-3200 32GB * 16	DDR5-4800 32GB * 16	DDR5-4800 32GB * 16
OS	Rocky Linux 8.5	Rocky Linux 9.0	
Kernel	4.18.0-348.el8.0.2.x86_64	5.14.0-70.13.1.el9_0.x86_64	

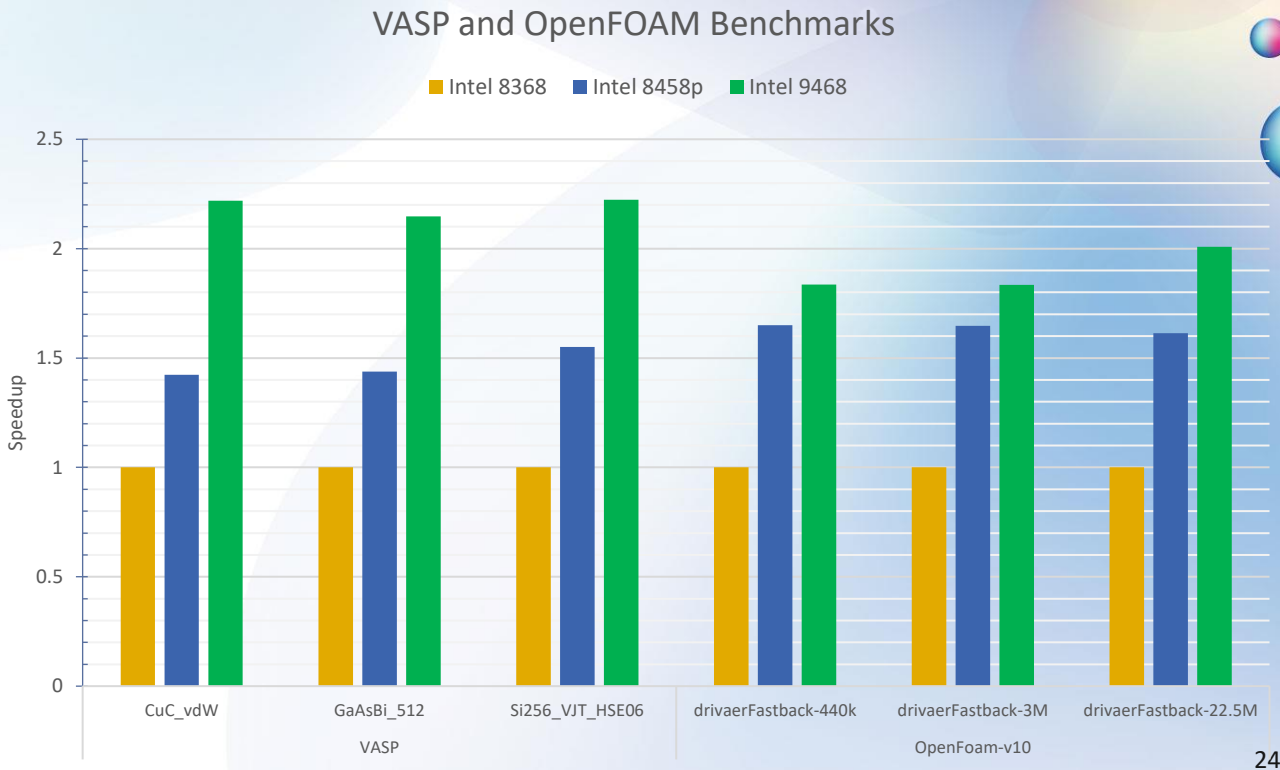


**Config HBM in Cache mode, disabled SNC in BIOS, setup Fake-NUMA with one fake-NUMA node for each physical NUMA node.*

CPU架構對效能的影響

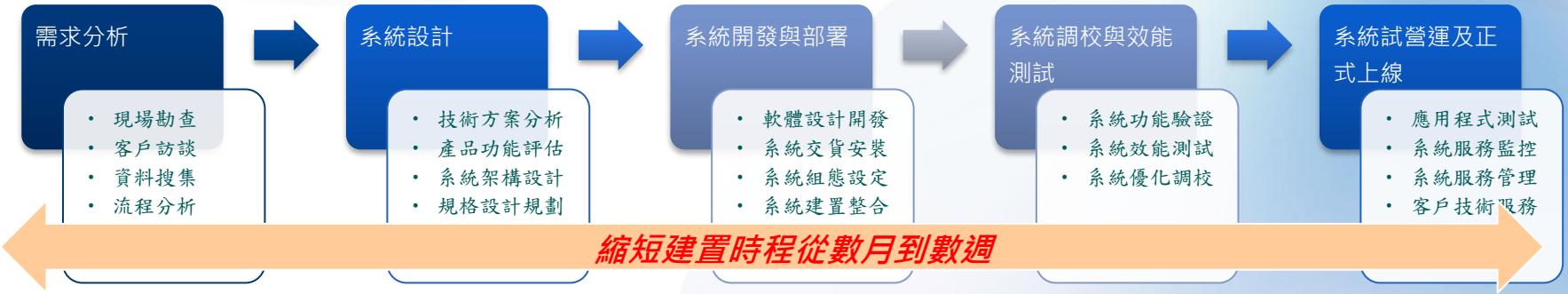
1. 不論是VASP或OpenFOAM，新世代Intel SPR平台相較於前世代Intel ICX平台，對於運算效能的提升，有極大的助益

2. 對於如VASP及OpenFOAM等Memory Intensive應用程式而言，HBM記憶體對於其運算效能亦有顯著的提升



應用服務平台建置歷程

- 企業建立應用系統需要經過需求分析(Demand Pattern Analysis)、系統設計(System Design and Architecting)、系統開發與部署(System Development and Deployment)、系統調校與效能測試(System Tuning and Performance Benchmarking)、系統試營運及正式上線(Pilot Run and Go)等階段
- 幾乎所有專案執行從初始階段提案規劃至最後開放上線使用，相當曠日費時
- 如何讓系統規劃建置從數月、數年縮短至數週甚至數天將會是提升競爭力的決定關鍵因素



預先驗證安裝、預先設定組態、預先調校優化的應用系統將是啟動成功的開關

QCT Platform On Demand (QCT POD)

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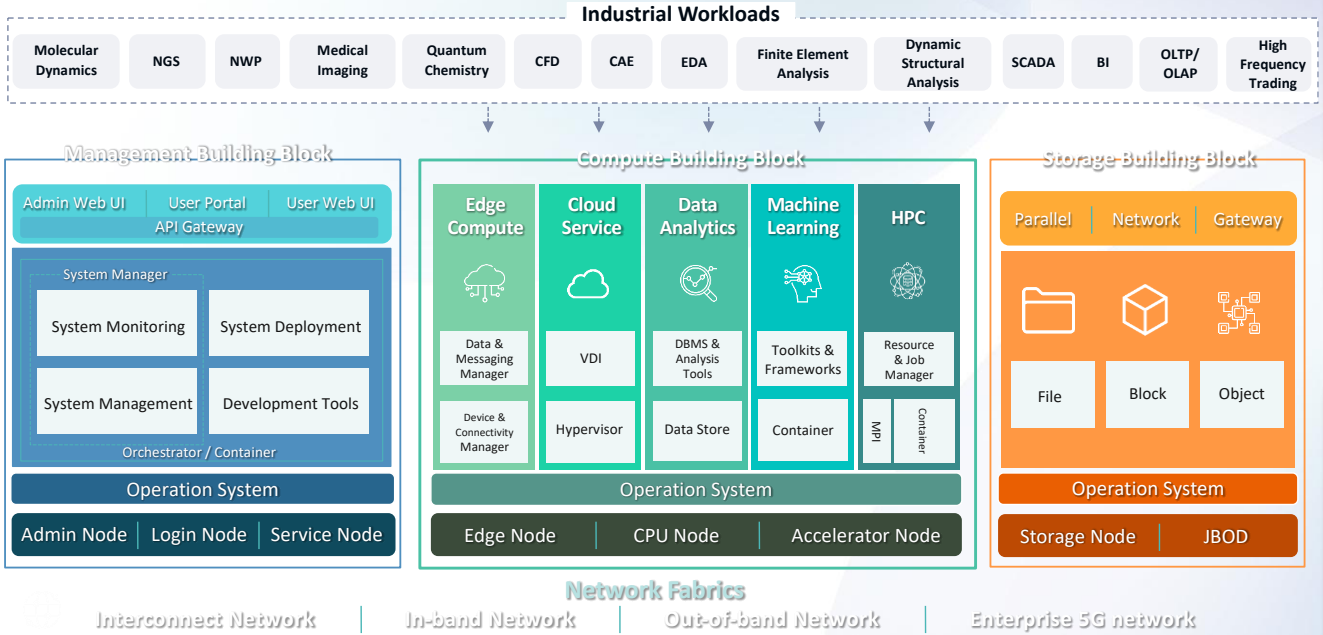
- QCT Platform on Demand (QCT POD)，其乃是針對特定工作負載特性所設計，具備軟硬體整合最佳實務之機櫃式系統方案
- 透過系統化共用模組，提供強大的靈活性與可擴展性，可滿足不同產業業務需求
- 藉由預先驗證安裝、預先設定組態、預先調校優化，可大幅節省建置時間和人力資源，實現快速部署和輕鬆管理，大幅加速客戶核心業務的拓展

主要特色

- 應用程式負載導向設計
- 簡易快速系統建置部署
- 優化驗證系統參考架構
- 彈性擴充系統測試整合

QCT POD系統模組



研究開發人員

提供完整的開發平台，以及預先編譯好的程式模組，幫助開發者專注並加速開發流程。

- 使用者操作平台
- 完整開發環境
- 預編譯程式模組

系統管理人員

透過系統管理模組，管理者可以讓佈署流程更加順暢，同時使用簡單操作的管理介面，提高監控與管理作業之效率。

- 系統部署
- 系統管理
- 系統監控

QCT POD主要功能及特色

Administrators

Developers & End users

Scalability

一鍵式自動化系統部署
One-key System Deployment

- 離線式自動化系統部署
- 自動化軟體安裝設定
- 內建系統軟體套件與容器映像管理
- 系統韌體與驅動程式自動安裝

Serviceability

即時系統監控管理
Realtime System Monitoring

- 即時系統服務狀態與效能監控管理
- 系統效能檢測與調校工具

Simplicity

簡化叢集系統管理
Simplified Cluster System Management

- 資源管理與工作排程管理
- 容器部署與管理
- 叢集系統管理
- 系統安全與事件管理
- 服務整合與自動化
- 使用者帳號及權限管理

Solid

可靠程式開發環境
Robust Development Environment

- 安全遠端桌面作業環境
- 多人使用者網頁式Jupyter Notebook操作環境
- 包含完整程式開發工具如編譯器、程式庫、應用程式框架及視覺化資料檢視分析工具

Streamline

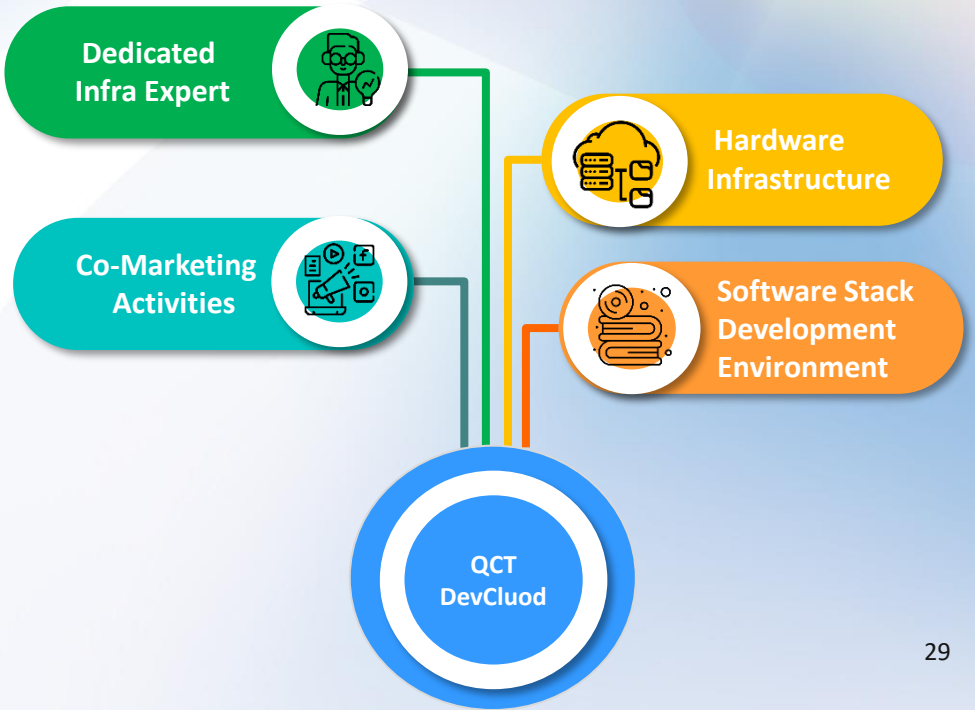
優化應用程式工作負載
Fine-tuned Application Workloads

- 高效能運算應用程式工作負載
- 機器學習應用程式工作負載
- 資料分析應用程式工作負載

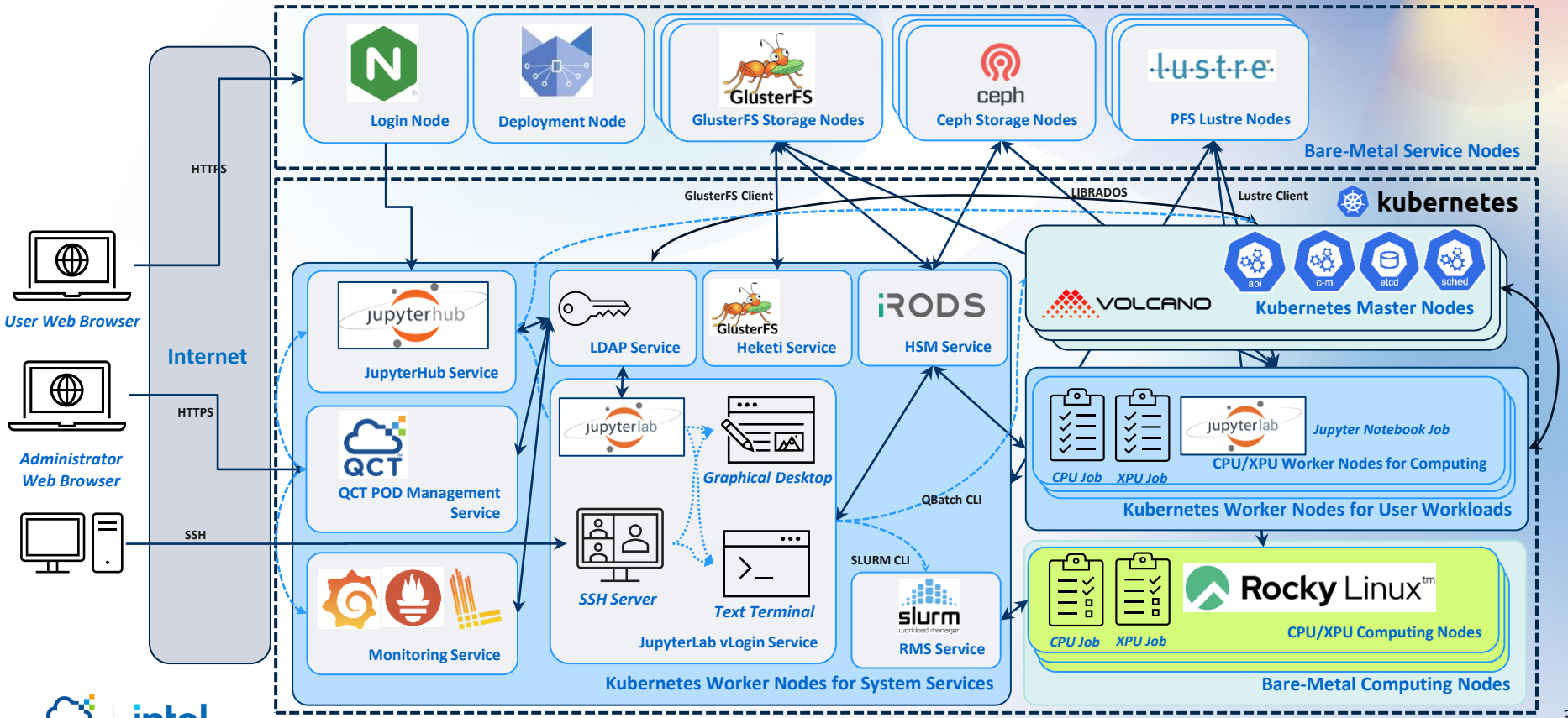
QCT DevCloud 測試計劃

QCT DevCloud 乃是針對高效能運算、資料分析與機器學習等應用服務工作負載，並基於QCT POD架構，整合了QCT新世代運算平台、預編譯HPC/AI應用程式及完整軟體開發工具環境之開放式平台，提供使用者藉由遠端快速存取以進行相關應用程式系統開發、整合測試與優化

- **特點**
  - 技術 (Technology)
    - 支援雲端原生架構 (Cloud Native)，採用Kubernetes容器化應用程式管理系統、Volcano先進工作排程與QCT QBatch CLI 軟體工具
  - 開放 (Openness)
    - 整合Rocky Linux 作業平台及HPC/AI/DA應用服務相關軟體套件
  - 彈性 (Flexibility)
    - 提供混合式運算資源與軟體定義資料儲存
- **適用對象**
  - 研究開發人員
  - 系統整合/軟體應用服務合作夥伴
- **期程**
  - 2023/01-2023/03 早鳥體驗方案
  - 2023/04 正式上線

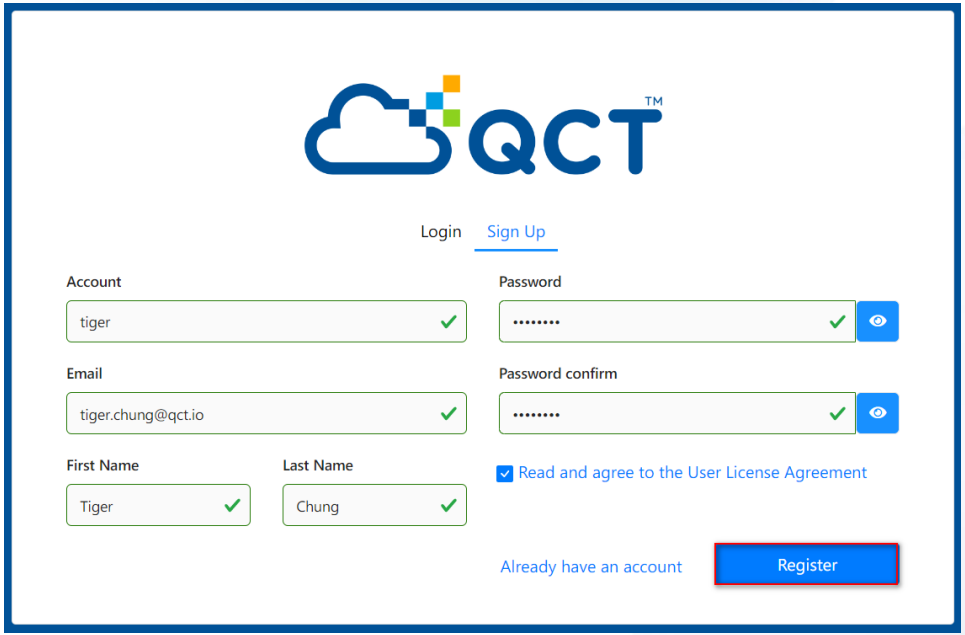


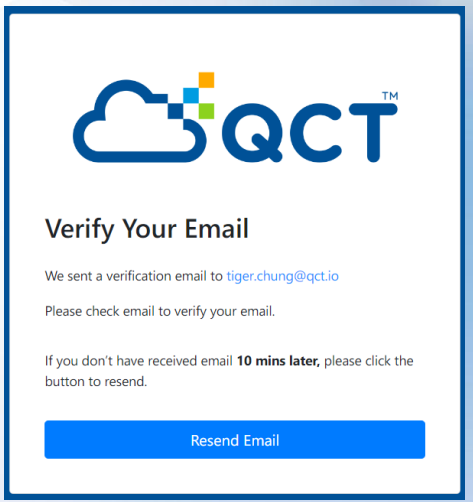
QCT DevCloud參考架構



QCT DevCloud巡禮 – 使用者註冊與登入

- Open a web browser and visit the following link - https://admin.openlab.qctio to access the service portal of QCT OpenLab DevCloud for user and system management
- For new users, they can activate their OpenLab DevCloud account as follows:





QCT DevCloud巡禮 – 本文模式遠端服務

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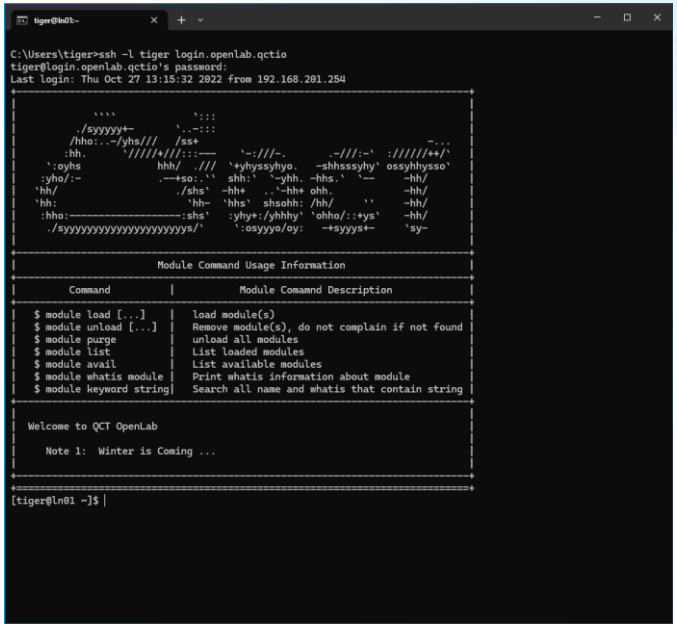
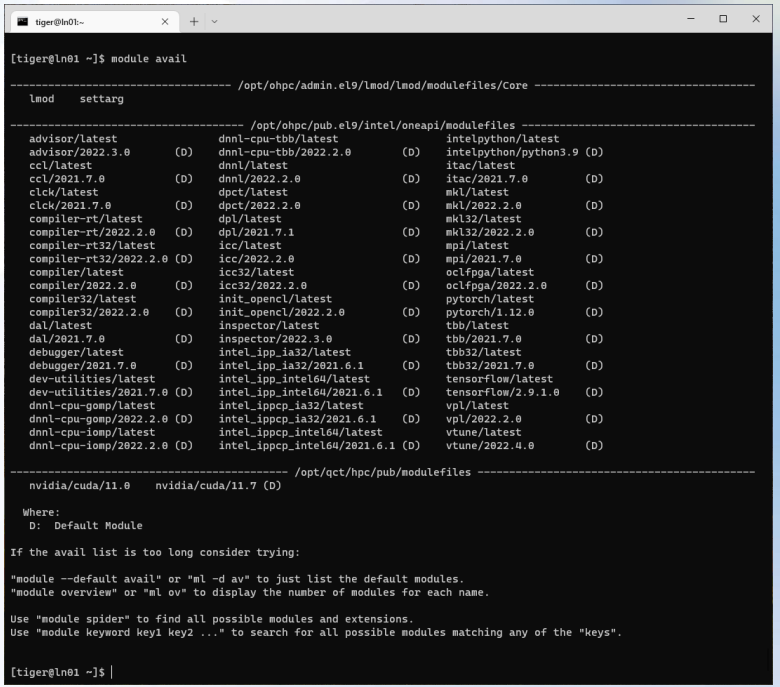
- User can access the OpenLab DevCloud via ssh protocol using the following command:
  $ ssh -l <account_name> login.openlab.qctio

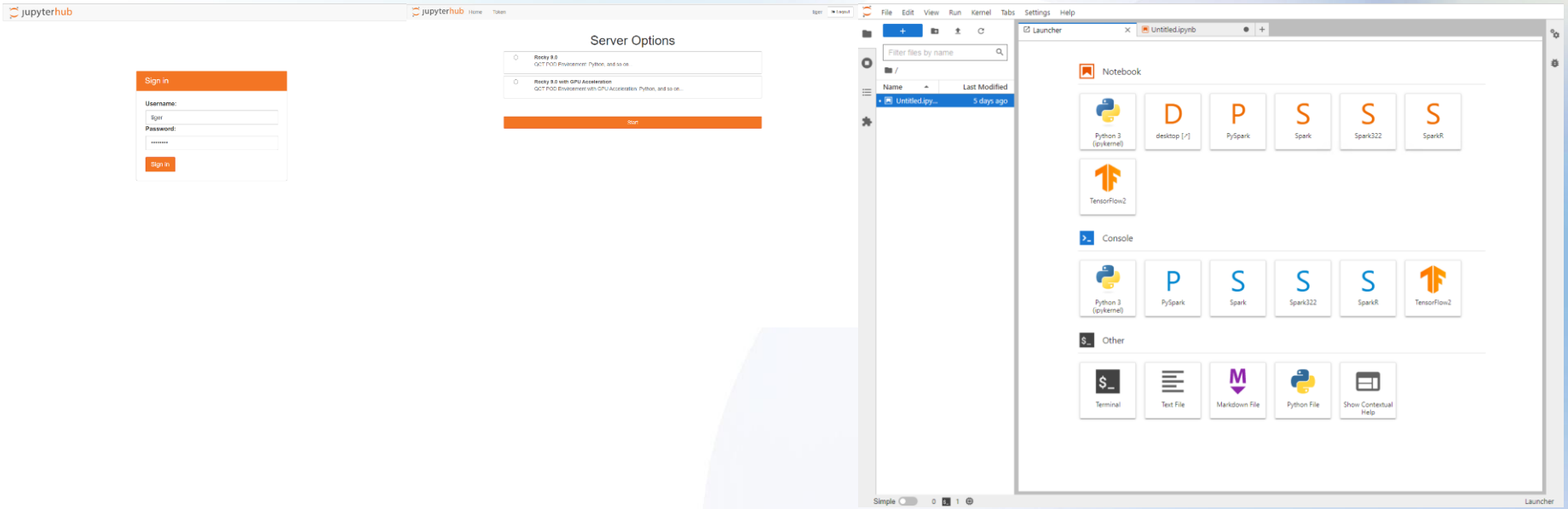


- Users can easily use all oneAPI toolkits by dynamically loading and unloading pre-defined modules



QCT DevCloud巡禮 – 網頁模式遠端服務

- User can access all services of the QCT DevCloud using their web browser.
- Just open a browser and visit the following link - https://login.openlab.qctio using their credential information to choose different profiles of the JupyterHub service as their major workspace



QCT DevCloud巡禮 – 網頁式互動服務

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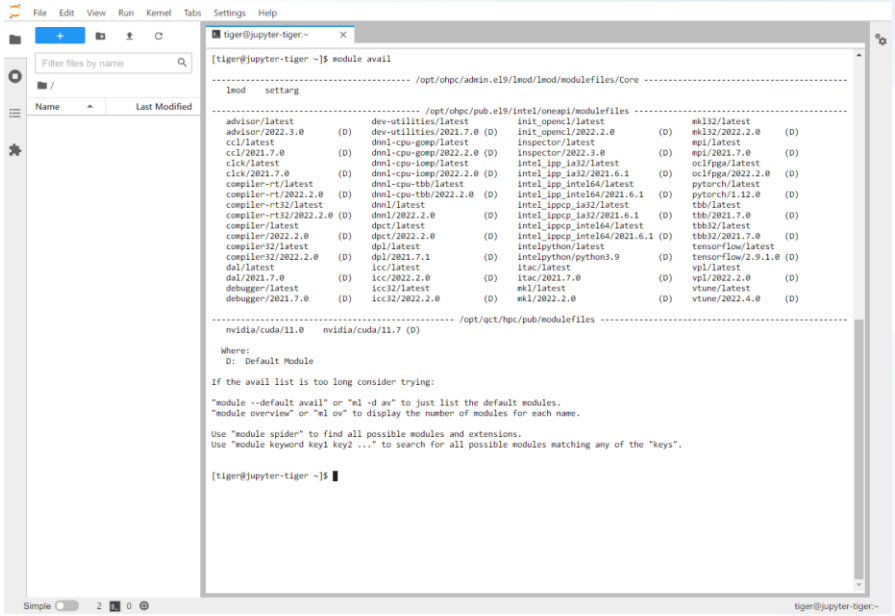
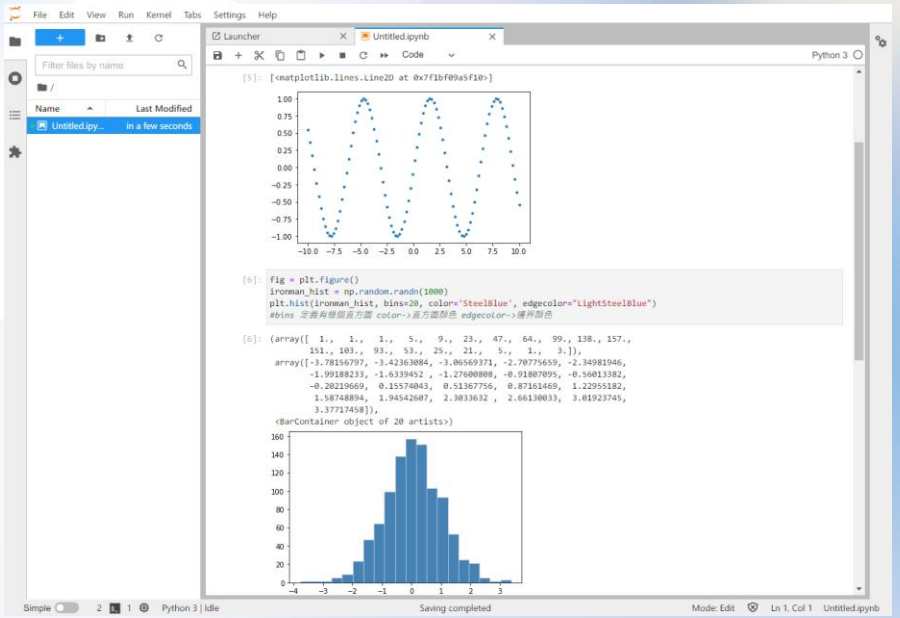
- Users can run their HPC, AI and DA workloads using all pre-installed and pre-configured software toolkits and frameworks such as Intel oneAPI, Python, Spark, PySpark and HPC modules tools through the JupyterHub service





QCT DevCloud巡禮 – 網頁式遠端桌面服務

RESHAPING THE FUTURE
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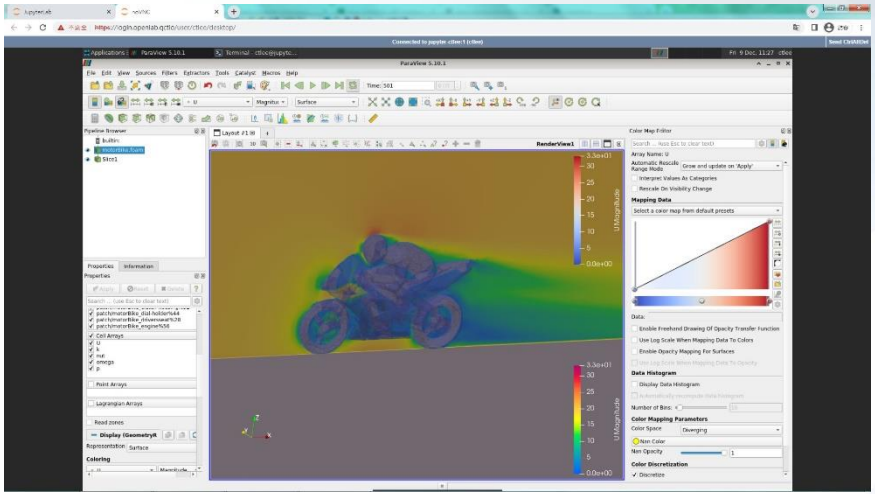
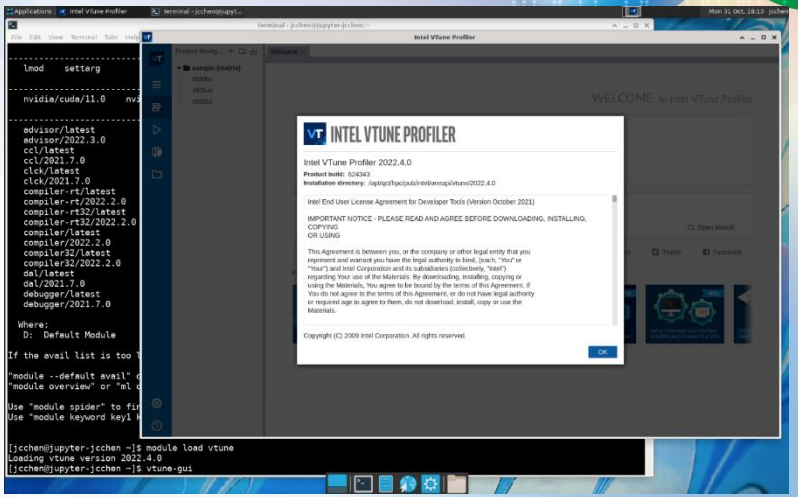




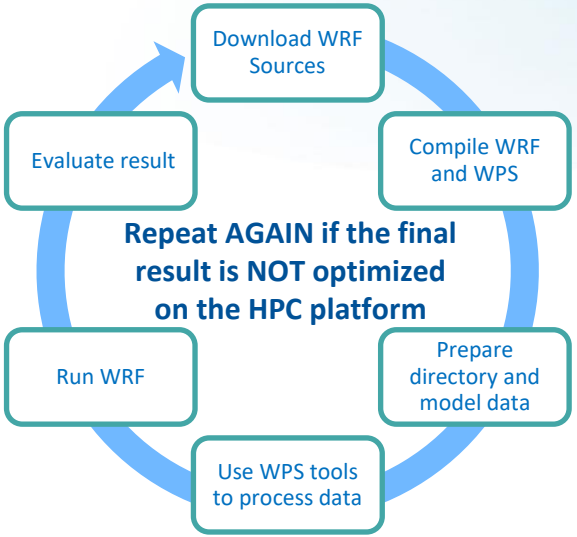
- Users can run legacy X11-based applications such as ParaVieiw on the JupyterLab environment without installing any software in their system
- Just only clicking the ”Desktop” icon on the Jupyter environment to access pre-configured “Remote GUI Desktop”

- Easily use Intel oneAPI toolkits such as VTune with pre-configured modules in just a few steps

```
$ module load vtune
$ vtune-gui
```

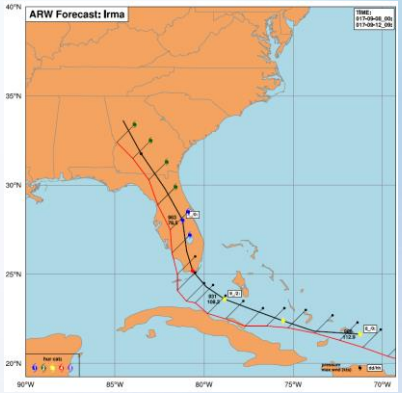
QCT DevCloud巡禮 – 預先優化工作負載

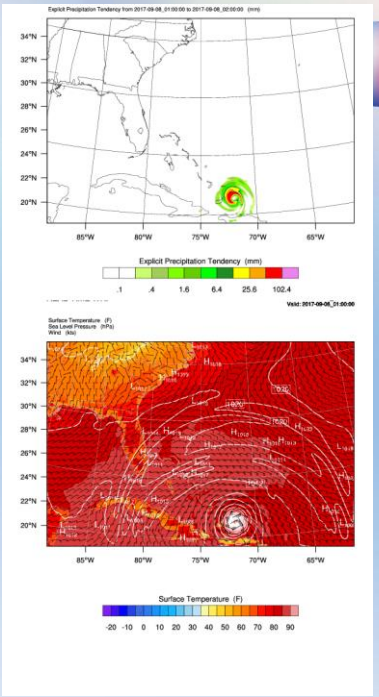
RESHAPING THE FUTURE
The Power Behind Digital Transformation



Process Simplified

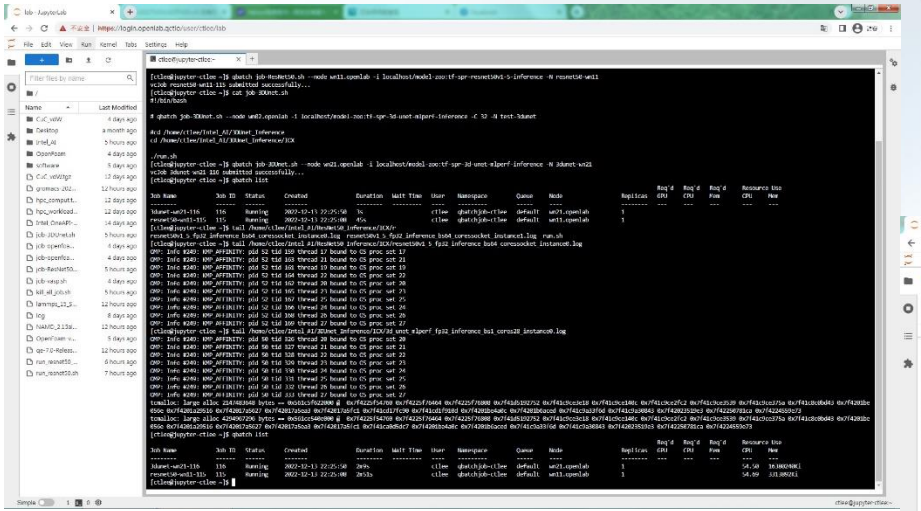
- Use pre-compiled QCT starter kit
- Prepare directory and model data
- Run WRF
- Evaluate result

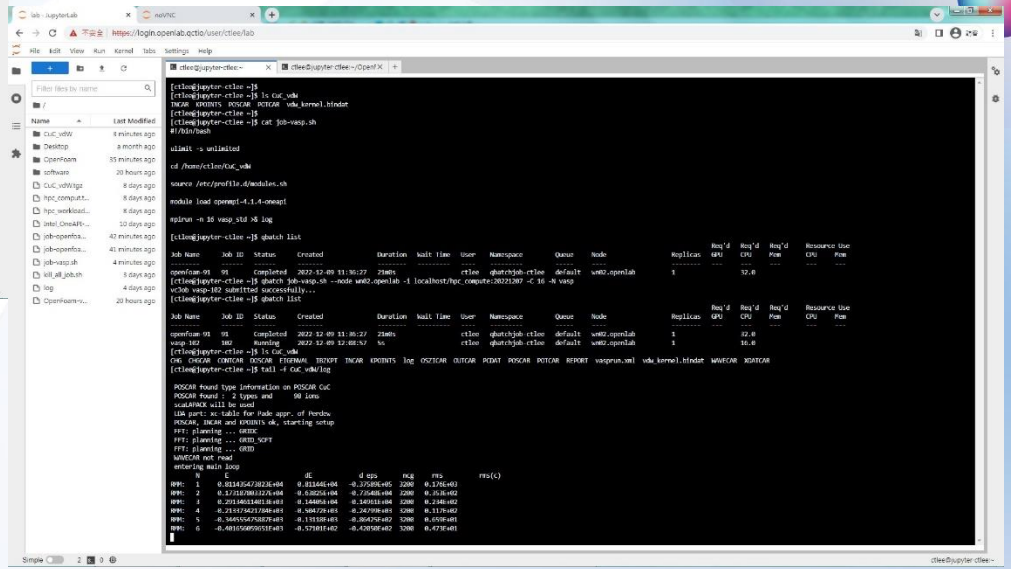




QCT | intel. Powered by Intel® Technology.

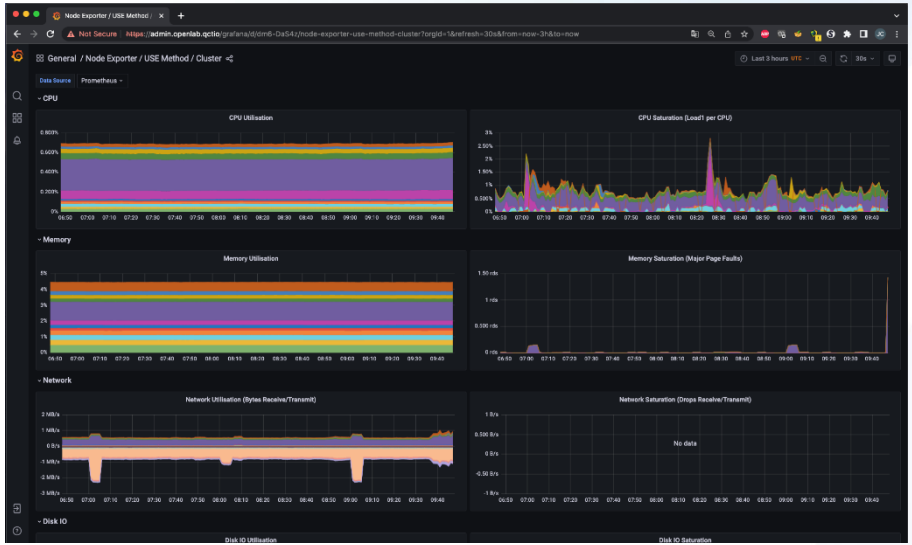
QCT DevCloud巡禮 – 應用程式工作排程

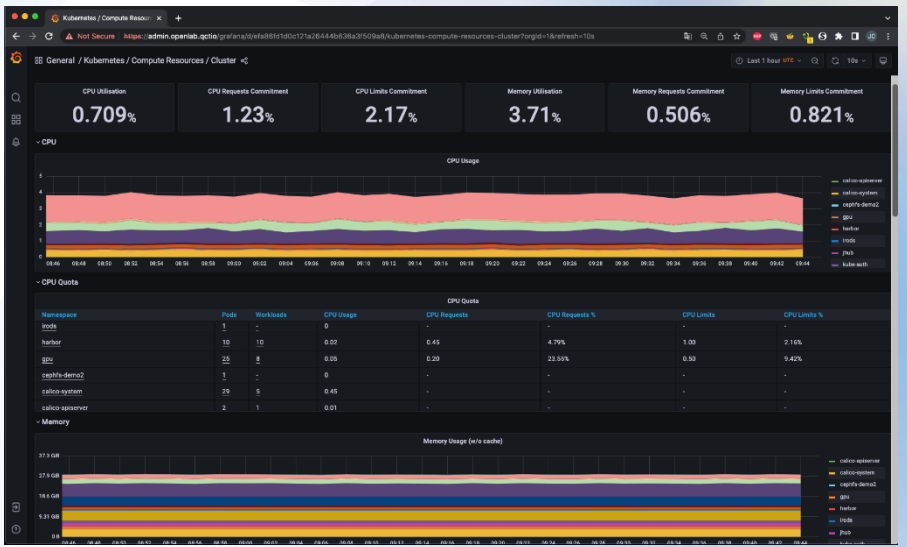




QCT DevCloud巡禮 – 即時系統監控

- Administrators or power users can interactively get all information about system health and events through the web-based real-time dashboard service





QCT HPC/AI解決方案及服務

Healthcare | Manufacturing | HER (Higher Education & Research) | Vertical X

Service & Maintenance | DevCloud Program | Regional Open Lab

Infra Technical Expert | Demand Pattern Analysis | Architecture Design | Workload Tuning & Benchmarking

QxStack Microsoft Solution

- Azure Stack HCI
- AKS on Azure Stack HCI

QxStack VMware Solution

- vSAN HCI
- VCF
- VDI
- Tanzu

QCT POD solution

Management	Compute				Storage
Cluster Mgmt.	Edge Computing	Data Analytics	AI	HPC	SDS

Data Center Solution Portfolio

Server

Intel Ice Lake


QuantaGrid D53X-1U


QuantaGrid D53XQ-2U


QuantaPlex T43Z-2U

Intel Sapphire Rapids


QuantaGrid D54X-1U


QuantaGrid D54Q-2U


QuantaGrid D54U-3U


QuantaGrid D74H-7U

Storage


QuantaGrid S54S-1U


QuantaGrid S24P-5U


QuantaVault JB4603

Switch


QuantaMesh T4048-IX8D


QuantaMesh T1048-LB9M

Rack


QoolRack

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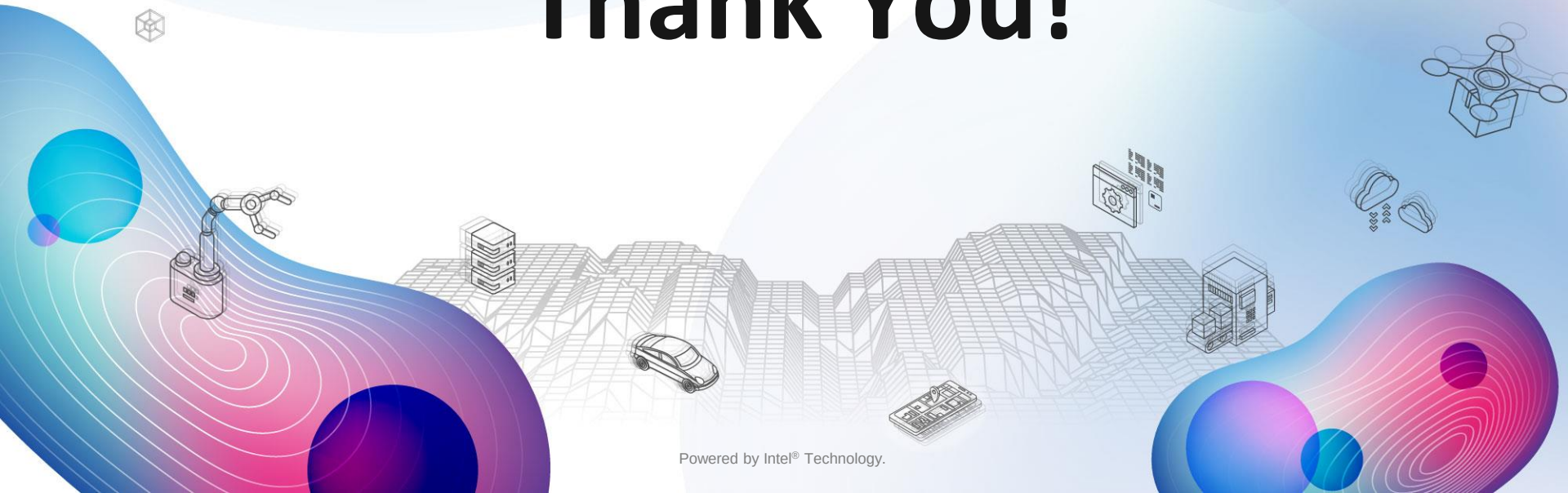
Thank You!



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