ABOUT DEVELOPMENT SYSTEM FOR THE ANALYSIS OF CHARGED PARTICLE BEAM DYNAMICS

M. Balabanov*, Saint-Peterburg State University, Saint-Peterburg, Russia

Abstract

Modern research process of scientific problems often requires large computational resources. To solve them we have to use distributed computing systems. Researcher groups need to use them simultanieously and mostly remotely. The paper describes build of the distributed system for collaborative research process. As example was chosen a problem of the optimization dynamics charged particle beams using high-performance computing systems. The solution of many topical tasks leads to nonlinear optimization problems for example the controlling beams of charged particles [1-10].

Optimization is performed by minimizing some quality functional the choice of which is a corollary fact that the control functions which provides a functional minimum should determine the accelerating structure with the desired characteristics. The problem is usually formulated as finding the control functions for which the controlled system satisfies the given constraints. There is a necessity of the quality functional choice which ensures the problem solution. Research objectives: the development of a distributed information-computational system for the analysis of charged particle beam dynamics.

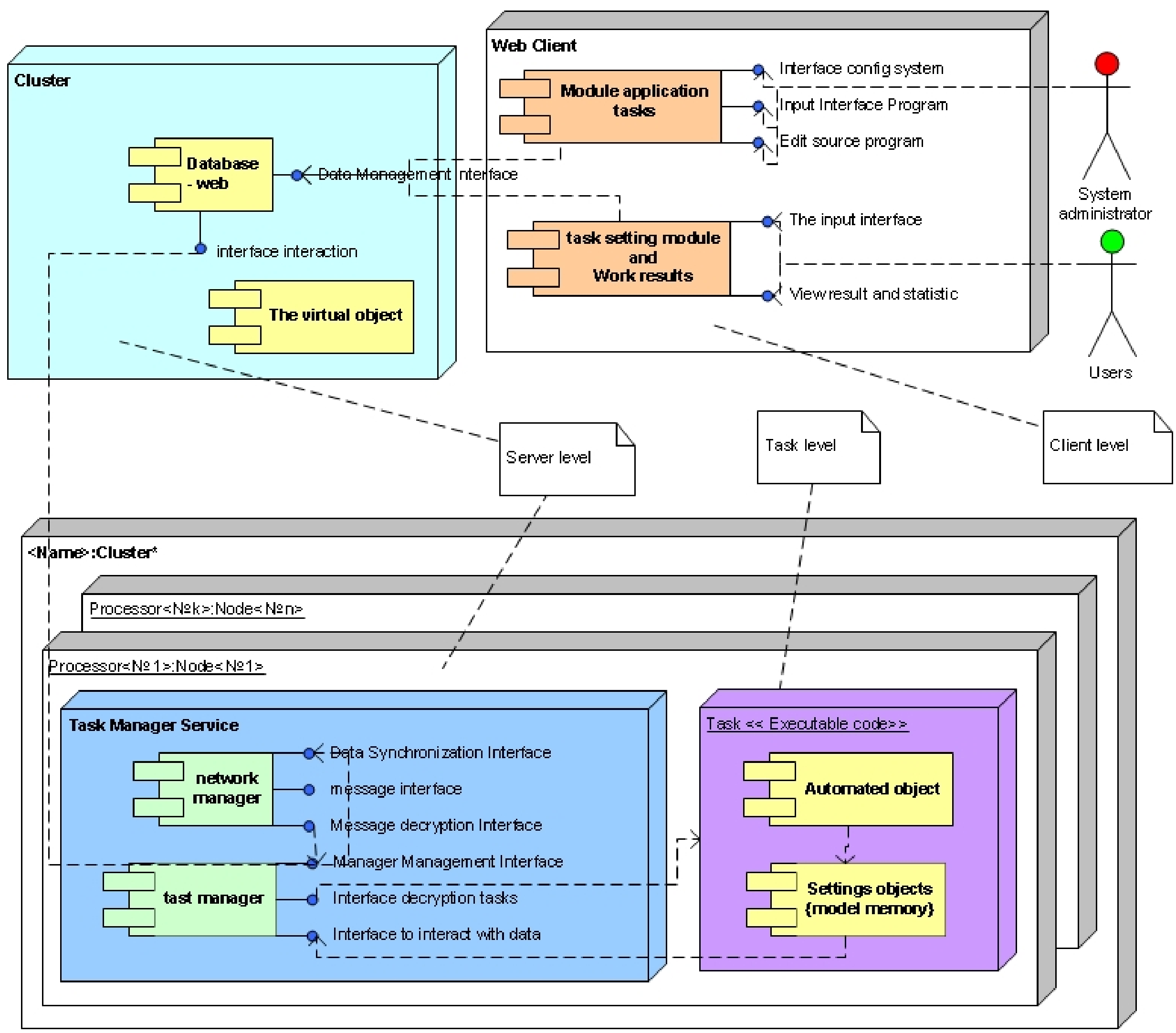


Figure 1: System architecture.

* BalabanovMYu@gmail.com

ISBN 978-3-95450-181-6

SYSTEM ARCHITECTURE

Three-tier architecture has been proposed at the design stage fig. 1. The system uses a mixed control model: centralized control manager (client-server interaction) and broadcast event management (internal client management)[11]. The main features of the system elements were determined in decomposition stages. System structure provides the problem encapsulation, virtualization of working with remote components, modularity and the external programs connect ability.

Application domain analysis allows to identify the main interaction interfaces and classes that allows to structure virtualization engine for models and methods implemented on late-binding technique. The database structure was derived from the application domain infological model.

Customer level is implemented as a web application fig. 2 and fig. 3.

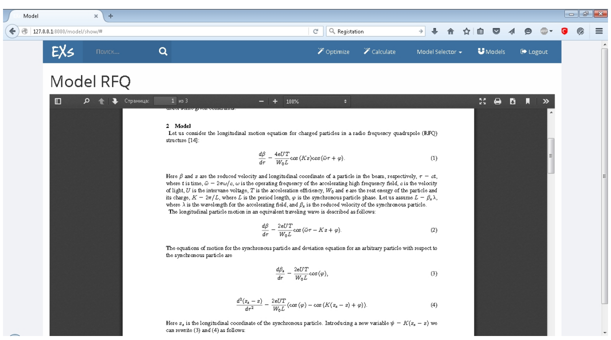


Figure 2: View web application: page about model.

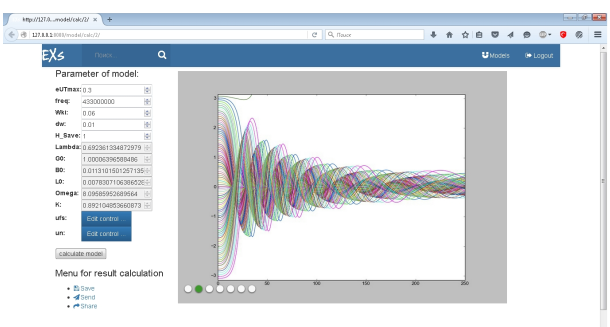
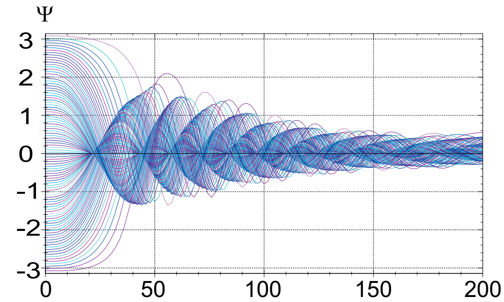


Figure 3: View web application: page calculate model.

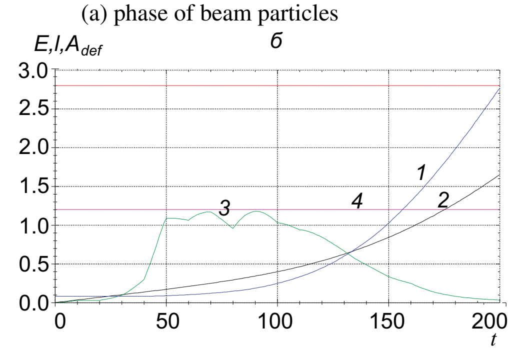
RESULT

The system approbation had carried out: implemented the longitudinal motion model of charged particles in the structure with spatially uniform quadrupole focusing. The model optimization had carried out (with augmenting the knowledge base).

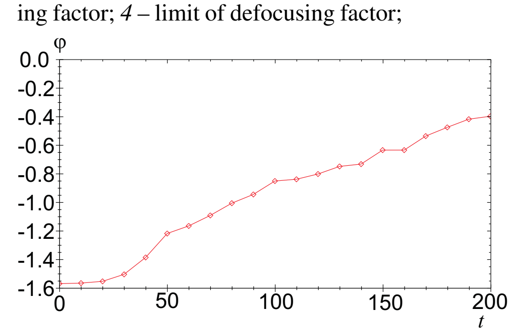
The following problem is the search admissible control. The following longitudinal motion equation for charged particles in a radio frequency quadrupole (RFQ) structure [9]. Search admissible control carried for the proton accelerator at 352 MHz frequency. The following limitations



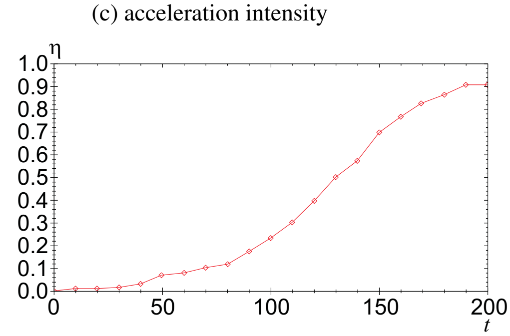
(a) phase of beam particles



(b) *1* – energy (MeV); *2* – length of structure (m); *3* – defocusing factor; *4* – limit of defocusing factor;



(c) acceleration intensity



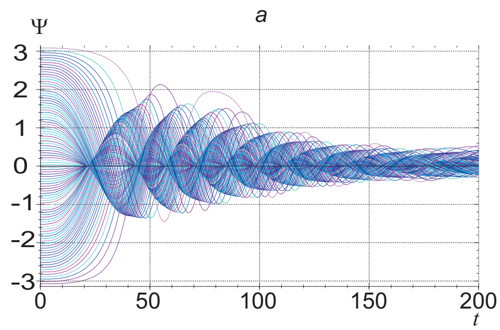
(d) synchronous phase

Figure 4: characteristics to optimize.

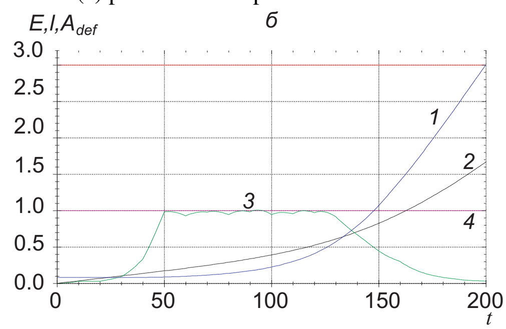
were taken into account: $(UT)_{\max} \leq 45$ and limitations on characteristics of the structure and controls.

At the first stage, the initial control search satisfying certain constraints extension, which is being implemented in several ways: searching in the knowledge base and applying initial control search techniques. One embodiment of the found structure has the following characteris-

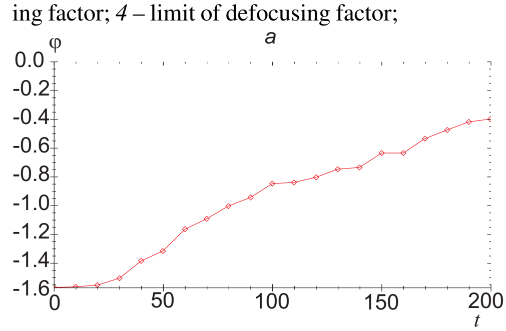
ISBN 978-3-95450-181-6



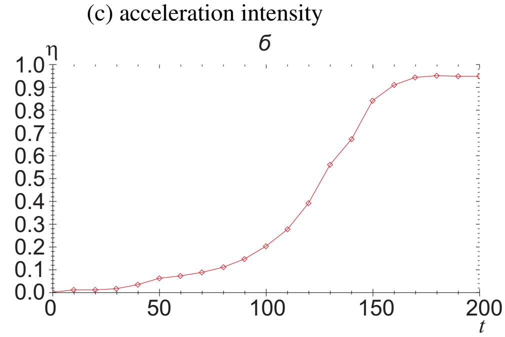
(a) phase of beam particles



(b) *1* – energy (MeV); *2* – length of structure (m); *3* – defocusing factor; *4* – limit of defocusing factor;



(c) acceleration intensity



(d) synchronous phase

Figure 5: characteristics after optimization.

tics: almost 99% particles captured into the acceleration mode, maximal defocusing factor 0.012, the output energy 2.9 MeV and length of structure 1.7 m. The properties of program motions, controls, and phase space portraits of beams in separatrices are illustrated fig. 4.

At subsequent stages the iterative process of improving the solution is carried out by one of the specified methods of optimization. After a few steps is received structure satisfies the given limitations. Structure has the following characteristics: almost 100% particles captured into the acceleration mode, maximal defocusing factor 0.01, the output energy 3.1 MeV and length of structure 1.65 m. The properties of program motions, controls, and phase space portraits of beams in separatrices are illustrated fig. 5.

REFERENCES

[1] *D. A. Ovsyannikov, A. D. Ovsyannikov, Yu. A. Svistunov, A. P. Durkin, M. F. Vorogushin.* Beam dynamics optimization: models, methods and applications Nuclear Instruments and Methods in Physics Research, section A 558, 2006, pp.11-19.

[2] *A. D. Ovsyannikov.* Transverse motion parameters optimization in accelerators Problems of Atomic Science and Technology (4), 2012, pp.74-77.

[3] *Yu. A. Svistunov, A. D. Ovsyannikov.* Designing of compact accelerating structures for applied com-plexes with accelerators Problems of Atomic Sci-ence and Technology (2), 2011, pp.48-51.

[4] *B. Bondarev, A. Durkin, Y. Ivanov, I. Shumakov, S. Vinogradov, A. Ovsyannikov, D. Ovsyannikov.* The LIDOS.RFQ.Designer development Proceedings of Particle Accelerator Conference 2001, 2001, Vol.4, pp.2947-2949.

[5] *A. D. Ovsyannikov, D. A. Ovsyannikov, S. -L. Chung.* Optimization of a radial matching section International Journal of Modern Physics A, Vol. 24, Issue 5, 2009, pp.952-958.

[6] *A. D. Ovsyannikov, D. A. Ovsyannikov, A. P. Durkin, S. -L. Chung.* Optimization of matching section of an accelerator with a spatially uniform quadrupole focusing Technical Physics, The Rus-sian Journal of Applied Physics, Vol. 54 (11), 2009, pp.1663-1666.

[7] *D. A. Ovsyannikov, A. D. Ovsyannikov, I. V. Antropov, V. A. Kozynchenko.* BDO-RFQ code and optimization models Proceedings of International Conference Physics and Control, 2005, pp.282-288.

[8] *D. A. Ovsyannikov, V. G. Papkovich.* On calculation of accelerating structures with focusing by acceler-ating field Problems of Atomic Science and Tech-nology, V.2(3). Kharkov, 1977, p.66-68.

[9] *D. A. Ovsyannikov , Ovsyannikov A. D., Balabanov M. Yu., Chung S.-L.* On beam dynamics optimization problem Intern. J. of Mo dern Physics A. February 20, 2009. P. 941-951.

[10] *M. Yu Balabanov* About Choosing initial control in optimization problems of the dynamics charged particle beams St.Petersburg, Vestnik SPbGU, Vol.10 (3), 2010, pp. 82–92.

[11] *Andrew S. Tanenbaum, Maarten Van Steen* Distributed systems: principles and paradigms Upper Saddle River, NJ: Pearson Prentice Hall, 2007.

ISBN 978-3-95450-181-6