Systems of Continuous Adaptive Monitoring Based on Hyper-Converged Structures of Processors in the Associative Memory*

На английском языке. Совместно с Г.М. Алакозом, С.И. Пляскотой, И.А. Степановской

Introduction

In the modern era of globalization and digitalization, there is increasing use of Network expert activities (NEA), which forms the basis of network technologies for the extraction and materialization of knowledge [1], associated with the development of new ideas for their implementation in competitive products.

A clear example is the "Digital Catapult" [2], an environment of the corporate activities of a large number of companies and organizations, technical experts, creative workers, representatives of business and academia. Perspective solutions in the field of NEA hardware support represent the development of Hyper-convergent systems [3,4]. They are focused on the implementation of the principle of "It as a service" (ITaaS). Against this background, is the development of applications of NEA is the most important in the framework of ontological engineering, supporting application-level customization services for content, context, and discourse management.

In this paper, we consider this problem for monitoring applications developed on the Internet platform of things, social networks, and systems of full online registration of all stages of all activities of individuals and legal entities. The basis of the proposed approach is the use of standards for processing big data in the expert the by Russian hyper convergent software and hardware processor structures in FIFO-register associative memory.

The conceptual approach to the auto-monitoring

Sources of current monitoring data comprise various modifications of the Internet of things (IoT, IIoT, IwT), social networks and systems of complete online registration of all stages of all activities of individuals and legal entities. The digital infrastructure of data is created and continues to develop on their basis providing unprecedented possibilities of creating a permanent online auto-monitoring.

International and many national standards capture and formalize best practices of online auto-monitoring. In this connection, there is a local problem of algorithm selection of the harmonized profile of regulatory documents which define the organization of inter-level information exchange in the network experts environment. Basic concepts of the proposed solution are as follows.

- Using the platform approach to building a layered appearance of NEA.
- Support for State Standard GOST R 53894-2016 "Knowledge Management. Terms and definitions" approve the organization of interaction between network experts on the level of knowledge sharing, intellectual resources, best practices, etc.
- Maintenance and active use of the registers of standards on the fundamental principles of extraction of knowledge from big data.
- Maintenance and active use of the registers of standards for generally accepted and universally valid priority areas of standardization: telecommunications and information exchange between systems; system and software engineering; interconnection of information technology equipment; coded representation of the video, audio, multimedia, and hypermedia information; automatic identification and data collection methods.

The ontological character of the technology of online auto-monitoring

Platform approach

Large-scale NEA is impossible without the transition to the principle of multilevel decomposition. One of the adequate approaches to solving this issue is software-centric structuring supported by Hyper-converged structures. The basic model may be a hierarchical structure using the concept of "platform" and "ecosystem" (see Fig. 1).

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The profile of normative documents of digital platforms of the first (lower) level includes the following components:

- standards of professional qualifications and certification of staff,
- rules of the digital network recordkeeping,
- software standards, cloud-based solutions, etc.

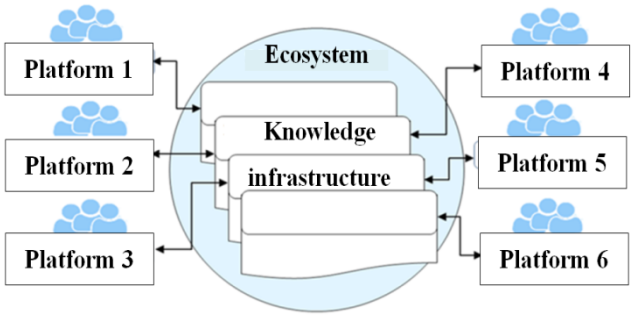

Fig. 1. A typical example for the formation of NEA character

Digital platforms of the second level include the ecosystem of digital prototyping, regulatory documents (RD) profile, which provides for standards for intelligent production technologies, robotic systems, new materials and methods of construction, etc.

Digital platforms of the following levels include network and hierarchical integration of ecosystem platforms. Multi-level platform structure allows presenting the full range of competence of all participants incorporate activities, clarify their functional roles, plan the management system for content, context, and discourse of the expert's environment to control its quality at the levels of technological coherence and situational awareness.

The modular platform structuring allows for further clarification of the ontological aspects. In particular, it applies to sessions of foresight studies for multi-stage long-term innovative activities of a permanent character, when each next innovation replaces the previous one, to merge the organizations into a single "digital company," etc.

The standard for exchange in the circuit of the NEA Platform approach

The conceptual framework of GOST R 53894-2016 includes such terms and concepts as the environment scanning, competitive intelligence, social network analysis, information architecture, knowledge audit, knowledge base, business intelligence, group and community of interests, group and community of interests, know-how, innovation index, innovation, intellectual capital, intellectual property, etc.

Conceptually GOST R 53894-2016 establishes the critical role of the final transfer of NEA to the processing, exchange, and integration of machine-readable digital formats for the presentation of interdisciplinary intellectual property (knowledge, experience, skills, methods, models, databases, factual information, etc.).

The purpose of this exchange lies in combining, systematizing and structuring the experience, knowledge, and intuition of experts, including analysts, practitioners, and decision-makers.

Standardization of software engineering and knowledge extraction from big data

To date, the online message monitoring service is a Big Data Stream Processing that operates by the following principles:

- Self-organization of “knowledge” and Data Fusion
- [4-7], provided by the Internet in everything, cartographic informatics, media representation, immersion in virtual and augmented reality, and others.
- Network situational awareness of the participants of NEA [8, 9].
- Virtualization of testing by mathematical modeling of reliability and quality of the products provided in digital format.

Software-hardware system-technical basis

In Russia, there is a scientific and technical groundwork in the field of creating scalable fault-tolerant energy-efficient computing technologies, laid down in the creation of aerospace engineering in the late 80-is of the XX century [11]. As the retrospective analysis shows, its theoretical basis is the work of S.N. Korsakof, who as early as 1832 created intelligent machines for comparing ideas in the form of mechanical homeoscopes [12,13]. The relevance of aerospace applications has only increased, since they have become an integral part of all global network technologies, without exception. The importance of aerospace applications has only grown, since they have become an essential part of all global network technologies, without limitation.

The main distinguishing feature of the entirely native to Russia hybrid technology was that it maximized the potential of the structural and functional flexibility of the traditional mechanisms of context-free grammars. In them, unlike the usual tools of context-dependent grammars, the rules take into account dynamically changing requirements for algorithms, content, and formats of the transformed data, the real substance of instructions performed by calculators, and so on. Such a hybrid architecture, called "processors in the associative memory," is currently used by various super-computers, with the difference that the Russian algorithmically oriented subprocessor: algorithmically oriented subprocessor path:

- functioning in according to the laws set by the user of the context-sensitive grammars, which complement the context-free grammar specified by the manufacturer of processors which are traditional for CPU;
- the combination with the CPU of an arbitrary architecture;
- package with a single associative VLSI N1841 VF1;
- microprogramming by the user, not by the manufacturer of VLSI;
- an optimal balance between power consumption and performance due to rapid redistribution of functionally polymorphic hardware resources between operating, switching and control the functions and features of FIFO register memory with randomly changed cells.

Developed samples of hybrid architecture have shown a record specific performance for that period at their convective cooling: ~0.167 billion op/(s*W) in the amount of ~ 0.7 dm^3.

To create entirely native to Russia space components of a Hyper-converged software and hardware systems for the adaptive remote monitoring requires no more than three part types, VLSI, performed according to not record topological rules in the range from 90 to 28 nm. In the same time, the specific performance of scalable, fault-tolerant, algorithmically oriented, hybrid calculator for associative data processing in monitoring systems will be from 1.5 to 15 billion op/(s*W) in the amount of ~(0.3–3) dm^3. The lower value of this range is comparable to the specific capacity of the Chinese supercomputer "Tianhe-2", who headed until recently the list of Top-500: (33.86*10^{15} op/sec)/(17.86 MW)=1.9 billion op/(s*W).

The potential of the system in ensuring the computational stability and persistence of the processors in associative memory

The primary source of the numerical instability of the computational algorithms (the ambiguity of the results of calculations for the same inputs) is the limited bit grid. Therefore, all arithmetic operations of computers in the strict sense are not associative, distributive and commutative, and the results of computations depend on the order of execution of arithmetic operations and the contents of the converted data streams. The effect of loss of numerical stability is due to the specific rounding procedures of the mantissa in the transition from the bit registers accumulator to the bus capacity, the first of which is larger than the second. The effect of rounding only increases in the arithmetic of floating-point format due to the denormalization procedures, and in multiprocessor and multicore systems due to the real growth of the operations of transmitting data.

Therefore, one of the main advantages of context-sensitive grammars used in algorithmically oriented sub-processing paths [14], consists of the use of mechanisms for rapid increase in the calculation process of the bit grid of all operating and interface devices that form macro conveyor of assembly instructions, and use “non-numeric” methods and tools for processing numerical information.

From the standpoint of fail-safe performance, the main specificity of the manifestations of failures in computing consists of that both natural and provoked incorrect functioning of even a single valve does not lead to the top of the calculator, but to the change of the implemented function and, consequently, to the expansion of the command system [15]. It makes unpredictable the behavior of the whole Technotronic complex of the adaptive continuous remote monitoring.

Hence, the survivability of the complex requires an adaptive software-hardware system at a real-time pace for in-depth and maximally complete diagnostics of the electronic component base and parrying failures with minimal hardware redundancy.

The system for ensuring the vitality of the processors in the associative memory:

– does not use the "hot standby" substitution, but the reassignment of tolerant current "failure map," which is possible only in the framework of context-sensitive grammars;

– manages at a pace close to real-time 27-30 functionally significant failures with a probability of 0.7 at 30-40% hardware reserve (see Fig. 2).

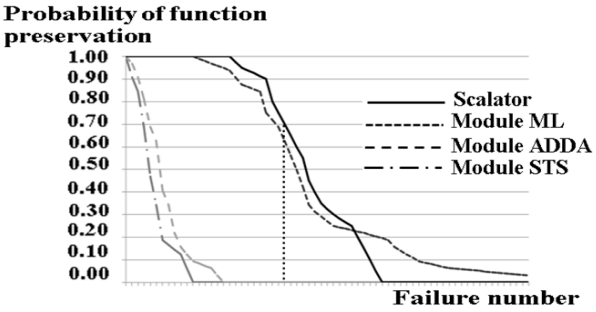

Fig. 2. The distribution of probability of failure management in the «Scalarization Module (scalator).»

Figure 2 also shows that in the processors on the associative memory the persistence of the “whole” is greater than the survival of the “parts” which is characteristic for all multicellular organisms. It is also essential that the natural structural and functional redundancy of cells in FIFO-register associative memory, as in living systems, maintains a high level of indifferent failure, which may be catastrophic in (30-50) % of cases for the majority of the von Neumann majority of systems with triple (300%) the reserve (see Fig. 3).

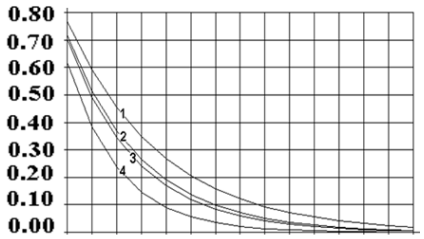

Fig. 3. The probability of preservation of operating modules from the concurrent indifferent failure of the cells of the FIFO-register associative memory for the median filter (1); the multiplier (2); divider (3); adder-accumulator (4).

The built-in diagnostics tools for modern multiprocessor and multicore systems that do not respond to a functional failure, but a hardware failure, in 30-50% of cases recognize a workable system about this program as an unusable system.

Achievement of these unique system characteristics to ensure the survivability of processors in the associative memory is facilitated by:

- system firmware means of localization and identification of failures running at a pace close to real time and with accuracy to the coordinates of the cell of FIFO-register associative memory and (not)implemented micro-command;
- high functional polymorphism characteristic of context-sensitive grammars, which allows to redistribute a uniform hardware resource between operating, switching, control and interface functions;
- efficient means for automatic (re)placement of functional firmware *tolerantly* operating in cells of FIFO-register associative memory in the failure map (see Fig. 4).

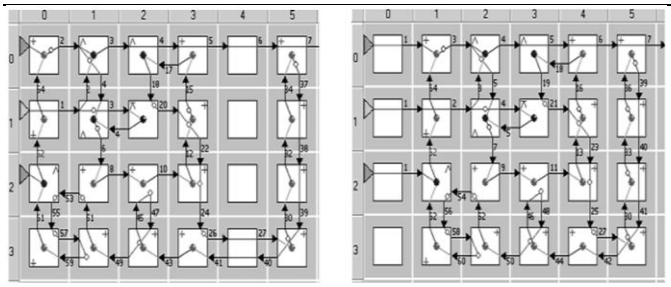

Fig. 4. Affine transformation of the firmware topology at their tolerant to (re)placement on the bit-matrix

Competitive advantages of the technologies of processors in the associative memory

Field studies of the hybrid technology of "processors in associative memory" showed that their competitive advantages are provided by other non-reproducible means by *the structural* and *parametric method* of transmitting, storing and converting information, which has deep molecular-biological and neurophysiological roots. This method opens new opportunities due to:

- constructive use of the duality between streams of commands and data during the associative interaction and adaptive bit grid, which is the basis of the numerical stability of hybrid RISC and DSP architectures;
- cryptographic protection of data not only at their storage and transit but also during processing in cloud computing;
- full convergence of the processes of storage, transmission, and processing of information in space and time (ideal processor in the memory) in supercomputers;
- “non-numerical” processing of numerical information with increased accuracy in the associative computing;
- invariance of both digital and analog forms of storage and transformation of information, as well as thermal synthesis and regeneration in near real-time scale of time of heterostructures in supramolecular and quantum computers.

Storage and transformation of information in quantum structures are not fundamentally new for computing. In our country, they have already received approbation in practice.

CONCLUSIONS

Proposed in the project is a hyper convergent architecture of Internet monitoring that implements the big data mining computational scheme based on the hierarchy of Hyper-converged processor structures in FIFO-register associative memory:

- allow to solve one of the fundamental problems of the practical implementation of cognitive systems of continuous adaptive monitoring, which rests on the solution of the task of highly dynamic control of computing processes "(hyper) of large dimension" and "great uncertainty" on computational resources in demand at the given time, which is typical for all vita systems [1];
- retain their relevance and continuity to the entire strategic depth of development not only of global network structures with aerospace components but also the elemental base "with a limited lifetime," characteristic of atomic and molecular interactions.

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