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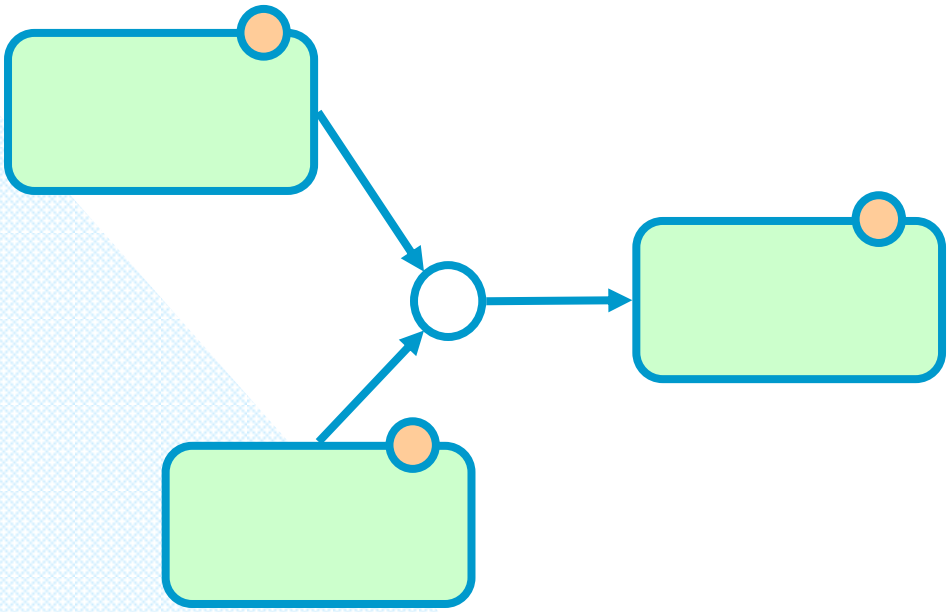


A GUIDE TO ROOT-CONFLICT ANALYSIS (RCA+)

For Business and Management Applications

Valeri V. Souchkov

Guide to Building Root Conflict Analysis (RCA+) Diagrams and Recommendations for Contradiction Selection

Edition 2.0

CONTENTS

Root Conflict Analysis (RCA+) is analytical tool aimed at helping to manage complexity of inventive problems by extracting, identifying and formulating contradictions which contribute to a problem and relations between these contradictions.

Root Conflict Analysis modeling is performed within the scope of three tasks:

1. To solve a specific problem related to a certain specific product, service or a process (e.g. to increase sales of a specific service produced by a specific company, to eliminate failure of a specific project).
2. To solve a broad problem related to a whole class of products, processes or services (e.g. to prevent all cars from creating road accidents, eliminate a possibility of errors made by pilots during flights, eliminate traffic jams, etc.)
3. To predict and eliminate potential failures within systems and processes (e.g. to identify possible causes of a machine or project failure).

This document explains how to analyze and model problems with RCA+ and assumes that the reader is familiar with the TRIZ basics; although RCA+ can be used without TRIZ for problem analysis.

PART A: INTRODUCTION AND TRIZ PROCESS WITH RCA+

INTRODUCTION TO ROOT CONLFICT ANALYSIS (RCA+)

Root Conflict Analysis (RCA+) was first introduced in 2003. It is a technique for defining, structuring, and visually representing problems and problem situations. RCA+ is mostly helpful in situation when a problem solver faces a problem which is not clear how to solve. The tool helps managing complexity of understanding and defining problems through top-down discovery of *contradictions* which prevent a problem solver from solving a problem in a straightforward way and defining how these contradictions are related to each other. Such contradictions convert standard problems which can be effectively solved with known means to inventive problems where a way of how to resolve contradiction is not known to the problem solver. Therefore, discovery and extraction of all contradictions which compose a problem is essential to properly identify relevant problem solving directions.

RCA+ is domain-independent tool. It was developed by combining key ideas of three approaches: a classical method of Root Cause Analysis, Theory of Constraints, and TRIZ.

It is very important to note that while traditional methods of cause and effect analysis of problems (for example, RCA: Root Cause Analysis) focus on finding *root* causes of problems, the underlying RCA+ philosophy ***is different***. Often problems cannot be easily solved even after we identify a root cause. Such situations usually emerge when either elimination of a root cause would require considerable change of a system where the problem arises, or elimination of the root cause is not possible due to constraints, for example, defined by laws or nature.

In addition, difficult problems are usually featured by situations when just finding a cause of a certain problem does not make it easy to solve the problem by eliminating the cause because the same cause contributes to a positive effect. For example, a traffic light slows down travel time of a car which is definitely negative effect. On the other hand, the same traffic light prevents the car from an accident. In this example, a traffic light is a cause of both negative and positive effects and therefore if we eliminate the traffic light, we eliminate the positive effect as well. Therefore, to get a more complete picture of our problem we should understand not only the causes of negative effects but also define if these causes contribute to positive effects. RCA+ helps to identify such contradictions that create a problem rather than investigate a causal chain of causes only.

Second important difference between the root cause analysis techniques and RCA+ is that instead of trying to find the lowest cause in a chain (root cause), RCA+ targets at discovering all contradictions that reside as close as possible to a general negative effect which represents a problem. Our experience of applying previous versions of RCA+ to hundreds of problems shows that it is easier to solve a problem by eliminating a contradiction *which resides closer* to a general negative effect than a contradiction which is lowest in the causal chain of contradictions and negative causes.

RCA+ is a universal technique which is not limited to any specific domain and can be performed within the scope of three tasks:

- To model a specific problem related to a certain specific product, service or a process (e.g. polishing glass takes too long, sales of a specific service produced by a specific company are too low).
- To model a broad problem related to a whole class of products, processes or services (e.g. to reduce traffic jams, to eliminate mistakes by a call centre, etc.)
- To predict potential failures within systems and processes (e.g. to identify possible problems which might be caused by a newly developed camera, or predict potential causes of project failure).

In summary, RCA+ helps with:

- Decomposing a problem to a number of related causes and effects.
- Identifying “invisible” causes and conflicts.
- Extracting and presenting contradictions.
- Structuring and visualizing a problem.
- Reaching a common agreement and vision of a problem situation.
- Improving collaboration among team members when defining and solving a problem.
- Providing direct input for contradiction resolution techniques.

RCA+ can be used in every area where problems, contradictions, and undesired effects take place and can be used independently of TRIZ to analyse problems and situations. In addition, coupled with TRIZ techniques for resolving conflicts, RCA+ provides a powerful platform not only for understanding problems but for solving problem as well.

RCA+ can be used both within a specific formalized TRIZ process and independently.

TYPES OF PROBLEMS WITH RCA+

In general, there might be four categories of problems which can be analysed with RCA+:

1. **Negative effect**. Something that happens which we do not want to happen at all. In most cases negative effects are caused by harmful functions. It can be a damage because of an accident, loss of control, irreversible emergence of a defect, process failure, etc.

   Examples: a) An unsatisfied customer returns a product. b) The manager is wrong in making decisions. c) An employee annoys his colleagues. d) A valuable employee leaves the company.

2. **Insufficient effect**. A positive result which we wish to obtain but which is not achieved with a desired degree of performance, completing, or quality.

   Examples: a) The speed of obtaining the required information is too low. b) The company's income is lower than planned. c) The effectiveness of the team is insufficient. d) Not enough information was received about the object of study.

3. **Excessive effect**. A positive effect which we wish to have but which causes excessive waste of costly resource.

   Examples: a) Much more time is spent on sales than planned. b) Renting the premises is too expensive. c) The project consumes too many resources.

4. **Ineffective control**. It happens when we wish to control a certain system, or its attribute, and we have the means of control, but the process of control takes too long, or is not accurate enough, etc.

   Examples: a) It is impossible to accurately determine the project timeframe in advance. b) The manager of the department does not manage well. c) The goods arrive either earlier than scheduled, or later.

Note that problems involving insufficient or excessive effects, or ineffective control are not the same as problems which relate to negative effects. Negative effects address situations when a certain action or result occur but we absolutely do not want even the smallest fraction of this action or result.

TRIZ PROCESS WITH RCA+

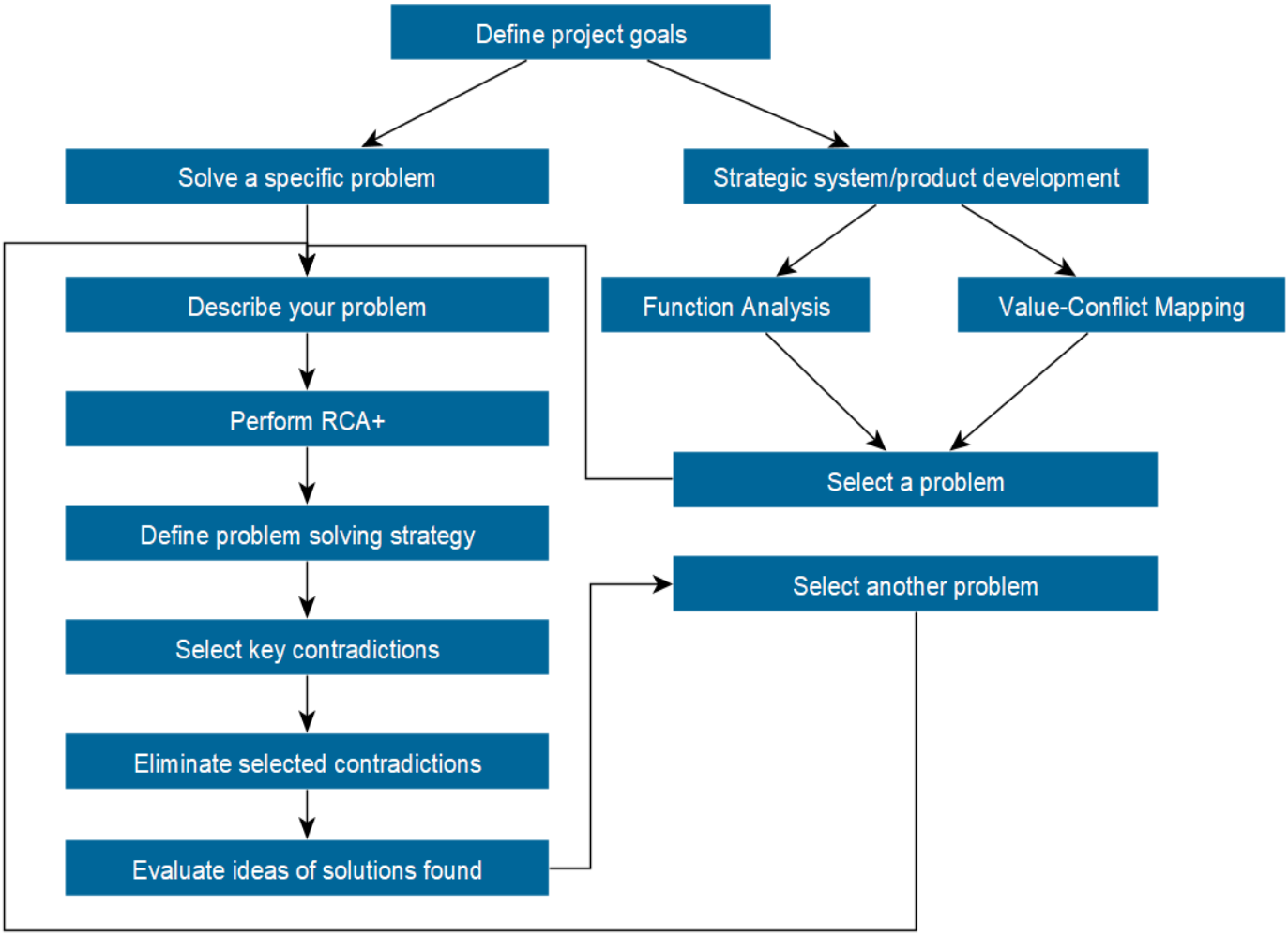
The figure below shows a general problem solving process based on the use of RCA+ in TRIZ to identify and select contradictions. The process is initially divided into two streams according to the condition: the goal of the project is to solve a specific

problem, or the strategic development of a given business system, which means analyzing the system and identifying a number of problems that need to be solved.

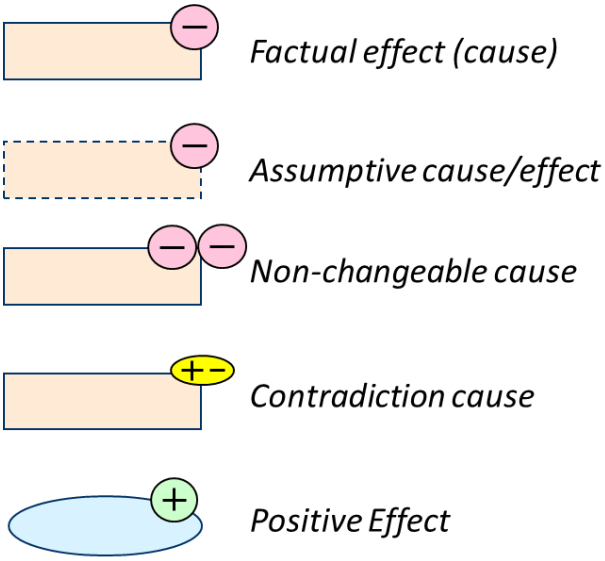
In the first case, we immediately proceed to the analysis using RCA+, in the second, we first apply the tools for analyzing the system and identifying its innovative potential: either Functional Analysis or the Value-Conflict Matrix. The result of working with these tools is a number of identified problems for further resolution.

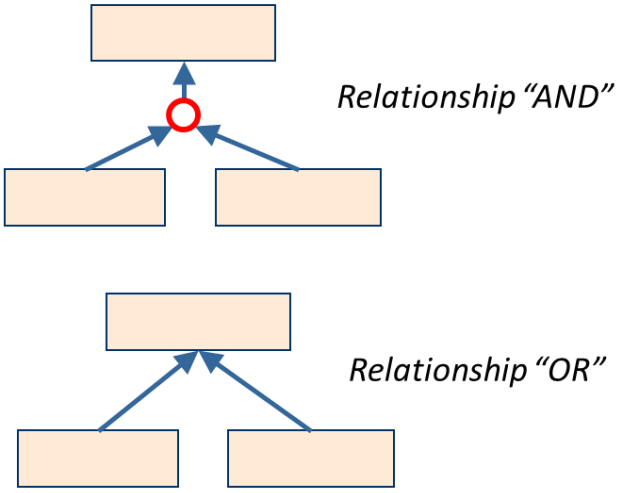
RCA+ does not solve problems: it is designed to identify and select inconsistencies. After RCA+, to resolve (eliminate) contradictions, the relevant TRIZ tools are used: the Matrix of Contradictions and 40 Inventive Techniques, ARIZ, Standard Inventive Solutions (Inventive Standards) and so on. The choice of tool depends on the degree of TRIZ knowledge of the problem solver.

Although RCA+ was developed as a method to support the analytical phase of the TRIZ process, today it is also used to analyze, understand and visualize complex problems as an independent and application-independent tool.



RCA+ Legend

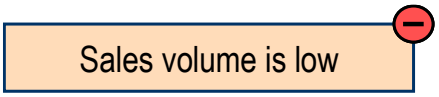

Factual effect (cause)
Assumptive cause/effect
Non-changeable cause
Contradiction cause
Positive Effect


Relationship "AND"
Relationship "OR"

PART A: PROCESS OF RCA+ MODELING AND BUILDING RCA+ DIAGRAMS

STEP 1 State the general negative effect of concern and start drawing the RCA+ Diagram in a top-down manner.

> **Example**: A company have developed a new product, however sales miss defined targets. We can define it as a general negative effect "*Sales volume is low*".



STEP 2 Ask the question "***What causes*** *this effect to occur?*" to find all the causes of the negative effect.

A cause should be stated as either:

- "A subject (noun) + a function or action (verb) + an object or of the action (noun) + sometimes conditions can be refined with extra words:

  > Example: Company does not reach targets; Manager is always late for the meetings; Supplier delays delivery; Customer does not pay in time; etc.

- A property (parameter) of an object or an action and its relative value with respect to the desired situation:

  > Example: Effectiveness of a team is too low; Speed of bringing a product to market is too low; Temperature is too high; Perception is wrong; etc.

- Change of a certain property of an object or an action and its relative value with respect to the desired situation: e.g. maintain (is), change, increase, decrease + a property or an object + its relative value:

  > Example: Rate of changes is too low; Increase of workload is too fast.

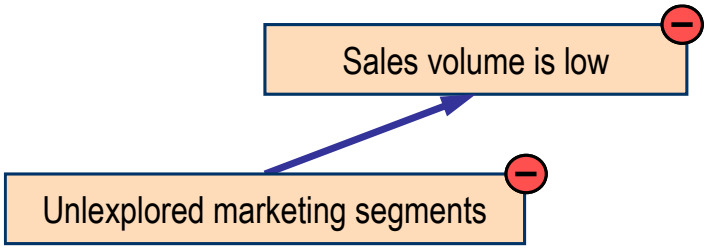
- Radical change of the state of an object on action:

  > Example: Advertisement was abandoned; Customers

disappear; etc.

When the cause is defined, add this new cause to the diagram, by using a line with an arrow from the cause towards the negative effect. It is important to use arrows to simplify further understanding of the RCA+ diagrams.

Example: We added the cause "*Unexplored marked segments*" by answering the question: What causes the effect "*Sales volume is low?*":



Note 1: Why to avoid question "why?"

The question "*why*?" in classical Root Cause Analysis (e.g. why are you going to the supermarket?) can be interpreted in 2 different ways: (1) what for? (a goal, e.g. "*to buy bread*") or (2) what causes? (e.g. "because I'm hungry"). In RCA+, **goals** and **intentions** are represented as **positive effects**, not causes! Therefore when constructing an RCA+ diagram we prefer to ask the question "*What causes …?*" When answering the question "*What causes …?*" we have to identify exactly:

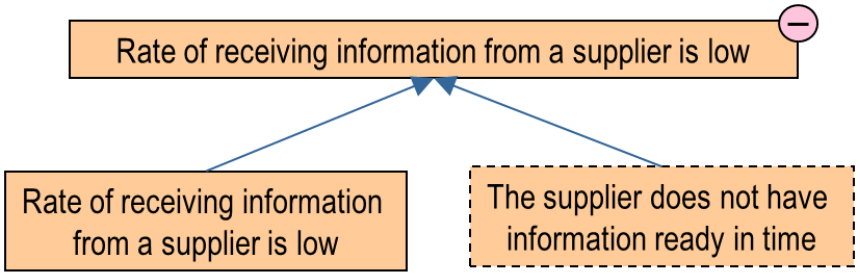
- Which object and which feature of this object causes the negative effect;
- Which physical parameter associated with an object or a field, like "temperature" and its relative value causes the negative effect;
- Which action (or its absence) causes the negative effect.

We must identify a specific feature or a condition which contributes to producing the negative effect. Try to be as much precise with a formulation as possible and do not limit to the formulation to a single word when presenting a cause.

Note 2: Factual and assumptive causes

There might be two types of causes which are presented at

RCA+ diagrams: *Factual* and *Assumptive*. Factual causes are based on verified information while assumptive causes are based on hypothetical information which remains unverified during a process of building RCA+ diagram and still has to be confirmed. For instance, during analysis of a problem "*Rate of receiving information from a supplier is low*" two causes might be identified: 1) "*Information overload in our office is too high*" and 2) "*The supplier does not have information ready in time*". While the first cause can be factual since we know exactly that we experience information overload and can not process information faster, the latter cause is assumptive: we might not be sure of it until we check it with the supplier. After a cause is confirmed, it can be either converted to factual, or if not it should be eliminated from the RCA+ diagram.



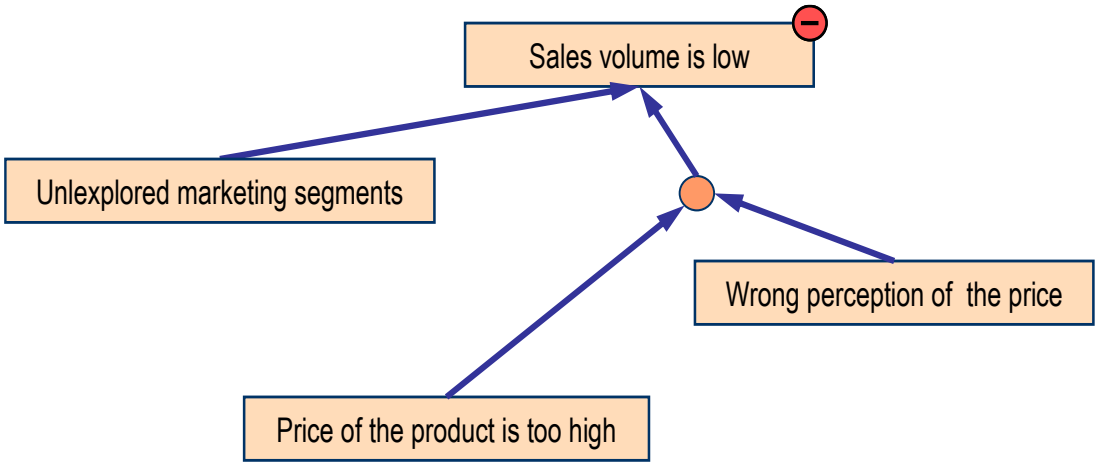
STEP 3 After identification of a cause in Step 2, check if this cause is the **only** condition which is enough to produce the negative effect. In many situations, just one cause is not enough, and two or more causes acting together are needed to produce the negative effect.

There are two types of relationships between causes which can contribute to the same negative effect: AND and OR relationships.

1. In case of the analysis of a *specific problem* different causes of the same negative effect are usually interrelated (AND) and cannot produce a negative effect independently of each other.
2. In case of analysis of *all potential causes which may possibly lead to a failure*, the causes can be either interrelated (AND) or independent (OR).

   Example: It is obvious that just having unexplored market segments is not enough to miss sales targets which were defined for known market segments. Other factors are also needed to produce the general negative effect. We need to add

these other conditions (causes) to the diagram:

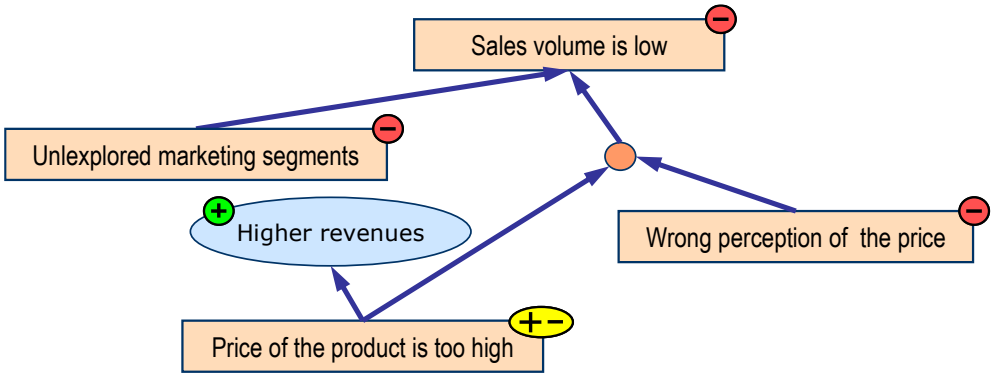


Note, that causes "*Price of the product is too high*" and "*Wrong perception of the price*" are interrelated ("AND" relationship: shown as a circle), because if we remove just any one cause, the negative effect will completely disappear. This is a particular situation for this specific product, since in the past customers used to buy much cheaper versions of the product. At the same time, "*Unexplored market segments*" has nothing to do with the price of the product, therefore it links with other causes via "OR" relationship.

STEP 4 Ask for each cause if it also produces a positive effect. A cause which produces both a positive and negative effect identifies a contradiction. We can have four types of causes/effects in an RCA+ diagram:

- *Negative* (-): the cause/effect is totally negative and we would like to fully eliminate it.
- *Positive* (+): the effect is positive, there is no need to change. Usually positive causes can not exist alone inside of the chain, otherwise there would not be negative effects resulting from them.
- *Combined Negative and Positive* (+/-): the same cause results in both positive and negative effects.
- *Non-Changeable Negative* (--): the cause contributes negatively but can not be eliminated, changed, or modified since it is beyond our control within a given problem scope. Usually such causes are produced by supersystem components.

Example: We need to keep the price of the product high since the product requires much investment and high production costs. Therefore the cause "Price of the product is too high" becomes a cause of a contradiction between positive effect "Higher revenues" and negative effect "Sales volume is low".



Note that we used different tags in the RCA+ diagram to distinguish between different types of causes:

"+-": a cause of a contradiction (or contradiction cause)

"-": a negative effect

"--": a negative non-changeable cause (e.g. state policy)

"+": a positive effect

A non-changeable cause is not included to this diagram.

STEP 5 For each negative cause already present in the diagram continue to ask the question "*What causes this effect to occur?*". Build a top-down tree-like Cause-and-Effect Diagram. However, for those causes which are beyond our control (non-changeable negative effects) and for contradictions we do not continue analysis.

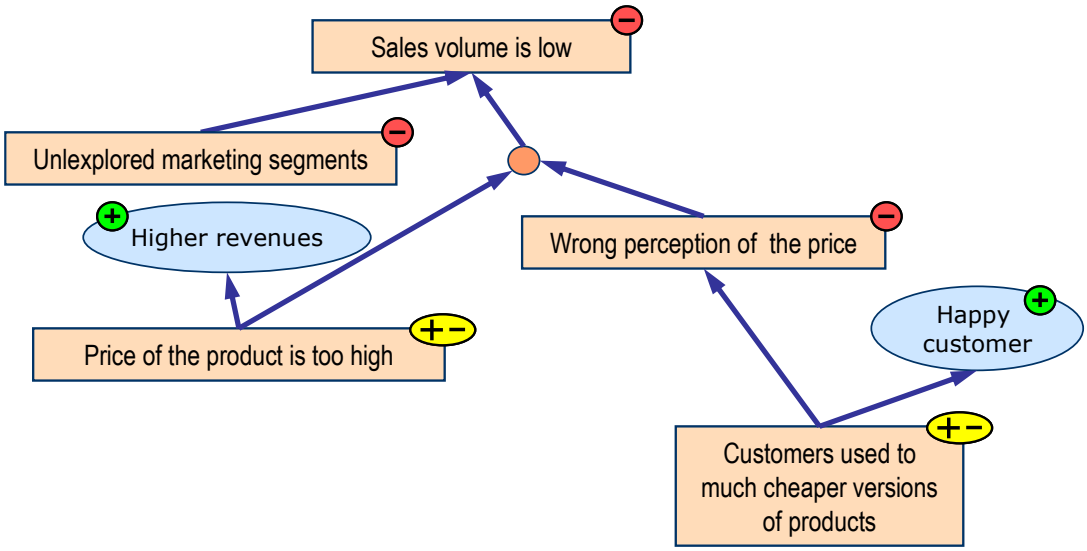
Stop a chain when either:

- You reach a cause which is a demand or requirement that is impossible to change, for instance, it is a policy requirement or it is a "must" part of technical specifications, or,
- You reach a cause which contributes to both positive and negative effects. This is what we call "a root conflict" or "root contradiction". However, in certain situations it might be useful to continue deeper analysis to investigate the underlying causes

of the conflict as well, or,

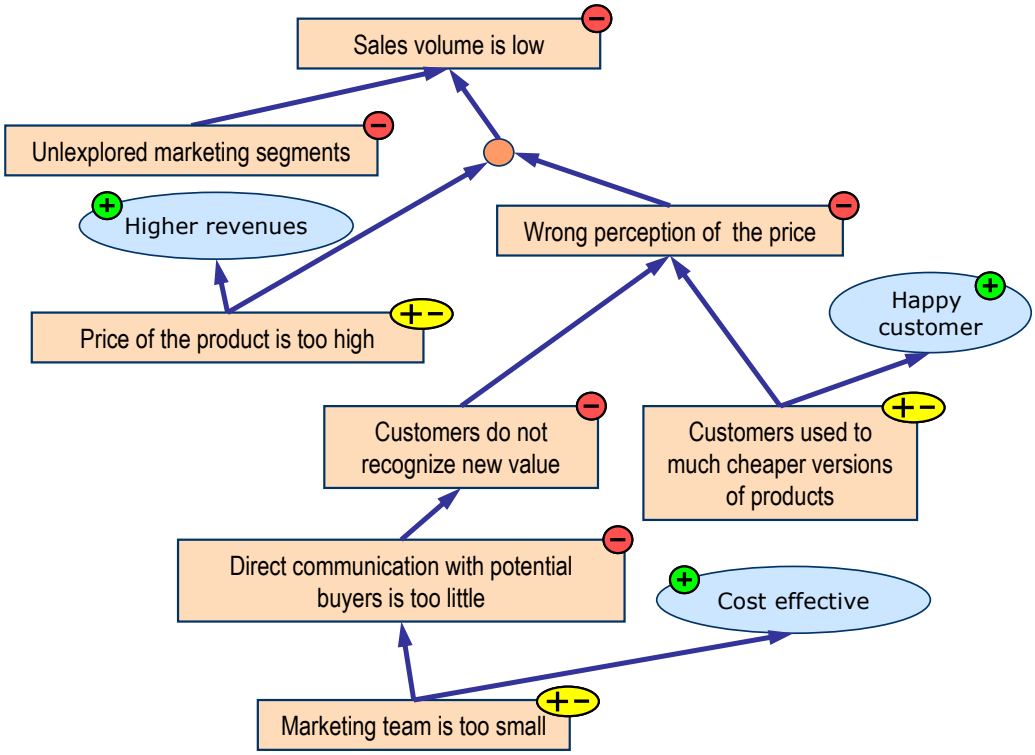
- You reach a cause that we can not influence in any way, for instance, when it has to do with unpredictable changes in environment or human behaviour.

Example: We decided to further analyse the cause: "*Wrong perception of the price*".



STEP 6 For each newly described cause, which is indicated as an underlying negative effect, check again if it is the only cause which creates the negative effect or if there are also other, additional causes interrelated with an "AND" relationship.

Example: We added a new cause "*Customers do not recognize new value*" as a cause of "*Wrong perception of the price*", which is caused by "*Direct communication with potential buyers is too little*". In turn, it is caused by the contradiction "*Marketing team is too small*".



STEP 7 Create a table of the revealed causes. The table has 4 columns: Cause, Type of Cause Positive effect from the cause, Negative effect from the cause.

There are 4 types of causes in RCA+: N: negative causes; N+P: causes which have a negative and a positive effect; NC: non-changeable causes; P: positive effects, which are not listed in the table.

Example:

Cause	Type of cause	Positive Effect	Negative Effect
Unexplored market segments	N	-	Sales volume is low
Price of the product is too high	N+P	Higher revenues	Sales volume is low
Wrong perception of the price	N	-	Sales volume is low
Customers do not recognize new value	N	-	Wrong perception of the price
Customers used to much cheaper versions of products	N+P	Happy customer	Wrong perception of the price
Direct communication with potential buyers is too little	N	-	Customers do not recognize new value
Marketing team is too	N+P	Cost-effective	Direct

small		marketing team	communication with potential buyers is too little

STEP 8 This step is optional. You can directly formulate all problems depicted in an RCA+ diagram in the following way:

a) N-type causes are formulated as either:

In case of a function:

"How to eliminate / prevent <N-cause>?

In case of a relative value of a property or field:

"How to reduce / control <N-cause>?"

b) N+P-type causes are formulated as either:

Contradiction at the level of effects:

"How to ensure <N+P-cause> to enable <P-cause> but to avoid <N-cause>?"

Contradiction at the level of a cause:

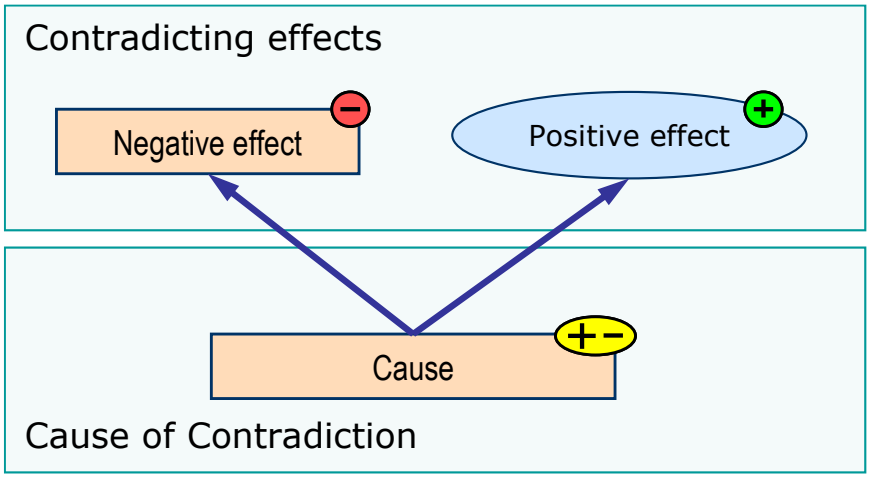
"<N+P-cause> should be present/high and <N+P-cause> should be absent/low."

STEP 9 Select your problem. Two scenarios are possible:

1. If the RCA+ contains a negative cause which is possible to change and without an underlying contradiction, solve the problem by eliminating the cause. In most innovative and complex problems, however, negative effects have underlying contradictions; and therefore they may not be directly eliminated.
2. Select a contradiction to solve by following section B of this Guide: "*Recommendations for Selecting Contradictions from RCA+ diagrams"*:
   - In case of "AND causes" selecting and solving one of the root contradictions will solve the entire problem;
   - In case of "OR causes" all of them need to be solved to solve the problem and prevent it from occurring again.

STEP 10 Use TRIZ techniques for contradiction elimination to solve a selected problem(s).

In every contradiction, we can separate between two types of the contradictions: a pair of contradicting effects and the cause of contradiction itself (a root contradiction, or a root conflict).



- A pair of contradicting effects is formed by a couple "Negative Effect" vs. "Positive Effect". These two effects can be directly matched against positive and negative parameters in the Contradiction Matrix.
- A source of contradiction is defined as two opposite states of a cause: one state of the cause should provide a positive effect whereas its state should be opposite at the same time to avoid appearance of a negative effect. Such contradictions can be solved either with Principles for Conflict Separation or ARIZ.

PART B: RECOMMENDATIONS ON SELECTING CONTRADICTIONS FROM RCA+ DIAGRAMS

An RCA+ diagram usually contains a number of contradictions which contribute to a general negative effect. These contradictions are related to each other in one way or another. We distinguish between five different types of relations between contradiction causes (further in the text we will call a contradiction cause which is tagged with a "+-" sign a "contradiction):

1. Independent contradiction causes (linked by ä logical "OR" relationship): contradictions which independently contribute to producing a negative effect.
2. Dependent contradiction causes (linked by a logical "AND" relationship): contradictions which "co-exist" at the same level and cannot produce a negative effect independently of each other.
3. Causally related contradiction causes: one contradiction is the cause of another one.
4. Complexly related contradiction causes: a combination of causally-related and dependent contradiction causes.
5. Root contradiction causes: two or more contradiction causes share the same cause (which is a contradiction cause too due to inheritance within a contradiction tree).

For these situations the following recommendations apply:

Situation	What to select
Independent causes	Comparative ranking
Interrelated causes	Ideality-based criteria
Chained causes	Ideality-based criteria
Contradictions with the same cause	A "root" cause
Complexly interrelated causes	Ideality-based criteria, Comparative ranking

Below we will explore each situation separately with specific recommendations and examples. Note that the diagrams shown in the examples below are only fragments of actual, more complex RCA+ diagrams. They are presented to illustrate the selection process.

B1. SELECTION CRITERIA

NAME	WHEN APPLICABLE	DESCRIPTION
Comparative ranking	Independent contradiction causes	In case of independent contradiction causes all contradictions should be eliminated independently to solve a problem, unless they cannot be eliminated because they are beyond the control of the problem solver. The contradiction that contributes most to the general problem can be identified by subsequently comparing the degree of contribution to the general problem by each contradiction and selecting the best candidate.
Ideality-based criteria	a) dependent, b) causally related c) complexly related	This is the most complex situation since it involves a number of related contradiction causes. Choosing a contradiction is difficult due to the fact that it is not possible to predict in advance what contradiction will provide the best solution. However, there are a number of heuristic criteria which we can identify as "ideality-based" criteria. Such criteria help to select the best candidate by estimating the expected degree of ideality of each potential solution: to solve a problem, only minimal changes should be made to a system while we achieve the maximum effect. This definition implies that we have to focus on a narrow conflict zone within a system or at the place of interaction between the system and its supersystem which is responsible for producing the contradiction, and which involves those elements which we are allowed to change or modify. We therefore use a set of rules to identify such a contradiction: • **Involving a minimal number of elements:** In case if a contradiction is caused by interaction by many elements, we should

		choose such a contradiction where the number of involved components is minimal. • **Easy to change:** It is logical to choose a contradiction which is formed by elements that are the most easy to change or possible to influence: modify, replace, access, protect, interact with, etc. However, there are a limited number of situations when it is easier to change the supersystem rather than the system itself (for instance, by combining several systems into a supersystem). Therefore the choice of a preferred candidate should be made by analyzing what system or supersystem elements are involved in each contradiction and selecting the contradiction which contains the elements that are the most easy to change or influence. • **Alignment with the overall strategy of the problem owner:** Finally, in case when there are several equal candidates, the contradiction which fits the best with the long-term strategy of the problem owner should be chosen. Usually, selecting a contradiction from the upper part of the RCA+ diagram solves a problem in a more specific way than selecting a contradiction from the lower part. To help defining what contradiction to choose in cases when there are more than two contradictions involved, we complete a table for each contradiction which includes the following elements: 1. The cause of the contradiction. 2. The positive effect produced by the contradiction.

		3. The negative effect produced by the contradiction. 4. Main system and supersystem parts which are responsible for causing the contradiction. It is recommended to specify exactly what parts of the system (or its supersystem) components are involved in the contradiction (e.g. surface, etc.). The physical space between components can be considered as well. 5. The property (or parameter) which is responsible for causing the contradiction. This can be any physical or non-physical parameter or a property of a system or a supersystem component which is responsible for producing contradicting effects. 6. The time when a contradiction (conflict) occurs. After the table is complete, we analyze what contradiction matches the criteria presented above best of all.
"Root" Criteria	Effects with the same root cause	In case of a single contradiction cause which contributes to two or more upper-level contradictions, this "bottom" (root) contradiction should be selected since its elimination will automatically eliminate all contradictions above it (unless they are also caused by some other independently related factors) and, therefore, the negative effect. However, in some cases the root contradiction can not be eliminated due to certain constraints such as, for instance, government policy or because it is caused by a supersystem component that we are not allowed changing. In such situations, other contradictions should be chosen for elimination. In cases when there are two or more root contradictions, their selection is defined by

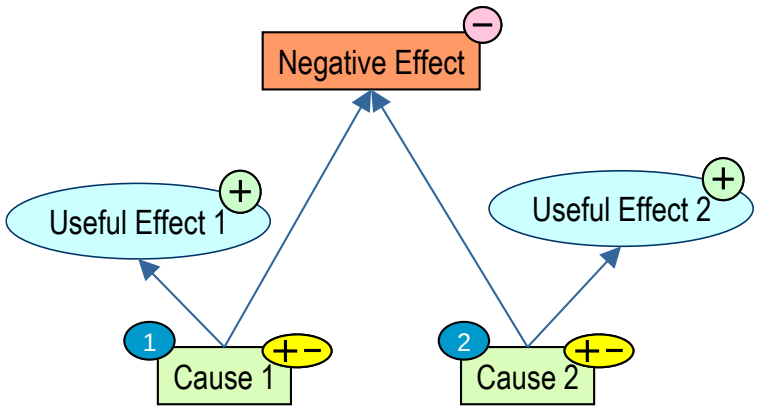
		ideality-based criteria

For all situations: when a selected contradiction does not produce a desired solution, the next best candidate should be chosen according to the same selection criteria and recommendations for each specific situation.

B2. FIVE SITUATIONS

SITUATION 1: INDEPENDENT CAUSES

Situation: These contradiction causes are independent of each other ("OR" relationship). In this situation, both (or more, in case when more than two contradictions independently contribute to the same effect) contradictions should be eliminated to prevent the negative effect from occurring, since both contradiction causes contribute independently from each other to the same negative effect.



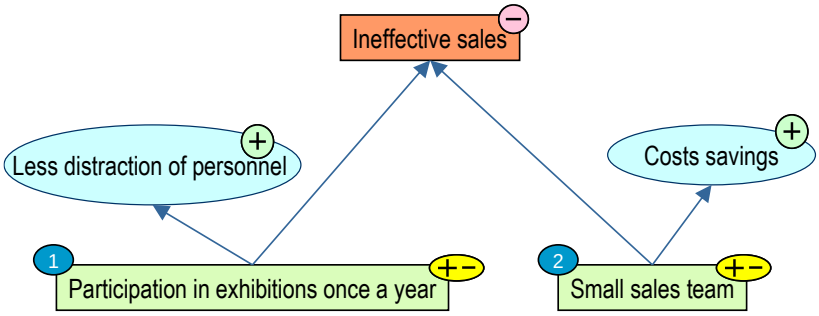
Selection Criteria: To decide which contradiction to resolve first, we estimate the degree of contribution of each contradiction to the negative effect, and select the most contributing contradiction. After that, if we want to completely eliminate all potential causes of the negative effect, we should eliminate the other contradictions too. Sometimes when resolving a selected contradiction we change a system in such a way that other contradictions are eliminated as well. However to predict what contradiction will lead to such changes is very difficult at this stage.

Since we build an RCA+ diagram within the context of a specific problem and focus on the causal relationships, the diagram only defines those contradictions which are relevant within this specific context. However, system components might have deeper connections, outside the presented problem, at a functional level. This situation addresses to general failure prevention or problems of

quality/performance decrease. An example: let's suppose that we have two contradictions related by a single "OR" connection. For instance, a car might not brake properly because either 1) the braking pad is worn off (has to be soft to enable better friction and hard to avoid wearing off), or b) the car is too heavy (it has to be lightweight for easy braking and fuel consumption and heavyweight to withstand the cargo load). These two contradiction causes are not related: the brake distance is still too long even if the pad is perfect in the second case. If we resolve the contradiction "lightweight-heavyweight" by completely redesigning the car to make it stop faster, we might come up with a solution that does not require the braking pad at all: for instance, braking might be performed by a field, or instead of pressing the pad against a disk we somehow use the road for braking. In this case the problem with the braking pad will cease to exist since we will not have the braking pad in the new design of the car.

Although the contradictions were causally independent within the context of this problem, we can see that solving one contradiction might completely eliminate the existence of the other contradiction.

Example 1: Ineffective Sales:

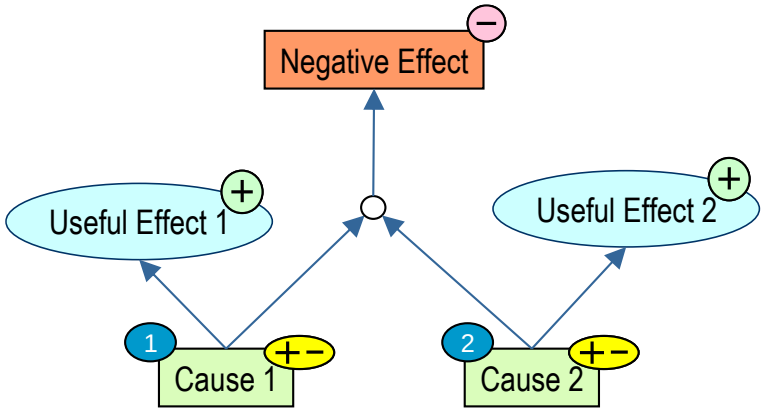


In this example we can see that both contradiction's causes (causes 1 and 2) act independently of each other. By judging what contradiction is more important to us, we decided to focus on raising effectiveness of sales team rather than on the participation in exhibitions. However, later on we might come back to increasing the number of

exhibitions as well.

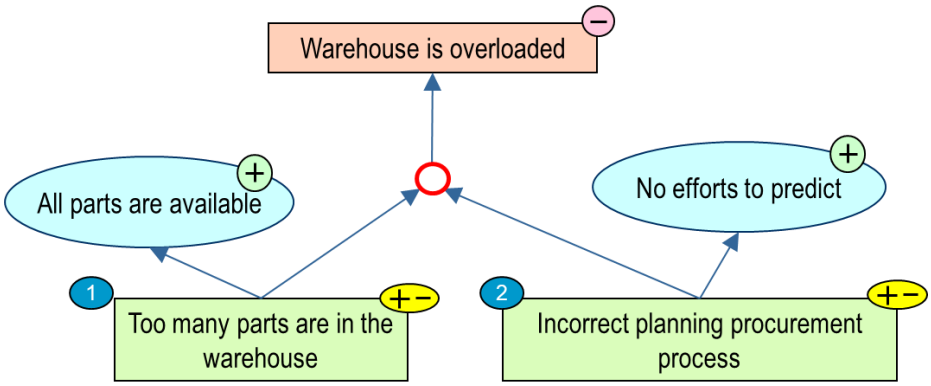
SITUATION 2: DEPENDENT CAUSES

Situation: These contradictions are interrelated with each other by an "AND" relationship and therefore contribute to the same effect. In this situation, no matter how many contradictions are interrelated via the same "AND" relationship, it is enough to eliminate just one contradiction, and the negative effect will be completely eliminated.



Selection Criteria: For such situations, we should select Ideality-based criteria which are defined in section B1, and thus select a contradiction which a) involves the least number of (supersystem) components, b) involves components we can change easily, and c) fits the best with our strategy.

Example 2. Warehouse is overloaded:

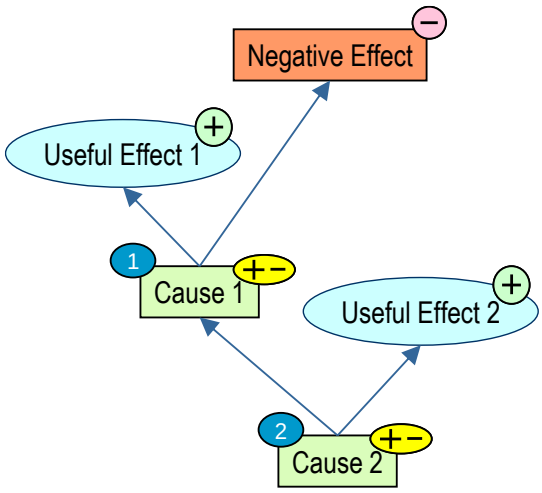


In this example, the two contradictions are dependent. If even one contradiction is eliminated, the problem will disappear. In such cases, the

contradiction is selected according to the ideality criteria, which are described above in the "Selection Criteria" section. In this case, it is easier and easier to solve contradiction 2: *"Incorrect planning procurement process*".

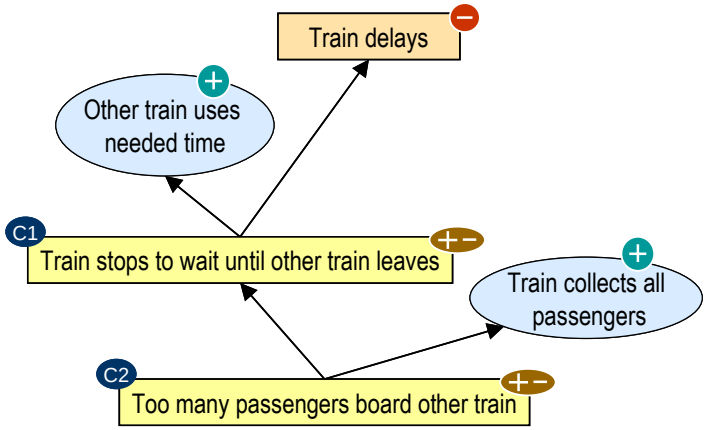
SITUATION 3: CAUSALLY-RELATED CAUSES

Situation: In this case, a contradiction cause is also the cause of another contradiction cause, and therefore they form a causal chain of contradictions which ultimately leads to a general negative effect.



Selection Criteria: It does not matter which contradiction is selected from the chain, since elimination of any contradiction will break the chain and will therefore remove the contribution of the entire chain to the negative effect. In such situations, we also chose the Ideality-based criteria.

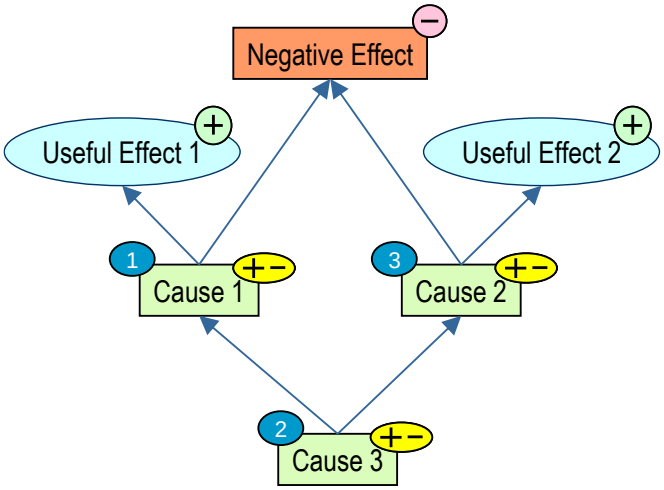
Example 3: Train Delay



In this example, two contradiction causes belong to the same chain. If we apply the Ideality-based criteria within the context of the problem owner (assuming we are a train operator), we can see that the contradiction caused by "*Train stops until other train leaves*" is at the system level, since in this case both the trains and the train station are under our control. In the second contradiction cause "*Too many passengers board other train*", we deal with the passenger flow which belongs to the supersystem and is therefore more difficult to control and influence.

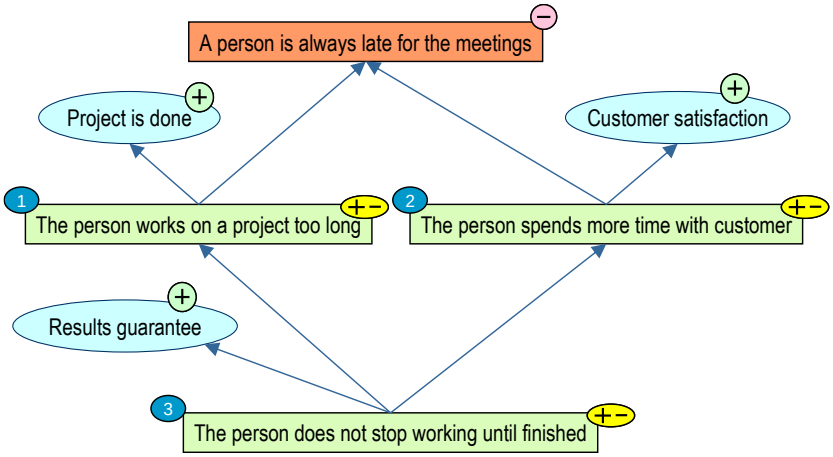
SITUATION 4: "ROOT" CAUSE

Situation: There are situations when two contradictions are independent of each other ("OR" relationship), but they are both caused by the same contradiction.



Selection Criteria: In this situation we apply the rule of the "root contradiction" and eliminate the single underlying contradiction (Cause 3). However in case when we are not allowed to solve this contradiction, we should select the other contradictions and apply the relevant selection criteria.

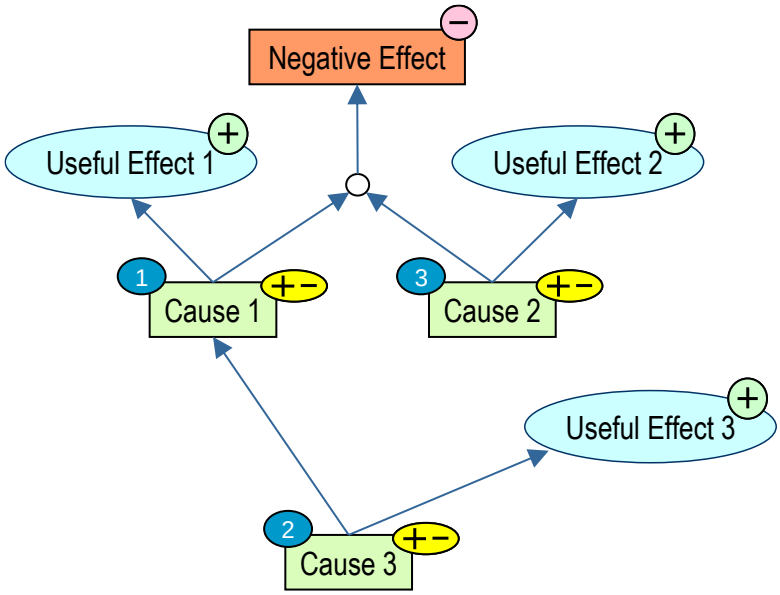
Example 4: A person is always late for meetings



In this example, two contradictions 1 and 2 are caused by the same root contradiction cause (3): "The person does not to stop working until finished". Therefore this root contradiction should be resolved if we would like to eliminate all causes leading to the negative effect of being always late for meetings.

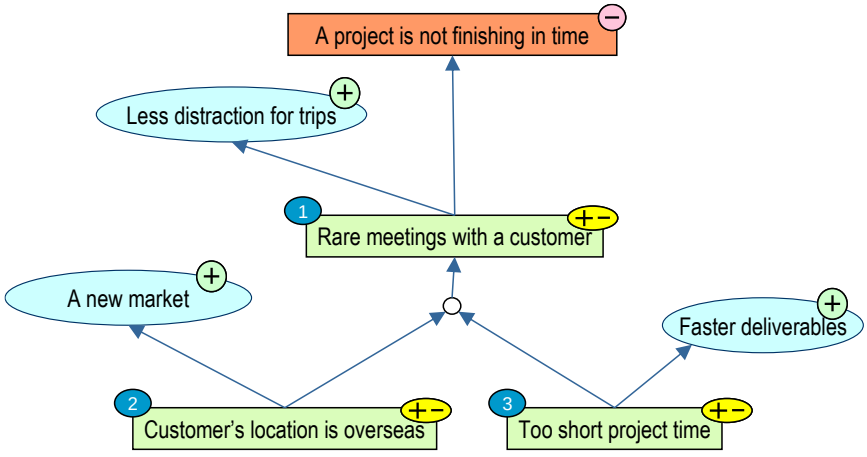
SITUATION 5: COMPLEXLY INTERRELATED CAUSES

Situation: In certain cases, contradictions can be interrelated in several different ways, for instance, linked by an "AND" relationship, and at the same time one of the contradiction causes is part of a chain of contradictions. In this case resolving any contradiction will provide a complete elimination of the negative effect.



Selection Criteria: In such situations, we also chose the Ideality-based criteria which are defined in section B1. Note that complexly related contradictions do not involve independent contradictions.

Example 5: Not finishing a project in time



In this example, all three contradictions are

interrelated and chained, which means that resolving any contradiction will result in complete elimination of the negative effect "*A project is not finishing in time*". By applying the criteria of ideality, we can see that the contradiction cause "too short project time" should be selected first, since both other causes "*Customer's location is overseas*" and "*Rare meetings with a customer*" involve a customer which is an element of a supersystem and thus are more difficult to influence.

PART C: GLOSSARY

General problem	A general description of a top-level negative effect which we would like to eliminate or prevent from occurrence.
Contradiction	A situation when the same cause causes both positive and negative effects.
Positive effect	Any positive result.
Negative effect	Any negative effect.
Negative cause	A cause which leads to a negative effect and does not cause any positive effects. A negative cause can become a contradiction cause in case it contributes to both positive and negative effects.
Dependent causes	If two negative causes must act together to produce a negative effect they are considered dependent.
Independent negative cause	A cause which leads to a negative effect (without any positive effect) and does not require other causes to act together.
Independent contradiction cause	A cause which contributes to both positive and negative effects and does not require other causes to act together.
Dependent contradiction causes	A cause of a contradiction which requires some other contradiction cause(s) to produce a negative effect.
Causally related contradiction causes	If one contradiction cause contributes to another contradiction cause, they are considered to be causally related.
Complexly related contradiction causes	A situation when different types of relationships exist between contraction causes which contribute to the same negative effect.
Root contradiction cause	A contradiction cause which contributes to two or more other contradiction causes.

Cause of a contradiction	A negative effect which produces both positive and negative effects.
System	A set of objects we can directly control and influence.
Supersystem	Any objects which interact or might interact with a system but do not belong to a system during performing an RCA+ process.
Ideality	One of the key concepts of TRIZ which states that all men-made systems tend to evolve towards the highest degree of ideality by reaching the highest value of ratio “Value/Costs”.
Factual cause	A cause that definitely takes place
Assumptive cause	A hypothesis that a cause may take place
Non-changeable cause	A cause which may not be changed due to constraints that we are unable to influence.

PART D: RCA+ CHART EXAMPLES

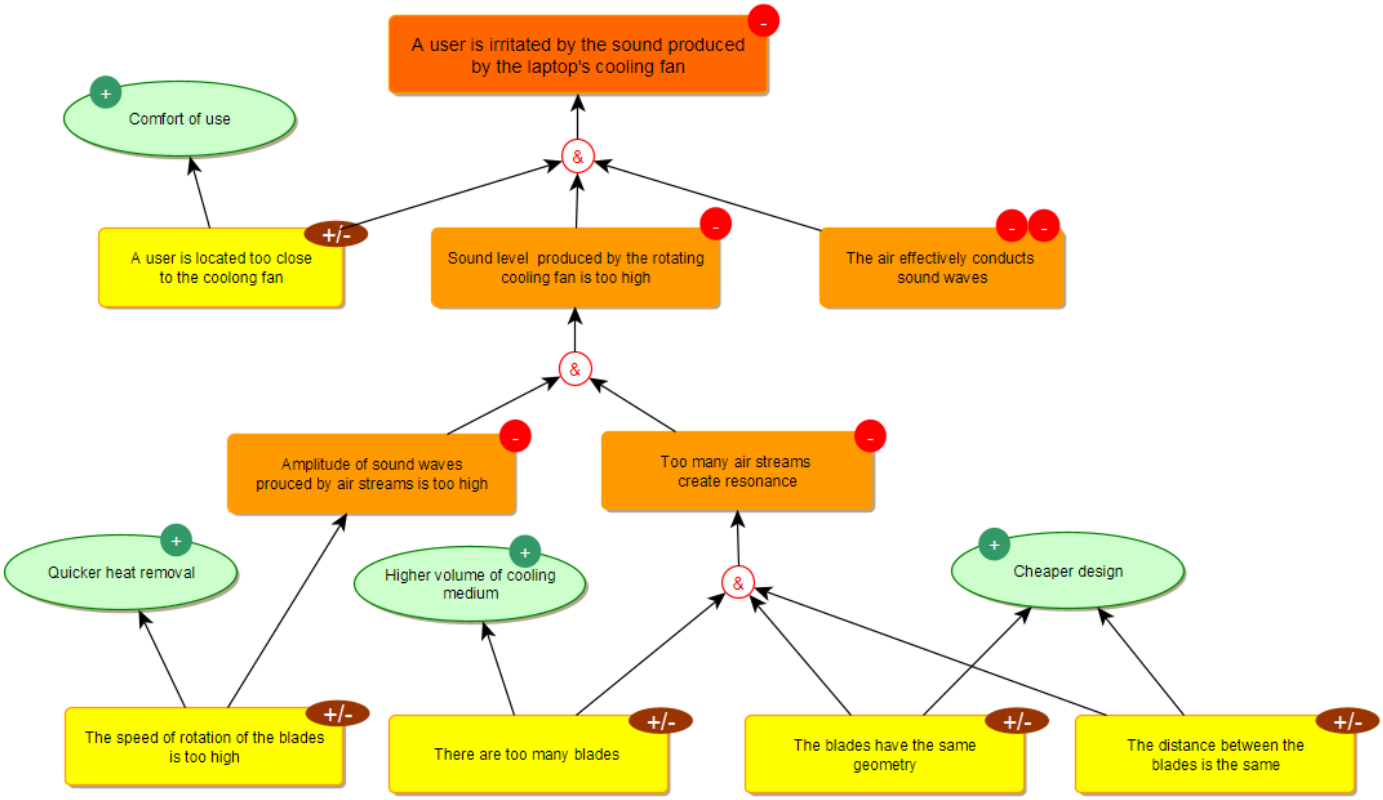
The RCA+ diagrams shown below are from different areas and should be self explanatory.

Note that these diagrams use RCA+ rules to stop the top-down analysis after the top-down analysis has found an inconsistency or immutable cause.

In addition, the completeness of the RCA+ diagram is subjective and depends on how carefully intermediate causes have been identified. Each problem can be decomposed into less or more detailed diagrams.

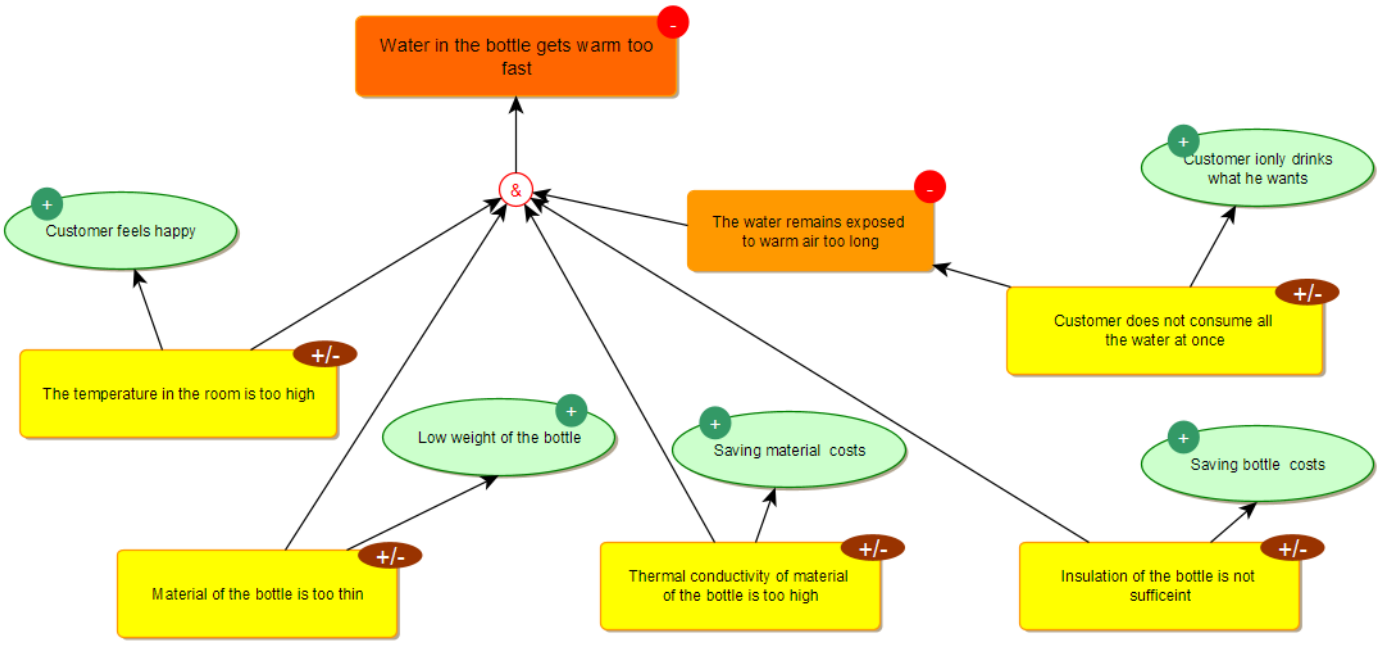
Example 1: The cooling fan installed in the laptop makes too much noise.

A typical situation with which almost everyone is familiar. After a while, the compact laptop overheats and its cooling fan speeds up, causing acoustic noise. Note that the RCA+ diagram does not include heat as the cause, as the analysis was stopped earlier in accordance with the RCA+ rules. There are 5 dependent contradictions in the model, which means that it is enough to solve only one of them to completely solve the main problem. If none of the inconsistencies can be resolved to obtain the desired solution, further analysis can be continued.



Example 2: Water in a plastic bottle heats up too quickly

After an ordinary plastic bottle of drinking water from a local supermarket is taken out of the refrigerator and moved into a room with a comfortable room temperature, the water in the bottle heats up quite quickly as it seeks to establish a thermal balance with the air temperature in the room. The problem model also includes 5 dependent contradictions.



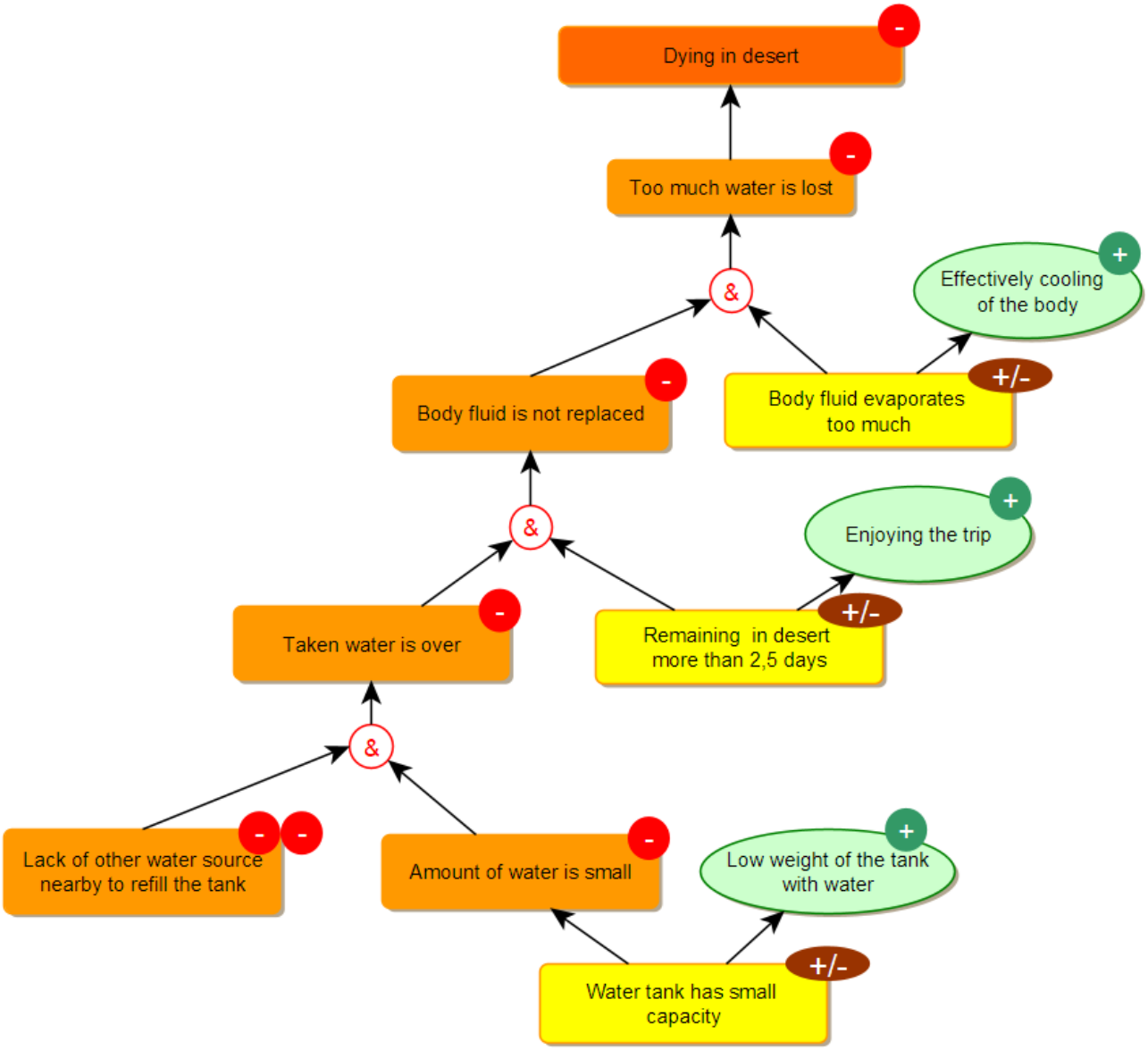
Example 3: Delayed review of insurance claims

This example demonstrates the use of RCA+ in business services. The problem is that the insurance company is late in processing claims by internal experts. This RCA+ model includes both dependent and independent branches with contradictions.

Example 4: Dehydration in the desert

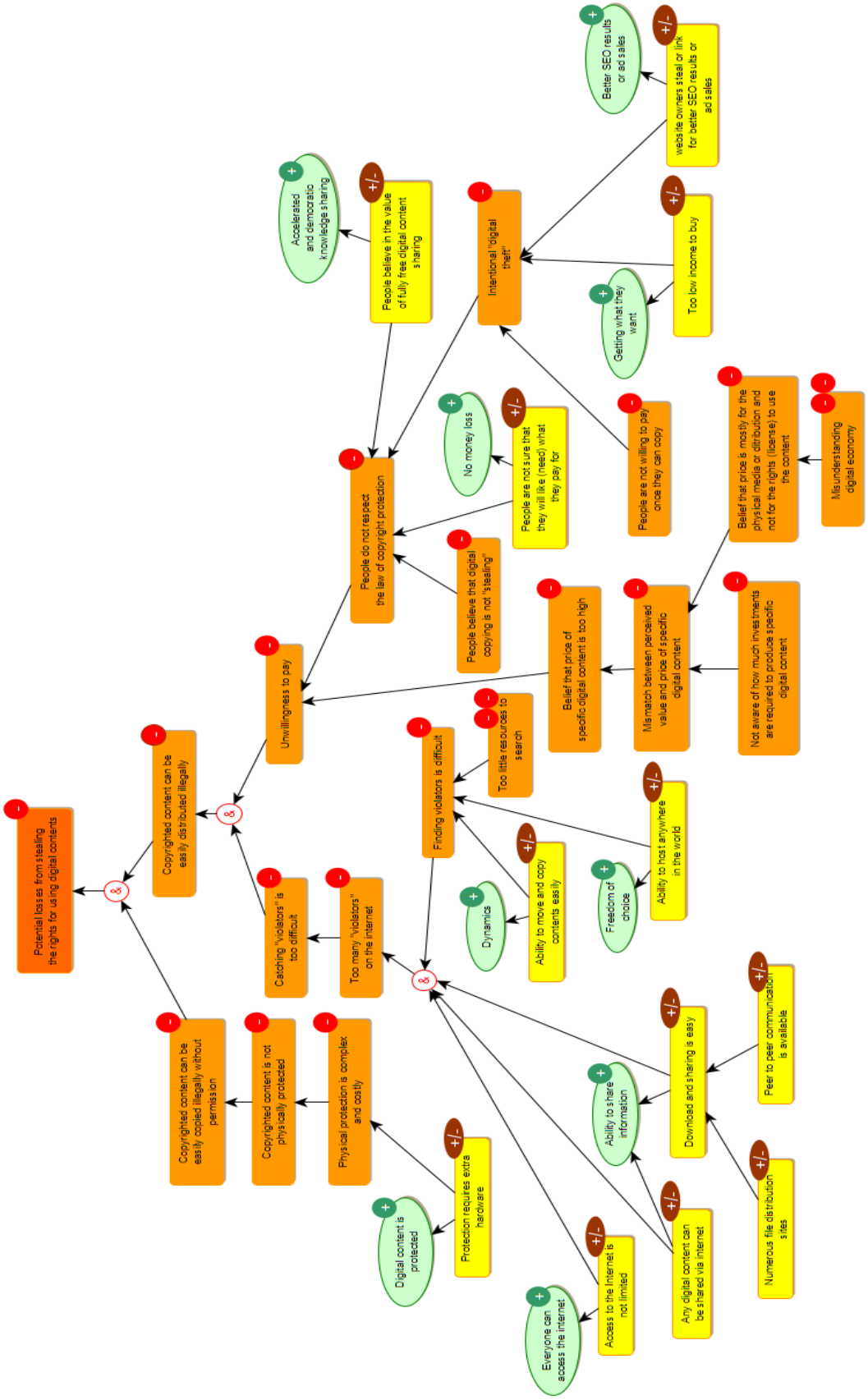
Problem: A tourist goes to the desert and takes a limited supply of water with him. To save money, he decides to take a walk without a guide through uncharted territory. Eventually the hiker gets lost, and when the water supply runs out, he suffers from severe dehydration and may die.

This diagram contains only dependent contradictions.



Example 5: Theft of digital content.

This model refers to a very general problem: many companies producing multimedia digital content (text, audio, video) suffer potential losses due to Internet piracy. Since the problem is quite complex, its model is also complex and includes a number of dependent and independent branches with causes of contradiction.



Example 6: Covid-19 situation

The chart below was created at the very beginning of the Covid-19 epidemic, in March 2020.