

スーパーコンピュータ『富岳』の概要

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PCCCワークショップ
2020/02/21

富岳



スーパーコンピュータ「富岳」



- 2018年夏、富岳の試作機完成
- 2019年12月2日（月）富士通工場から出荷開始
- 富岳の約10ラックで「京」と同じピーク性能（「京」は864ラック）。電力は 1/20

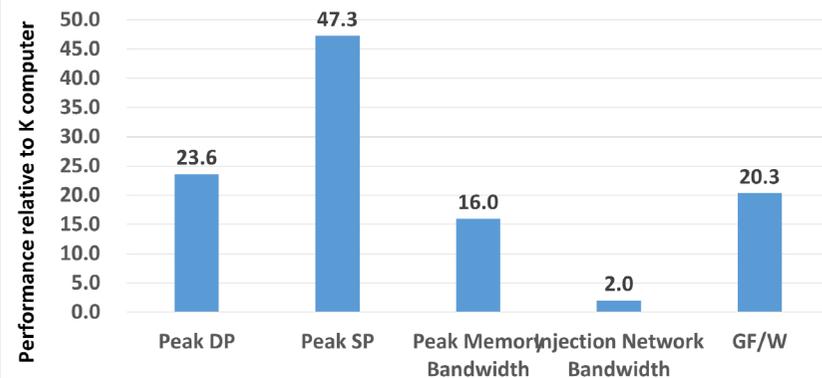


10 racks =

写真は2ラック分



		Fugaku	K
CPU Architecture		A64FX (Armv8.2-A SVE +Fujitsu Extension)	SPARC64 VIIIfx
Node	Cores	48	8
	Peak DP performance	3.0720 TF (3.3792 TF)	0.128 TF
	Main Memory	32 GiB	16 GiB
	Peak Memory Bandwidth	1024 GB/s	64 GB/s
	Peak Network Performance	40.8 GB/s	20 GB/s
Rack	Nodes	384	102
	Peak DP performance	1.2/1.3 PF	< 0.013PF
Process Technology		7 nm FinFET	45 nm

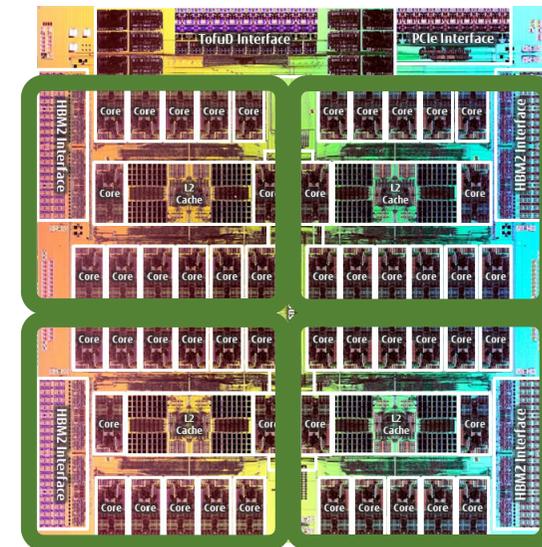


CPU A64FX

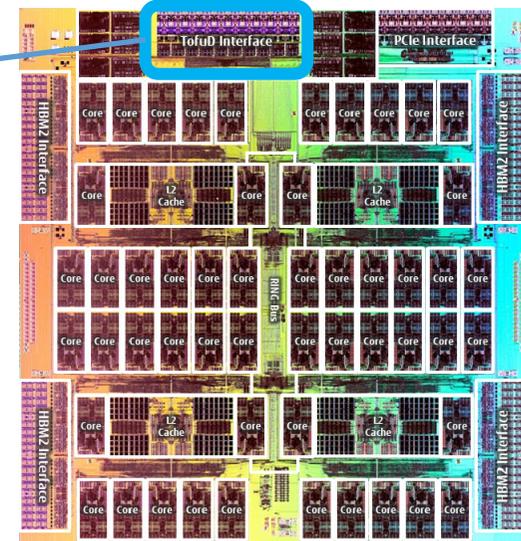
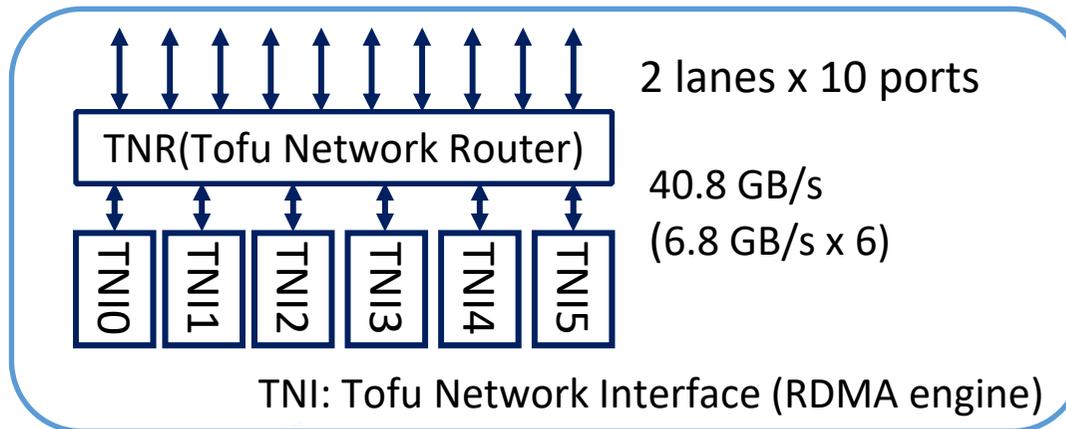


Courtesy of FUJITSU LIMITED

Architecture	Armv8.2-A SVE (512 bit SIMD)
Core	48 cores for compute and 2/4 for OS activities
	DP: 3.0720 TF (3.3792 TF)
Cache L1	64 KiB
Cache L2	CMG(NUMA): 8 MiB, 16way
Memory	HBM2 32 GiB, 1024 GB/s
Interconnect	TofuD (28 Gbps x 2 lane x 10 port)
I/O	PCIe Gen3 x 16 lane
Technology	7nm FinFET



TofuD Interconnect



- 6 RDMA Engines
- Hardware barrier support
- Network operation offloading capability

8B Put latency	0.49 – 0.54 usec
1MiB Put throughput	6.35 GB/s

rf. Yuichiro Ajima, et al. , “The Tofu Interconnect D,” IEEE Cluster 2018, 2018.

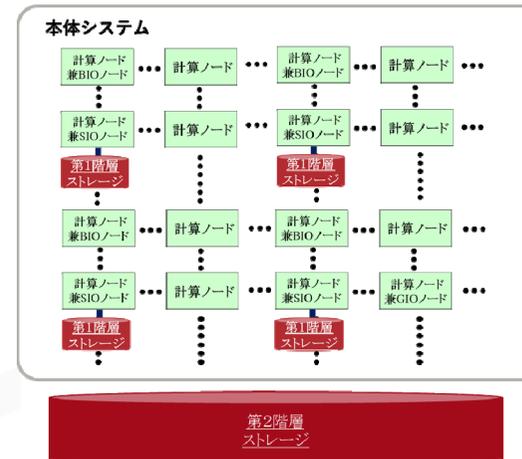
スーパーコンピュータ「富岳」



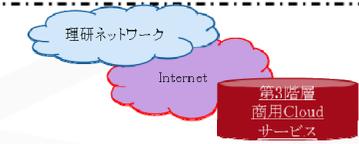
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写真は2ラック分



フロントエンド部
 ログイン兼ファイル転送ノード(Intel)
 ログイン兼ファイル転送ノード(Arm)
 大容量メモリ搭載ログインノード
 可視化用ノード
 クラウドストレージゲートウェイ
 Web API用ノード
 Web API用コンテナノード
 Web API用DBノード

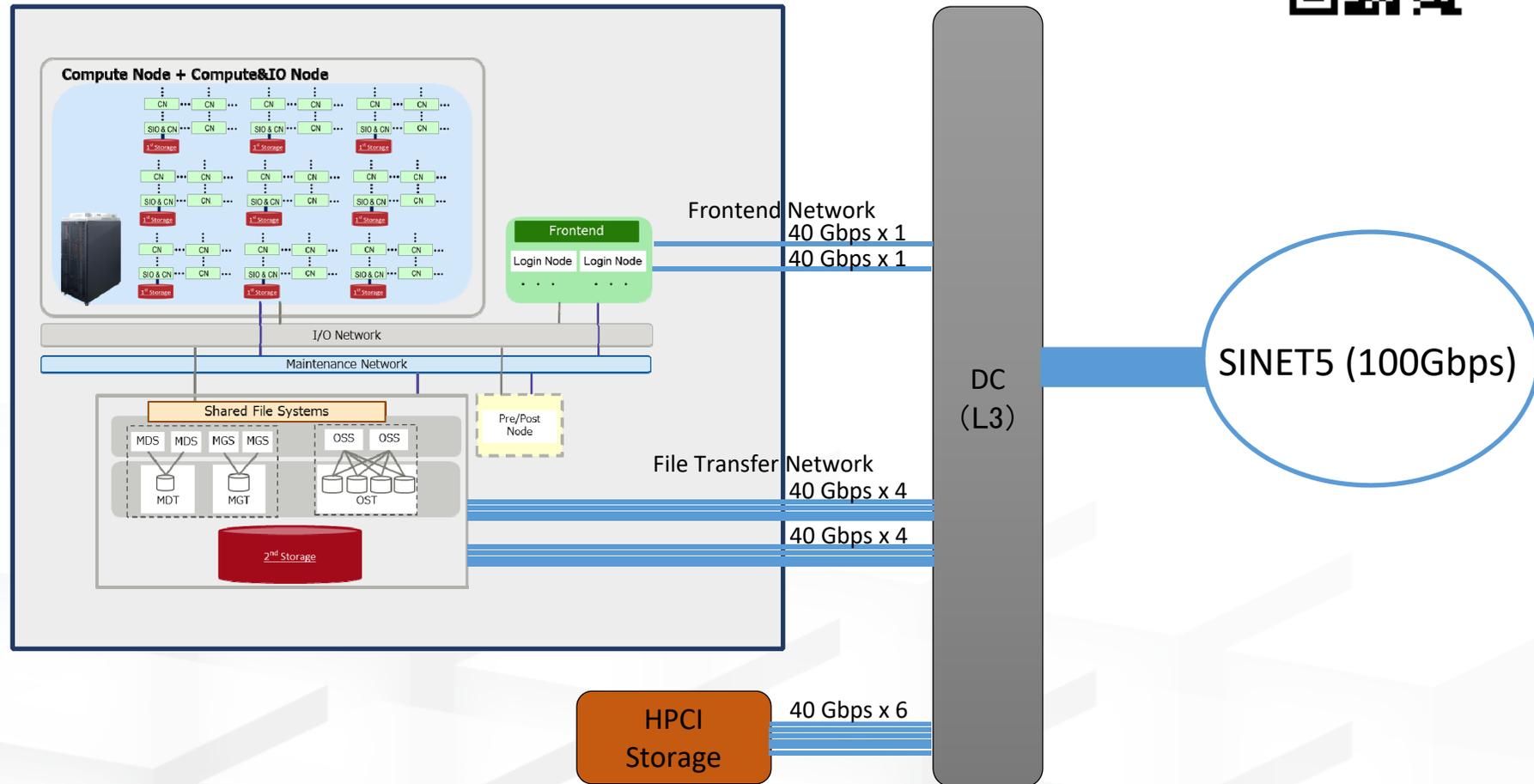


- 総ノード数：150kノード以上
- 第1階層ストレージ
 - 16計算ノード毎に1計算兼ストレージノード 約1.6 TB
 - 提供サービス
 - 第2階層ストレージキャッシュ
 - 計算ノード向けローカルファイルシステム
 - ジョブ向け共有ファイルシステム
- 第2階層ストレージ
 - Lustreベースグローバルファイルシステム 約150PB

- Pre/Post処理
 - 大容量メモリログインノード (約6TB)
 - 可視化用ノード

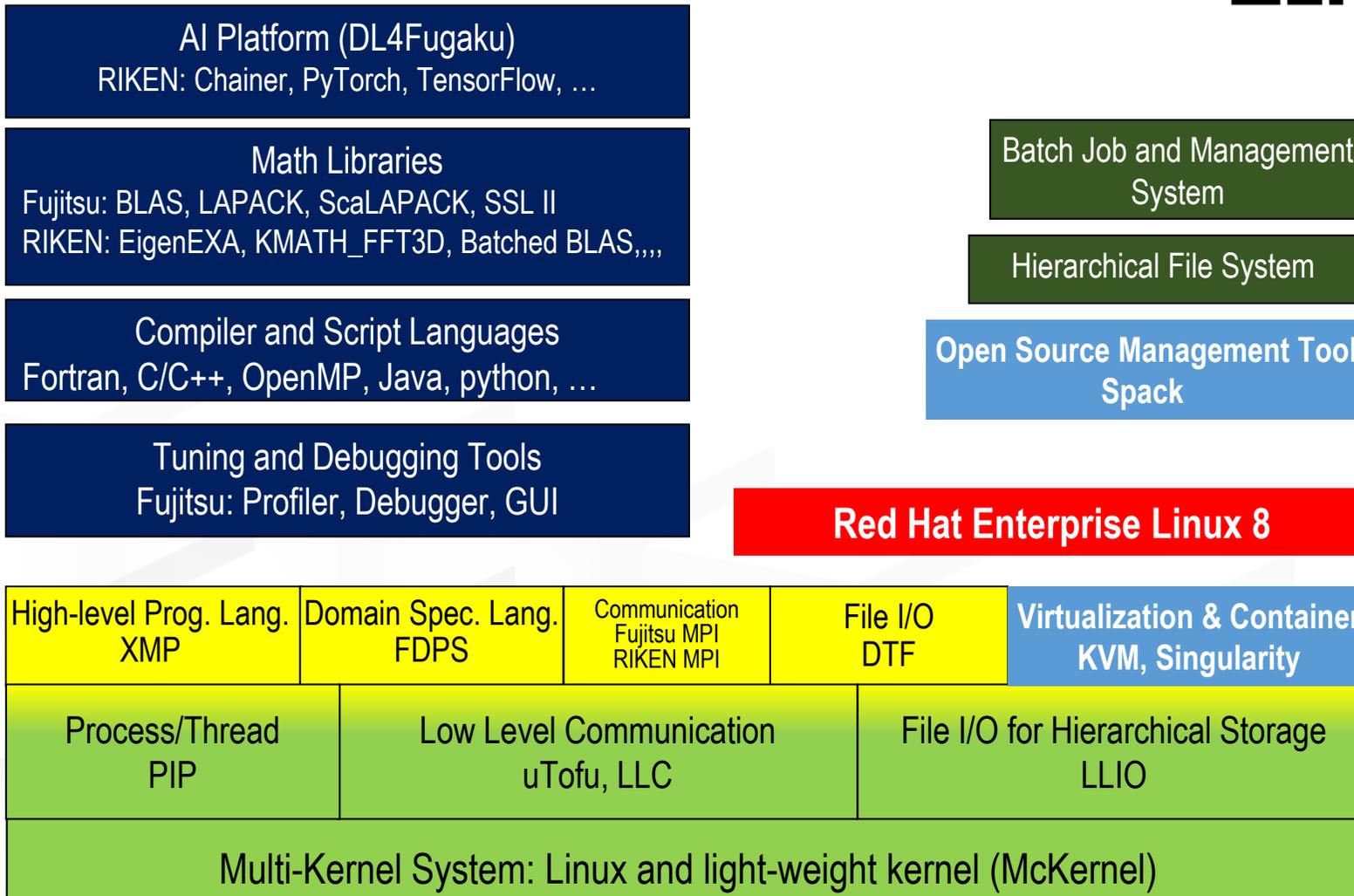


外部ネットワーク 接続



次期SINETにも対応できるように
機器構成としている

システムソフトウェアスタック



想定プログラミングモデル

● MPI Programming Model

- 1 process/CMG (12 cores)
 - 1 MPI process with OpenMP parallelism or automatic parallelization runs on 12 cores.
- 1 process/node
 - 1 MPI process with OpenMP parallelism runs on 48 cores

- Many processes with OpenMP parallelism / CMG

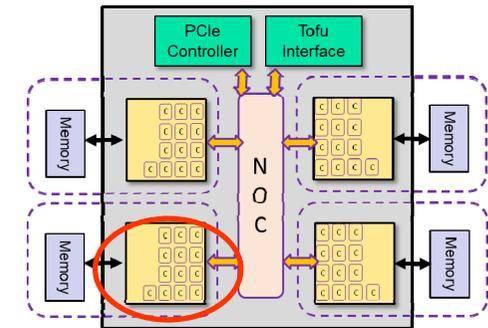
● PGAS Programming Model

- PGAS + OpenMP
 - 1 PGAS process with OpenMP parallelism runs on one node or 1 CMG

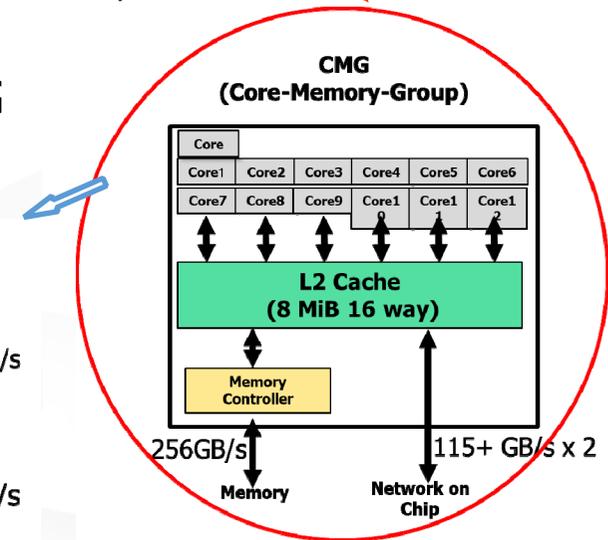
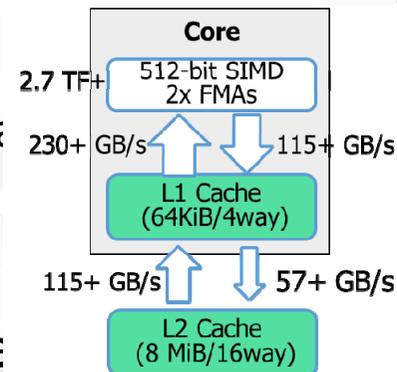
- 1 PGAS process / core

● DSL (Domain Specific Language)

- FDPS



Two compute nodes are implemented on one board



Spack

- Spack, developed at LLNL, is a package manager for supercomputers enabling easy software installation
- 3,000+ packages have been registered, e.g., abinit, lammps, openfoam, namd, blast, blat, ...
- Build Verification Status of version: 6th September 2019

	GCC	Clang	Fujitsu Compiler
x86	2479/3451(71.8%)	768/3574 (21.49%)*	N/A
aarch64	2387/3451(69.1%)	288/3451(60.04%)	2072/3451(60.04%)

* Version 31st October 2019

- Pull Requests: Riken 66, Fujitsu 56
- Results of Verification of Compilation:
 - <https://postk-web.r-ccs.riken.jp/oss/public/>

We have not tested execution of applications



Build Verification of Spack Recipes



- Spack version: 6th September 2019
- Verification Environment:

理研 株式会社理研 鼎業 意味 - Google 検索 新しいタブ Open Source Software

https://postk-web.r-ccs.riken.jp/oss/public/ 67%

理化学研究所 計算科学研究センター Post-K (Fugaku) Information
RIKEN Center for Computational Science

Top Specifications Performance Applications OSS Misc Perf. Eval. FAQ/Survey

> Top > Open Source Software

List of Open Source Software which can be built on Fugaku

Spack will be used to manage open source software packages on Fugaku. Fugaku users can easily use pre-installed packages and built packages based on Spack recipes. The following list shows the results of building/compiling packages for aarch64 according to the Spack recipes. Note that the results in this list do not guarantee that each package will work properly.

Build success rate per compiler

- Fujitsu Compiler: 1745/2861(60.99%)
- GCC: 2387/3451(69.17%)
- Clang: 288/3450(8.35%)

Search

Last Modified: 11/8/19, 3:35 AM GMT
Spack Version: [9/6/19, 1:15 AM GMT](#)

Click YES/NO for further information.

Package ↓	Version	Fujitsu Compiler	GCC	Clang
abinit	8.10.3	NO	NO	NO
abyss	2.1.4	NO	NO	NO
accfft	develop	NO	YES	NO
ack	2.22	YES	YES	YES
activeharmony	4.5	NO	NO	NO
acts-core	0.10.1	NO	YES	YES

y 128GB

N/A

361(64.1%)
until mid Nov.)
242(65.3%)
3rd June 2019)



富岳の性能



□ Predicted Performance of 9 Target Applications

As of 2019/05/14

Area	Priority Issue	Performance Speedup over K	Application	Brief description
Health and longevity	1. Innovative computing infrastructure for drug discovery	125x +	GENESIS	MD for proteins
	2. Personalized and preventive medicine using big data	8x +	Genomon	Genome processing (Genome alignment)
Disaster prevention and Environment	3. Integrated simulation systems induced by earthquake and tsunami	45x +	GAMERA	Earthquake simulator (FEM in unstructured & structured grid)
	4. Meteorological and global environmental prediction using big data	120x +	NICAM+ LETKF	Weather prediction system using Big data (structured grid stencil & ensemble Kalman filter)
Energy issue	5. New technologies for energy creation, conversion / storage, and use	40x +	NTChem	Molecular electronic simulation (structure calculation)
	6. Accelerated development of innovative clean energy systems	35x +	Adventure	Computational Mechanics System for Large Scale Analysis and Design (unstructured grid)
Industrial competitiveness enhancement	7. Creation of new functional devices and high-performance materials	30x +	RSDFT	Ab-initio simulation (density functional theory)
	8. Development of innovative design and production processes	25x +	FFB	Large Eddy Simulation (unstructured grid)
Basic science	9. Elucidation of the fundamental laws and evolution of the universe	25x +	LQCD	Lattice QCD simulation (structured grid Monte Carlo)

スケジュール

