A LAW OF NATURE

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ABSTRACT

Complexity plays an important role in all kinds of human activity as well as in nature. Complexity can be defined in terms of the number of relations that must be handled accounted relative to the number of potential relations. Modularization is an efficient methodology that helps reducing the number of relevant relations. It has the property that it becomes more efficient when the availability and the diversity of modules that can be coupled increase. Its efficiency can grow exponentially when modules can be generated out of simpler modules. In nature this effect leads to the generation of very complex creatures, such as intelligent species.

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COMPLEXITY

Relations can be encountered in several areas of physics and in human interactions.
We will define complexity in terms of the number potential relations divided by the number of relevant relations.

There exists a tendency in nature to reduce complexity via modularization.

This tendency grows when more suitable modules become available.
Finally this tendency enables nature to create very sophisticated and intelligent creatures.

POTENTIAL COMPLEXITY

Potential complexity of a set of objects is a measure that is defined by the number of potential relations that exist between the members of that set. Actual complexity of a set of objects is a measure that is defined by the number of relevant relations that exist between the members of the set.

It takes time and other resources to determine whether a relation is relevant or not. Only an expert has the knowledge that a given relation is relevant. Thus it is advantageous to have as little irrelevant potential relations as is possible, such that mainly relevant and preferably usable relations result.

If there are n elements in the set, then there exist n(n-1) potential relations.*

PHYSICAL RELATIONS

Physics is based on relations. Quantum logic is a set of axioms that restrict the relations that exist between quantum logical propositions. Via its isomorphism with Hilbert spaces quantum logic forms a fundament for quantum physics. Classical logic is a similar set of restrictions that define how we can communicate logically. Quantum logic only describes static relations. Traditional quantum logic does not treat physical fields and it does not touch dynamics. However, traditional logic can be extended such that physical fields are included as well and by assuming that dynamics is the travel along subsequent versions of extended quantum logics, also dynamics will be treated. The set of propositions of traditional logic is isomorphic with the set of closed subspaces of a Hilbert space. This is a mathematical construct in which quantum physicists do their investigations and calculations. In this way fundamental physics can be constructed. Here holds very strongly that only relevant relations have significance.

MODULARIZATION

Actual complexity can be reduced by modularization, by applying standard module interfaces and standard inter-module communications, by increasing the diversity of modules and by increasing the availability of modules. Another important factor is the ease of modular system configuration.

Modularization can easily reduce the relational complexity of large complex systems by several orders of magnitude. The resources needed to devise and generate that system reduce by the same factor.

Nature secures its modules literally by brute force or when those binding forces are not available by enveloping the module in a skin such that only controlled access must be accepted by the module.

MODULAR SYSTEM DESIGN

The system configuration process profits most from modularization, but reuse of modules and interfaces also saves resources and building time. The capability to create modules out of simpler modules gives the improvement an enormous boost.

The complexity of a modular system can be many orders of magnitude less than the complexity of a monolith.

Systems can be atoms, molecules, (in-) organic stuff, organs, living objects, products, modules, modular subsystems, organizations, governments, stars, galaxies, et cetera.

Two kinds of modular system design exist. Modularization can be done randomly, as is done in nature by the evolution process, or it can be done in an intelligent way as is done by human system designers.

1. Stochastic module and modular system design. In this way modules and their coupling are created via stochastic processes. This way of system creation is used by nature.
2. Intelligent module and modular system design. In this way modules and their coupling are designed via well planned processes that are controlled by intelligent individuals.

The efficiency of modular system generation is influenced by the following factors:

- Resources needed to generate modules
- Availability of modules
- Diversity of modules
- Availability of provide interfaces
- Availability of require interfaces
- Diversity of interfaces
- Mutual static adaptation of provide and require interfaces
- Mutual dynamic adaptation of modules via their interfaces

In intelligent modular system design the following extra factors play an important and stimulating role:

- Public knowledge of available modules and their static and dynamic specification
- Public knowledge of available interfaces and their specification
- Availability of standardized module design tools
- Availability of standardized interface design tools
- Availability of standardized modular system configuration tools
- A market of standardized modules
- Publicly accessible repositories where automatically and humanly readable modules are published
- Publicly accessible repositories where automatically and humanly readable interfaces are published

A large availability, couple-ability and diversity of modules ease and stimulate the system configuration both in the random trial and error approach as well as in the case of intelligent system configuration.

Too much diversity works negative. So there exists an optimum diversity both for modules and for interfaces.

The same holds for availability. Too much availability exhausts precious resources, which are not used effectively and could be better used otherwise.

INTELLIGENT MODULARIZATION

Generation, management, improvement and support of modular systems normally cost a fraction of the time and the resources that the equivalent for a monolith or a layered system takes.

In intelligent modularization publication of the capabilities of modules and interfaces will reduce the complexity and increase the efficiency of system configuration and will increase the effectiveness of module and interface design.

Intelligent designers of modular systems secure the integrity of their modules by power such as a patent mechanism or by proper encapsulation. The first measure secures the intelligence property that went into the design. The second measure guards against unwanted access that may hamper the integrity of the module. Still the module must have publicly accessible interfaces.

Providing tools for component and interface generation and providing system configuration tools will also reduce the complexity of system generation. Via modularization the complexity of system configuration can be reduced so strongly that it becomes possible to automate the configuration process.

In intelligent modularization interfaces make only sense when they are standardized, when they are well known and when their use is widely spread.

When they are well known, connected interfaces can be seen as a single relevant relation. In this way they replace a number of potential relations.

COUPLING

Provide interfaces couple the server module with the require interface(s) of one or more client modules. Communication occurs via relations and via relation paths. It must be done via a well-defined protocol. Otherwise the communication makes no sense. Interfaces can couple modules directly or they can couple via communication channels. Another way of coupling occurs via broadcasting controls or messages.

Intelligent communication is usually regulated via standardized protocols. The regulation may concern a handshake, a send with immediate return or a single send or receive. A broadcast is a special type of communication.

In high urgency communication and in message streaming measures must be taken against deadlocks and race conditions.

An important aspect of functioning of interfaces is the quality of coupling. It is important with which partner they couple. It might even be a matter of life and death. If the serving partner has no intention to save the integrity of the coupled module and the module has insufficient defense against such attacks, than that client module may get disturbed.

When the modules have the capability to generate siblings, as is the case in biologic systems, then the quality of mating is important for the success of the siblings. Thus in evolution not the survival of the fittest, but the quality of coupling is of crucial importance for the survival of species. In more abstract sense, the quality of coupling is important for the abundance of module types.

INTERFACES

Interfaces have a type definition. Not only the static aspects of the interface coupling play a role, also the dynamic properties may be important.

Interfaces have several general aspects. Interfaces have static characteristics and dynamical characteristics that mostly can be specified separately. An interface can be a require-interface or it is a provide-interface. Often a require-interface and a provide-interface are combined in a single physical realization. In intelligent system design the require-interface is often just a link with a type definition. It may fit at several types of provide-interfaces. The capabilities of this server may be larger than required by the client.

For example in software there exist SW-SW interfaces, SW-HW interfaces, streaming interfaces and notification interfaces. A given environment may ask for an adapted physical implementation of the interface.

Communication-channels may connect require interfaces to provide interfaces.

In nature in most cases physical fields play the role of interfaces. In biology and technology all kinds of interfaces are explored.

Thus, there is a lot to be said about abstract interfaces.

THE POWER OF MODULARIZATION

Modularity enables and stimulates nature to create sophisticated creatures via a random process called evolution.

The intelligent modular system creation process enables humans to create very sophisticated systems in much shorter time than nature took in order to create smart individuals.

The laws of entropy are directed towards the increase of chaos. The tendency to reduce complexity via modularization works in the reverse direction. When more capable modules come into being, then it becomes possible to generate more complex systems and it becomes also possible to construct more complex modules out of these modules.

Both nature and intelligent system designers make use of the advantages of modularization. It enabled nature to create intelligent and very sophisticated creatures, such as human beings.

Evolution is a stochastic process. Set against the fact that the system generation process acted by human individuals profits from the intelligence of the actor, nature has enormous resources like time, energy and matter. This gives nature an enormous potential. If one starts from the assumption that universe is its own creator, then it creates all of its parts. That also holds for such immensely complex creatures as human beings. The law of increasing complexity reduction via advancing modularization forces nature to create such hyper-complex things.

Modularization is a very complex concept. Its aspects may easily fill a thick book.

It would be best to put the influence of modularization into a law of nature, but due to the complexity of the modularization process it is difficult to formulate such a law.

ABUSING MODULARIZATION

The fact that the advantages of modularization can be denied is shown by several human system generation processes. The most prominent are the ways software is generated and the way that fusions of large organizations are promoted.

See:

Story of the war against software complexity.pdf;

Managing the generation process.pdf

SOFTWARE

The fact that modularization is not or hardly applied in software is responsible for the exponential growth of the costs of the development and generation of complex software systems. The software industry is responsible for this deficiency. Their customers suffer.

A demo project showed that if modularization is fully implemented in embedded software generation, then:

- The whole world can contribute in the design of a large variety of modules.
- The operating systems can be generated by the system configuration tool from dedicated modules that are adapted to the needs of the collected application modules.
- The configuration tool can simulate and test a large part of the envisioned system that is generated from such a dedicated operating system and skeleton components that are generated on the basis of specifications that are taken from machine readable repositories. The skeletons can be replaced one by one by real binaries and the system can be tested at each phase.
- Such a generation process can be largely automated and can be controlled by a creative system designer rather than by a genial system architect that takes a high risk to get a burnout when the project fails.
- The overall system generation will take a few weeks of a few specialists compared to the hundreds of man years that are currently spent on comparable projects.
- Compared to the current way of system generation the process is very democratic. Everybody who knows a niche of expertise can contribute his modules.
- Compared to the open software solution, everybody who generates modules is allowed to earn money from the investment of his intelligent property.