Components as Resources and Cooperative Action

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Summary

- Resources link a (technical) system to its outer “living” world.
- Components provide *implemented* functionality and thus are (functional) resources.
- The operation of components provided by third parties.
- Interoperability of components, specifications and component frameworks.
- The role of services instead of components and their relation to an almost *Ideal Machine*.
- Szyperski on (software) components and objects.
- Proposal: A developed technical infrastructure requires *resource management* in socio-cultural ecosystems instead of resource exploitation.

Systems and Problem Solving

The concept of system is basic for TRIZ to delimit and reduce problems to their essentials.

1) A system is a unit which is delimited against an environment.

2) The delimitation takes place under at least three aspects:

1. As unit of analysis (design functions)
2. As unit of operation (set up processes)
3. As unit of development (resolve contradictions)

3) A system provides *emergent functions* that cannot be reduced to its individual parts (components), but are the result of the interaction of its parts in a systemic whole.

Systems and Problem Solving

There is a basic contradition between decomposition and indecomposability in every systemic approach: To *analyse* a system it has to be decomposed, but it can be *operated* only in assembled state.

Moreover, the connectedness of the operational conditions does not end at the system's boundary, since

4) A system requires a qualitatively and quantitatively determined throughput of substance, energy and information as an operating condition to maintain its inner structure.

Thus, to operate a system, to "bring it to life" it must be inserted into this living environment.

TRIZ as "Conditional Mind Game"

In Darrell Mann's four phases of TRIZ (Define the model, Select the tools, Generate solutions, Evaluate solutions) the TRIZ solution of the problem ends with a taylored solution plan.

Hence TRIZ is a *conditional mind game:* "If the operational requirements (input specification) are provided, the system provides its functionality (output specification)".

To operate a system a living environment it is required to fill the *places* with *content*.

EXAMPLE: The hoover as technical device. The place (plug) must be connected to the content (socket) to operate the device, but more is required: The socket must be "alive", it must be "power in it".

The TRIZ Mind Game and the Ideal Machine

In the TRIZ methodology *functional* properties, e.g. the Main Useful Function of a system, as “usefulness for others” are in the foreground.

The terms *usefulness* and *harmfulness* of functions play an important role alongside the objectives of profitability and efficiency as socio-cultural guiding principles of operation.

With the concepts of *Ideality* and *Ideal Final Result* a mental construct of anticipation of the functional properties of a system stands at the beginning of its genesis.

Koltze/Souchkov, p. 40

The ideal machine is a solution in which the maximum utility is achieved but the machine itself does not exist.

TRIZ Concept of the Ideal Machine

The ideal machine is therefore *pure functionality* without any resource-related underpinning.

Nonetheless, that fictitious idea is central to TRIZ, for it develops a strong orientation towards the intended usefulness and thus has a socio-cultural guiding effect.

Machine here stands very generally for "potentially working solution" and hence applies also to problem solving in socio-technical systems as, e.g., organisations.

Implement

To implement such a machine in (or after) a TRIZ solution process means:

1. The machine must be “built”.
2. The machine must be “deployed” at the given location and “come to life”.
3. The *operating conditions* must be provided.

Hence resources are needed (input) and made available (output).

What are resources in TRIZ?

On the Notion of Resources in TRIZ

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Substance Field Resources are substances and fields that are already available or are (easily) obtainable according to the conditions of the task.

Wessner lists a whole variety of concepts of resources proposed by different TRIZ schools. The spectrum ranges from

- "a means that can be used to solve a problem" (Souchkov)
- to "anything in or around the system that is not being used to its maximum potential" (Mann, Salamatov)
- to the notion of resource as source of a problem itself: "a problem always arises, if a needed resource is not present" (Orlov).

On the Notion of Resources in TRIZ

In (Koltze/Souchkov, p. 51) a resource is understood as “a means, a tool to carry out an action or to make a process take place” and equipment, money funds, raw material, energy or even people (human resources) are mentioned as examples of resources.

Furthermore Souchkov classifies ressources according to certain *operational* aspects

- *value* (free, not expensive, expensive),
- *quality* (harmful, neutral, useful),
- *quantity* (unrestricted, sufficient, insufficient) and
- *readiness for use* (ready, to be modified, to be developed).

On the Notion of Resources in TRIZ

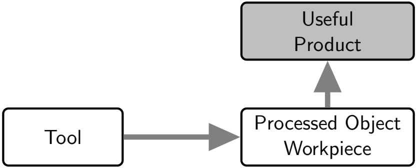
But specific *qualitative* determinations of such “substances and fields” as resources play almost no role.

Qualitative determinations in the sense of the fulfilment of a *specification* are, however, essential in more complex technical contexts in order to ensure the interoperability of the *implementation* of a specific functional property in a systemic context.

What does it mean to operate a technical system?

Operating a Minimal Technical System

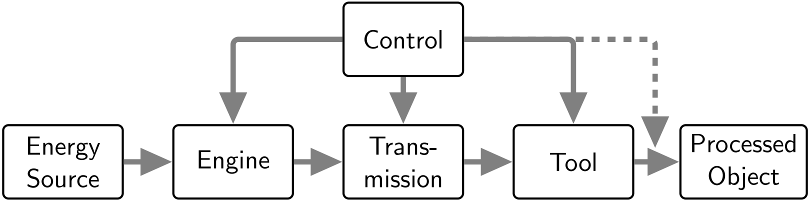
In the TRIZ notion of a *minimal technical system*, a *tool* acts on an *object* (workpiece) to be processed in order to transform it into a *useful product*.



The concept of the *ideal system* considers the tool as a purely functional property, the effect of which to intentionally change the state of the workpiece to a useful product is achieved without any additional efforts and any wear of the tool.

In other words, it is not the tool but the *imaginaton of the tool* that creates the required action in such an *ideal machine*.

Operating a Complete Technical System



In the classical understanding of the operation of a *complete technical system*

- the energy throughput is centered on the tool,
- the throughput of substance transports the workpieces
- and the throughput of information is directed to the control of the action (added dashed line).

Operating a Complete Technical System

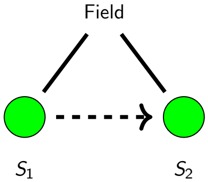
Thus the concept of a resource (as providing this "throughput") is understood as "means that can be used to solve a problem", i.e., to exploit the environment.

The understanding of the relationship of action conveyed here is asymmetrical.

An active tool has a state-changing effect on a passive workpiece, while retaining its own functionality and – ideally – without undergoing a state change itself.

Resources, Tools and State Changes

In *substance-field models* this understanding is replaced by a more symmetrical model of a field-mediated action between two substances.



At the same time, in the systemic abstraction, the materiality of the *tool* is pushed back further in favour of the concept of *action* and a distinction between components as state-less and objects as state-bearing is prepared as proposed by C. Szyperski for Component Software.

Resources, Tools and State Changes

A similar idea develops Souchkov when he describes the two goals of *Resource Analysis* as an essential component of TRIZ:

- Analysis of the resources that are to be *treated or consumed* in the course of a process,
- and analysis of the resources that can be *used* to carry out the process or to solve the problem,

i.e., he distinguishes resources of the first kind, which undergo state changing transformations as *workpieces* and resources of the second kind, which are used as tools to *mediate* these state changes.

Resources, Tools and State Changes

Such a notion also corresponds well with the widespread organisation of production processes, where a distinction is made between operating and maintenance mode.

In the operating mode, the focus is on the functional properties of the tool, while in the maintenance mode its material properties are focused.

As an independent technical system in a narrower sense, only the operating mode is modelled as the target of a "problem solution".

The maintenance mode is part of the supersystem, which is concerned with the *reproduction* of the tools as *resources* used in the operating mode.

Resources, Tools and State Changes

We worked out an **conceptional asymmetry between tool and workpiece**: The tool (as a component within the system) provides a *main useful function* that is applied to change the state of the workpiece. The state of the tool remains (at least conceptually) unchanged.

In SF-modelling this asymmetry moves into the background, but the state-change is rather matter of the **action** (as “pure functionality” of the Ideal Machine – the machine disappears) and no more the tool.

This matches the component concept as proposed by C. Szyperski for Component Software.

The World of Technical Systems

The operational demand of a technical system is formulated in the form of *specifications* as requirements to the "environment", which must be fulfilled for the *operation* of the system. Thus the implementation of the "TRIZ solution plan" presupposes a sufficiently powerful *environment* as given, in which the necessary *resources* can be found to fulfil the operating conditions.

Sommerville emphasises in his book *Software Engineering* the importance of such interface specifications for the development of software systems that "need to interoperate with other systems that have already been developed and installed in the environment."

Components as Resources and Component Models

Such a coordinated development process (as "cooperative action") in turn requires (according to Sommerville) a more extensive socio-technical infrastructure with

1. *independent components* that can be fully configured via their interfaces,
2. *standards for components* that simplify their integration,
3. a *middleware*, which supports the component integration with software
4. and a *development process* that is designed for component-based (software) engineering.

Components as Resources and Component Models

Components are thus conceptually integrated into an overarching *component model*, which essentially ensures the technical interoperability of different components beyond concrete interface specifications and thus forms a moment of unity in the diversity of the components.

However, this unity extends not only to the model, but also to the operating conditions of the components (as functional property of the middleware) as well as to their socio-technical development conditions (as a partial formalisation of the development process).

This frame constitutes as *component framework* (Szyperski) a socio-technical supersystem as an "environment" of components that were created according to the specifications of that component model.

The World of Component Models

Szyperski, for his part, analyses this diversity of compatibilities and incompatibilities of different component models and identifies different levels of abstraction for the reuse of concepts that go beyond the use of prefabricated components.

In his 20-year-old book he already emphasises

> *the growing importance of component deployment, and the relationship between components and services, the distinction of deployable components (or just components) from deployed components (and, where important, the latter again from installed components). Component instances are always the result of instantiating an installed component – even if installed on the fly. Services are different from components in that they require a service provider.*

Components as Resources in a Modern Society

Szyperski shows that the component approach is an approach of reuse that is not limited to the (possibly modified) abstract reuse of the technical functionality of a problem solution, but always reuses components together with their operating conditions as *services* and thus cannot be grasped detached from their environment.

Beyond the connection of place and content an operational process dimension is essential for a living system. Shchedrovitsky develops that as a *second concept of a system*. This cannot be explained here.

We are dealing with a typical phenomenon of a modern society, in which the electricity comes from the socket and the milk from the shop. The division of labour in such a modern mode of production leads to the emergent phenomenon of social unity and stratification of the reproduction of infrastructural conditions.

Components as Resources in a Modern Society

The existence, reliability and robustness (resilience) of such an infrastructure has a significant influence on the way people organise their daily lives.

With the insight into ever more complex interrelationships, a concept of resources as "anything in or around the system that is not being used to its maximum potential" (Mann, Salamatov), which focuses on the *exploitation* of resources, becomes increasingly counterproductive.

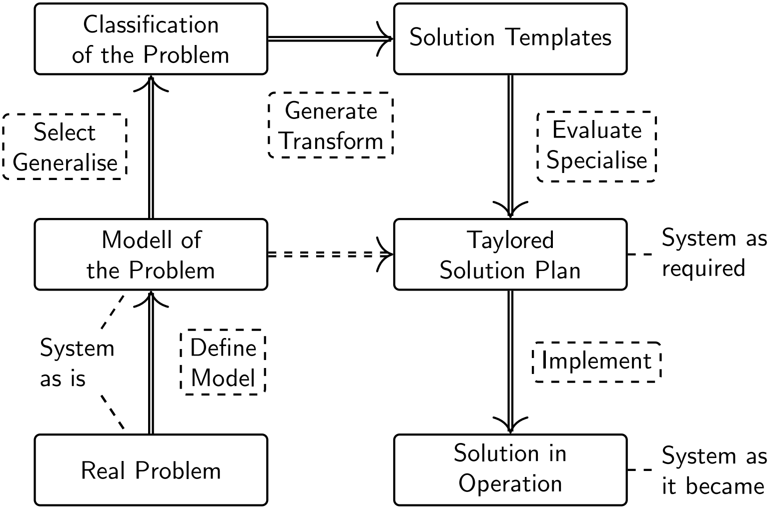
Resource Management

It has to be replaced by a concept of resources with socio-culturally institutionalised forms of *resource management* at its center.

Thank you for your attention!

Additional Material

The TRIZ Way of Thinking



Functional and Attributive Properties

Szyperski shows that the component approach is an approach of reuse that is not limited to the (possibly modified) abstract reuse of the technical functionality of a problem solution, but always reuses components together with their operating conditions as *services* and thus not detached from their environment.

For this, Shchedrovitsky's distinction between functional and attributive properties as well as the distinction between the notions of *part* and *element* are essential.

> Elements *are what a unity is made up of, so an element is a part inside the whole, which functions inside the unity, without as it were being torn out of it. A simple body, a* part, *is what we have when everything has been disassembled and is laid out separately. But elements only exist within the structure of* connections*. So an element implies two principally different types of properties: its properties as material, and its functional property derived from connections.*

Functional and Attributive Properties

In other words, an element is not a part. A part exists when we mechanically divide something up, so that each part exists on its own as a simple body. An element is what exists in connections within the structure of the whole and functions there. [...]

Functional properties *belong to an element to the extent that it belongs to the structure with connections, while other properties belong to the element itself. If I take out this piece of material, it preserves its* attributive properties. *They do not depend on whether I take it out of the system or put it into the system. But functional properties depend on whether or not there are connections. They belong to the element, but they are created by a connection; they are brought to the element by connections.*

Filling the Places with Content

The terms *part*, *element*, *connection* describe the *structure* of the place in the system itself, where the connection of the "dead" system with the "living" world must be carried out in order to bring the system itself to life.

In the further system genesis, this conceptual frame has to be filled with suitable resources. How conceptualise this “filling”, the combination of the functional properties at the “connections” with resources to an almost ideal machine?

To describe this composition process (“components are for composition” – Szyperski) Shchedrovitsky distinguishes the concepts *place* and *content*.

Filling a Place with Content (Shchedrovitsky)

> *An* element *is a unity of a place and its content – the unity of a functional place, or a place in the structure, and what fills this place.*
>
> *A* place *is something that possesses functional properties. If we take away the content, take it out of the structure, the place will remain in the structure, held there by* connections*. The place bears the totality of functional properties.*
>
> *The* content *by contrast is something that has attributive functions. Attributive functions are those that are retained by the content of a place, when this content is taken out of the given structure. We never know whether these are its properties from another system or not.*

In particular **human resources** with *role definition* and *role occupation* have this structure.

Components and Objects according to Szyperski

Components (which are "for composition") are conceptualised

- as unit of independent deployment,
- as unit of third party composition
- having no (externally) observable state.

In contrast to this *Objects* are conceptualised

- as unit of instantiation,
- that may have externally observable states
- and encapsulates its state and behaviour.

Instantiation is important to maintain a certain standardisation of workpieces required for a repeated application of a function within a production process.

Socio-Cultural Ecosystems

Ecosystem (Biodiversity Convention): A “dynamic complex of communities of plants, animals and microorganisms and their non-living environment interacting as a functional unit”.

Today, we also speak of technical ecosystems, energy ecosystems, business ecosystems, etc. when we are talking about social structures of a large number of independent stakeholders with diverging interests.

This is summarised under the term *socio-cultural ecosystems*.

Socio-cultural ecosystems have to fulfil specific functions within the human community. Hence there are many similarities to both biological ecosystems and technical systems in the sense of TRIZ.

Socio-Cultural Ecosystems

The nature and characteristics of an ecosystem are understood differently by ecologists: Some assume the actual existence of the system, which is only discovered and described by researchers (ontological approach). Most researchers, however, regard it as abstractions first created by the observer, which must be appropriate for a certain purpose, but could also be defined and delimited differently in another context (epistemological approach).

We assume that in socio-cultural ecosystems both aspects are in a contradictory dialectical interrelationship that can be well modelled by the concept of systemic development and thus by TRIZ approaches.

Components as Resources in a Modern Society

Thesis:

The concept of resource exploitation is a characteristic feature of all existing so far forms of a capitalist mode of production.

It manifests a fundamental contradiction of socio-cultural development: without such exploitation we would not have reached the current state of technology, but at the same time we undermine our own conditions of existence.

The formulated contradiction is of a global, planetary dimension that cannot be solved by the regional disposition of individual power groups over exploitable resources.

TRIZ systemic evolution trends of increasing coordination, controllability and dynamisation refer not only to *system-internal development lines*, but also to the coordination *between* systems which are operated by independent third parties.