Information Technology

Development of the computing infrastructure

The aim of the further development of the JINR computing infrastructure is to provide performance of a whole range of competitive research activities at the world's level at JINR and cooperating centres worldwide both within the JINR programme for scientific research and development, in particular the NICA megaproject, and within the priority research tasks that are performed in cooperation with leading research centres such as CERN, FAIR, BNL, etc.

For the Laboratory of Information Technology, one of the major objectives in the Seven-year plan is the creation of a unified information environment integrating a number of various technological solutions, concepts and techniques. Such environment should integrate supercomputer (heterogeneous), grid- and cloud-complexes and systems in order to grant optimal approaches for solving various types of scientific and applied tasks. The necessary requirements to such an environment are scalability, interoperability, and adaptability to new technical solutions.

Expected results:

1. Creation of a JINR Multifunctional Information and Computing Complex (MICC) of a global level for the development of advanced information technology;

2. Development of a territorially distributed research environment to provide the use of the Complex capacities by the JINR and cooperating centres worldwide including joint international projects;

3. Research in the field of intensive operations with mass data in the distributed systems (Big Data), development of corresponding tools and methods of visualization, including 3D;

4. Scientific studies in the field of integrating base, cloud, grid and high performance computing technologies with the purpose of their optimal use within the MICC;

5. Research on issues of optimizing the processes of using the existing capacities, in particular supercomputers, for data processing in distributed environment;

6. Introduction and development of a methodology of a short-term/medium term/long-term forecast of the MICC development;

7. Research in the field of integration of heterogeneous computing resources and data sources into a unified distributed computing system;

8. Creation of a software technological complex providing introduction of cloud technologies for organization of research by distributed user groups, introduction of intellectual methods of new generation grid-cloud structures management;

9. Research in the field of the global monitoring of the distributed computing systems;

10. Development of new parallel applications, cross-platform and multi-algorithm software complexes in a heterogeneous computing environment that allow one to expand a spectrum of computationally intensive solved fundamental scientific problems.

One of the main components of the Multifunctional Information and Computing Centre providing access to the resources and opportunity of work with Big Data is the network infrastructure. For this infrastructure and its telecommunication data links to correspond to the requirements on reliability and availability of the complex for the JINR and cooperating centres worldwide using the resources of the complex to perform their investigations, the obligatory double reservation of all the connections and reliable 100 Gbps and more telecommunication channels are required.

A major task of the Seven-year plan will be further expansion of the engineering infrastructure of the MICC connected with the start-up of the NICA accelerator complex and conduct of its experiments.

Another important task of the Seven-year plan is the development of the JINR corporative information system for collective use and management of the information produced by JINR laboratories and departments to establishing of the general information space, improvement of information provision and decision-making process support.

Mathematical support of studies conducted at JINR

The solution of problems in computational physics and mathematics, encompassing a wide spectrum of research underway at JINR, requires the development of new mathematical methods and approaches, the creation of algorithms and software for numerical and symbolic-numerical simulations with the help of the newest computer hardware with multi-core architecture, coprocessors and graphic accelerators. Such computational systems provide the way towards significant speed-up of mathematical calculations by selecting the paralleling technology which takes into account the specificity of the problem under solution. The adaptation to the heterogeneous architectures of previously developed software and the creation of new applications based on modern parallelization techniques making the best use of the opportunities provided by the available computing resources are of particular importance. A separate task is the development of software platforms and environments for designing parallel applications and development of services that will significantly simplify the user work on such computing complexes.

Expected results:

1. Software development and realization of mathematical support of experiments conducted at the JINR basic facilities and in frames of international collaborations at the largest installations worldwide, including introduction of high-speed methods, algorithms and software for parallel processing and analysis of experimental data on heterogeneous and distributed computer complexes;

2. Development of numerical methods, algorithms and software complexes for modelling complex physical systems, including interactions inside a hot and dense nuclear matter, physico-chemical processes in materials exposed to heavy ions, evolution of localized nanostructures in the open dissipative systems, properties of atoms in magnetic optical traps, electromagnetic response of nanoparticles and optical properties of nanomaterials, evolution of quantum systems in external fields, astrophysical studies;

3. Development of methods and algorithms of computer algebra for simulation and research of quantum computations and information processes, low-dimensional nanostructures in external fields, discrete quantum systems with nontrivial symmetries.

4. Development of mathematical, algorithmic and program methods of description of tangled (entanglement of) conditions of qubit systems as a basic resource of quantum informatics.

5. Development of symbol-numerical methods, algorithms and software complexes for the analysis of low-dimensional compound quantum systems in molecular, atomic and nuclear physics.

Plan for the development of the Multifunctional Information and Computing Complex

	2017	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Tier1-CMS and NICA data storage							
Performance upgrade: CPU kHS06	67.2	83.2	160.0	200.0	240.0	300.0	350.0
Disk storage upgrade (TB)	5070	6100	8000	8800	10800	13100	16100
Mass memory upgrade (TB)	20000	20000	20000	25000	30000	35000	42000

Tier2 and computer resources with a storage system for local users							
Performance upgrade: CPU kHS06	59.2	75.2	96.0	110.0	130.0	150.0	170.0
Upgrade of disk storage (TB)	2970	3400	5000	5500	6000	6500	7000
Heterogeneous cluster for parallel computations							
Performance (Tflops)	180	240	300	360	420	480	540
Upgrade of disk storage (TB)	55	60	60	65	70	75	80
Cloud infrastructure							
Cores	630	1000	1500	2250	3500	5000	7500
RAM/GB	1280	2000	3000	4500	7000	10000	15000
Disk servers/TB	40	80	160	320	640	1200	2500
External telecommunication data links and JINR local area network							
Data link bandwidth/Gbps	100						

Financing schedule (k$)

	2017	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**Total**
Modernization of the climate control system and sources of uninterrupted power supply	398.0	432.0	300.0	342.3	487.8	331.7	353.0	**2 644.8**
Gradual upgrade of computing resources	537.0	768.9	807.4	537.0	830.3	1 000.0	1 200.0	**5 680.6**
Stage-by-stage expansion of the data storage system on disk servers	640.0	960.0	960.0	960.0	1280.0	1280.0	1280.0	**7 360.0**
Stage-by-stage expansion of the robotized tape storage	350.0	400.0	400.0	400.0	550.0	650.0	750.0	**3 500.0**
Upgrade of the local network	450.0	400.0	400.0	400.0	400.0	400.0	550.0	**3 000.0**
Increase of computing resources and disk arrays of the heterogeneous cluster	245.0	462.0	470.0	470.0	470.0	470.0	470.0	**3 057.0**
Licensed software	280.0	300.0	300.0	300.0	300.0	400.0	400.0	**2 280.0**

Consumables, equipment and specialized licensed software	105.0	200.0	200.0	200.0	300.0	300.0	300.0	**1 605.0**
Cloud infrastructure development	223.0	500.0	500.0	500.0	500.0	600.0	600.0	**3 423.0**
Replacement of critical and obsolete equipment	157.2	250.0	450.0	250.0	250.0	340.0	250.0	**1 947.2**
Equipment for the central core of the network infrastructure	100.0	100.0	150.0	150.0	150.0	150.0	175.0	**975.0**
External data links and transition to 100 Gbps	180.0	0.0	0.0	100.0	100.0	100.0	100.0	**580.0**
Diesel generator plant (DGP)	565.0	0.0	0.0	528.7	0.0	0.0	0.0	**1 093.7**
Replacement of transformers and repair of the cooling stack	185.0	0.0	0.0	0.0	0.0	0.0	0.0	**185.0**
Repairs of the 2nd and 4th floor	150.0	100.0	150.0	100.0	0.0	0.0	0.0	**500.0**
Current expenses	210.0	210.0	218.0	227.0	236.0	252.5	300.0	**1 653.5**
Total	**4 775.2**	**5 082.9**	**5 305.4**	**5 465.0**	**5 854.1**	**6 274.2**	**6 728.0**	**39 484.8**