Solving Problems in a Connected World

The era of complex problems

On October 4, 2021 at 3:39 PM, a digital silence fell over the world. Suddenly, billions of people received the notification: 'Cannot connect.' This was not just a minor glitch or technical hiccup. Facebook, along with its subsidiaries WhatsApp and Instagram, had completely disappeared from the internet. As if someone had literally pulled the plug on their massive data centers.

By Gijs Verrest

Facebook experienced a Major Incident. Downdetector recorded a whopping 14 million outage reports that day, a record. Technical experts worked frantically to solve the problems in the complex world of digital infrastructure, IP addresses, Border Gateway Protocols, and Domain Name servers.
This was not easy because Facebook's *internal* communication was also severely disrupted. Employees could no longer make phone calls or send emails, and they lost access to various services, which blocked remote access to their own servers.
To make matters worse, security badges stopped working as well. As a result, buildings and meet-

ing rooms became inaccessible, including the spaces where the physical servers were located.

A complex problem of gigantic proportions unfolded behind the scenes. What was going on? How did this happen? And how could everything be brought back online as quickly as possible?

The era of complex problems

The 'Future of Jobs Report 2023' by the World Economic Forum shows that many of the skills essential for the future are related to problem-solving.

To some extent, this has always been true, but today's problems are more complex than ever before:

> *'Cognitive skills are reported to be growing in importance most quickly, reflecting the increasing importance of complex problem-solving in the workplace.'*

The world around us is changing at a rapid pace. Driven by technological advancements, increasing interconnectedness, and an abundance of data, problems are becoming more complex.

The disruption at Facebook is a striking example of this. While in the past, many challenges could be attributed to local, isolated events, problems now often result from networks and interactions that are intricately intertwined in unpredictable ways. We are faced with problems that were previously unthinkable.

Not too long ago, if a light bulb didn't work, it was probably due to a burnt-out bulb. Very simple. With today's 'smart' lighting, it could be anything: is the Wi-Fi connection unstable? Does the smart bulb need a firmware update? Is the hub not cooperating or has the app on your phone crashed? Or maybe it's just the battery in the lamp's remote control that needs replacing?

What used to be a simple object is now a technological marvel. As a result, we have all become problem solvers in this new era - perhaps without even realizing it. Everyone now faces complex problems. But are we ready for them?

What were the consequences?

The broad Facebook network (including WhatsApp, Instagram, etc.) encompasses much more than just social interactions. In many parts of the world, it is practically synonymous with the internet. Over a billion people in Asia, Africa, and Latin America have access to the internet through Facebook's "Free Basics" program. Many apps and services also use "Log in with Facebook" for authentication. All very convenient... until it stops working. Suddenly, users couldn't log in to websites, smart TVs, thermostats, and other internet-connected devices.

The disruption resulted in a tsunami of additional internet traffic. Apps didn't accept error messages and kept trying to connect... over and over again. Human behavior also had an exponential effect with constant page refreshes, app closures, and restarts. DNS resolvers (which translate domain names into IP addresses) received thirty times more requests than usual worldwide, causing delays and timeout issues for other sites.

Meanwhile, users flocked to platforms like Twitter, Discord, Signal, and Telegram, causing disruptions on their servers as well. Facebook's stock price plummeted by 4.9%, resulting in a loss of $47 billion. It took more than five hours for the various services to slowly become accessible again.

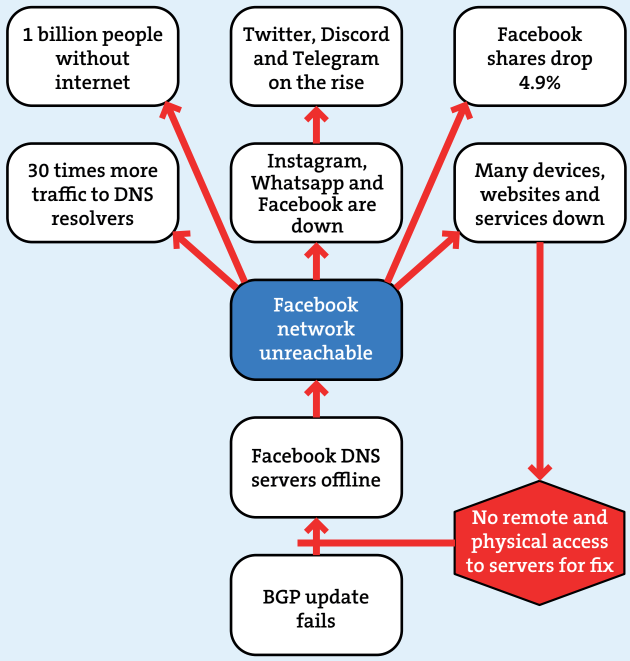

Figure 1: The outage at Facebook.

What was the cause?

The internet is literally a network of networks held together by Border Gateway Protocol (BGP). BGP enables a network (like Facebook) to advertise its presence to other networks. To make the internet work, enormous constantly-updated lists are needed with possible routes that can be used to send each network packet to its destination.

Due to the issues, Facebook stopped advertising its presence, which prevented Internet Service Providers and other networks from finding its network, rendering it unavailable. Ultimately, it was discovered that the cause was a configuration change on the backbone routers responsible for handling network traffic between the company's data centers. The change unexpectedly affected communication between data centers, triggering a chain reaction that disrupted all network traffic and brought services to a halt.

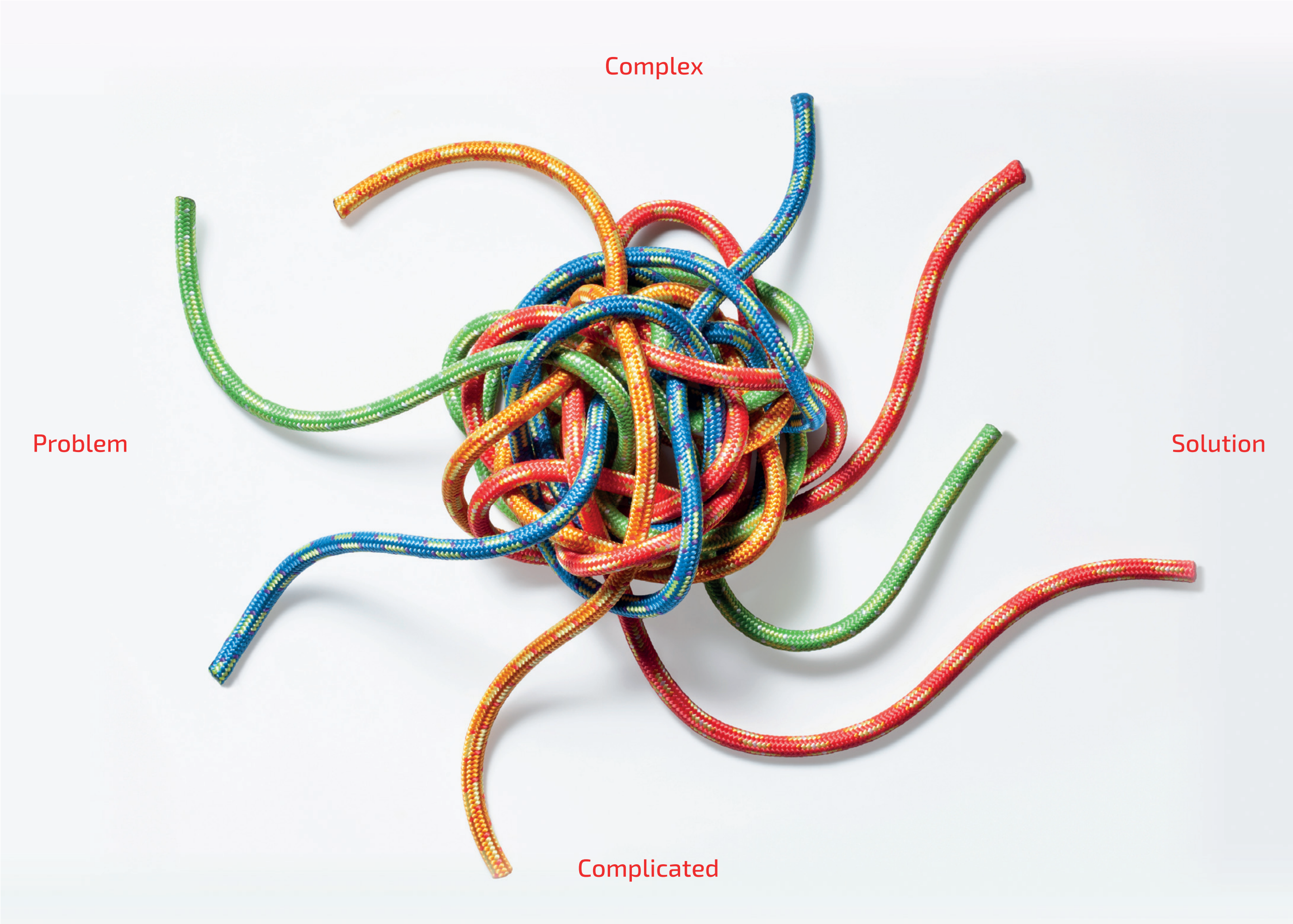

Figure 2: There are different types of complexity. Sometimes it is the problem itself that is complex. At other times, it's the solution itself that is complex. Many of the problems we often describe as complex are not actually complex, but rather complicated. These problems need to be unraveled and separated from one another.

What makes complexity complex?

Let's start by examining complexity itself. It is useful to gain more clarity on this because there are different types of complexity. Sometimes, it is *the problem* itself that is complex. On other occasions, it's the *solution* itself that is complex. The latter was the case with COVID-19. Controlling the virus proved to be quite challenging because everything was constantly changing: knowledge about the virus, its rapid spread, treatment options, strain on healthcare systems, regulations, human behavior, and not to mention the virus itself which kept mutating (and continues to do so). Solving such a problem is indeed complex.

Sometimes, the challenge is in understanding and identifying the cause of the problem. Take semiconductor manufacturing as an example; semiconductors are made using photolithography where light-sensitive chemicals are exposed on a silicon wafer to create extremely fine patterns. Various chemical processes and etching methods are then applied to form electronic structures on the wafer. This production process consists of hundreds of steps and takes several months. When quality tests at the end reveal a defect, it can be quite challenging to determine the cause. The complexity in this case lies in the actual problem.

There is another dimension of complexity that is relevant. Some problems are genuinely complex, really *difficult*. Take a particle accelerator, for example. It is complex in the sense that it deals with extremely challenging matter. We are pushing the limits of scientific knowledge here. Problems in this field often arise due to a lack of knowledge and require scientific research. The good news is that many problems we consider complex in practice are not actually *complex*; they are *complicated*. These problems need to be unraveled and separated from each other. We often look at multiple problems simultaneously and lose sight of the bigger picture, making effective and efficient solving more difficult.

So, there are different types of complexity. A first step to becoming better at solving complex problems is realizing what kind of complexity we are dealing with. Now let's focus on 'the human being': the problem solver themselves.

The problem solver's brain

All problem-solving really happens in just one place: inside our minds – our human brains. If we want to improve our ability to solve complex problems – really, truly solving them right the first time, with the least amount of effort – then that's where we should start. We begin by ensuring that the input we receive is of high quality: accurate information about the problem, involving the right people. This is often where things go wrong. Information may be missing, incorrect or unclear, or relevant individuals may not be involved.

And then there's our brain, where thinking about those problems occurs. That thinking needs to be of high quality too. But where have we learned that? How often do we follow a clear, structured thinking process? The reality is that we don't do it nearly often enough. We have learned to rely on our intuition, and that is not always wise.

Let me give you an example. You only have a few seconds to answer, so be quick! A pencil and a pen together cost €1.10. The pen costs €1 more than the pencil. How much does the pencil cost? Listening to your intuition, the answer '10 cents' comes up quite quickly. And that is completely wrong.

So, don't rely too much on your intuition. As Daniel Kahneman, one of the world's most renowned psychologists, writes in his book 'Thinking, Fast and Slow', we make many decisions based on our intuition every day, and there is nothing wrong with that. However, we are susceptible to cognitive biases or thinking errors. Our subconscious mind relies on our knowledge and experience. This makes 'jumping to conclusions' likely: wrongly and unconsciously assuming that a problem is clear, that it is the same as last time, or that a certain solution will work again.

Where does this thoughtless behavior come from? Simply put, it takes less effort because good thinking requires energy. In addition, we actually find complexity quite challenging. We prefer a world that is simpler and more coherent than it really is. This leads us to simplify things more than is justified.

Therefore, in these times, when problems are becoming more complex and their impact ever greater, problem solvers will not only need their own expertise and that of others but will also be required to approach problem-solving in a more conscious, deliberate manner. It is important to critically examine your approach. Here are some recommendations.

Tip 1: Don't start with solving

Your boss says: 'Don't bring me problems, bring me solutions.' We are often encouraged to take action, which creates a sense of urgency. The pressure is on! This leads us to start solving immediately. However, without understanding the problem (and its cause), any approach quickly becomes trial and error.

Being in action mode feels great. We think we don't have time to dwell on things for too long. Something needs to be done! However, taking the wrong actions very efficiently is still wrong.

There is also a misconception that you can't be both fast and deliberate at the same time. You can, but you need to be organized and make this part of your plan. The fire department rushing to a fire needs to be fast, but they also take the time to understand the situation before rushing into any building. When? During the ride in the firetruck.

So, first invest your energy in understanding the problem (or, more often, the problems).

Tip 2: Separate, separate, separate

We don't realize that we often try to tackle more than one problem at a time. Complex problems are often complicated and require being separated first. Therefore: separate, separate, separate.

Take Pareto charts as an example; bar graphs showing problems in order of frequency. This helps prioritize solving them. It is logical to want to address frequently occurring problems first. What is not logical is that we then often start shooting in the dark hoping to hit something. With the best intentions, we bring experts together who come up with actions to tackle the specific problem. What is overlooked is that this almost always involves a *complicated* problem that needs unraveling first. Maybe the *symptoms* are similar, but there are guaranteed multiple problems with different causes. Only when we recognize and separate these different problems can we analyze and solve them further (see figure 3).

Tip 3: Make thinking visible

We humans are incredibly good at talking past each other. Our statements are full of

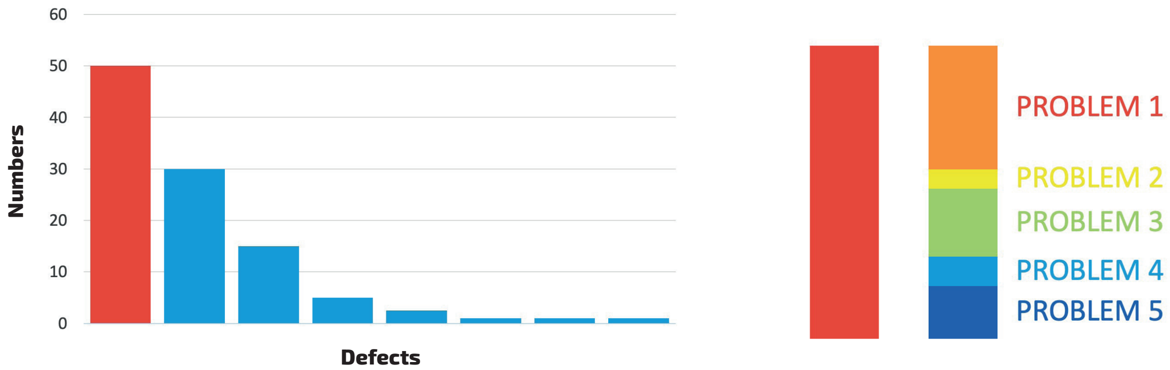

Figure 3: Only when we recognize and separate the different problems can we analyze and solve them further.

unclear language, abbreviations, and jargon. We use the same words for different things and different words for the same things. As situations become more complex, this invites (even more) problems because our thinking remains invisible, confusing us about what's going on and what to do next. A crucial tip is therefore making *visible* what the facts are, what assumptions are made, what information is still missing, what actions are proposed, and who will do what.

In many complex problem situations, there is a combination of circumstances: a combination of factors that lead to a deviation. Several things are not going well; one security measure doesn't work, one solution leads to another problem, and so on. Soon, the situation becomes complicated, difficult to understand, and challenging to communicate. By visualizing the different factors in relation to each other, clarity is brought forth and makes it solvable.

Take another look at the visualization of the problem at Facebook. The image greatly helps in understanding the explanations about causes and consequences.

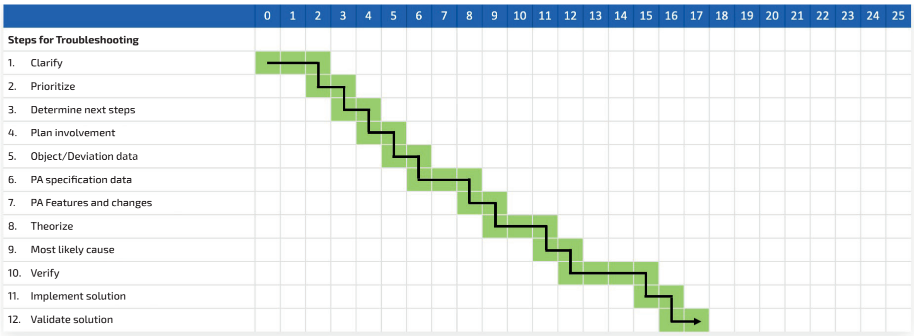

Figure 4: Ideal flow of problem-solving.

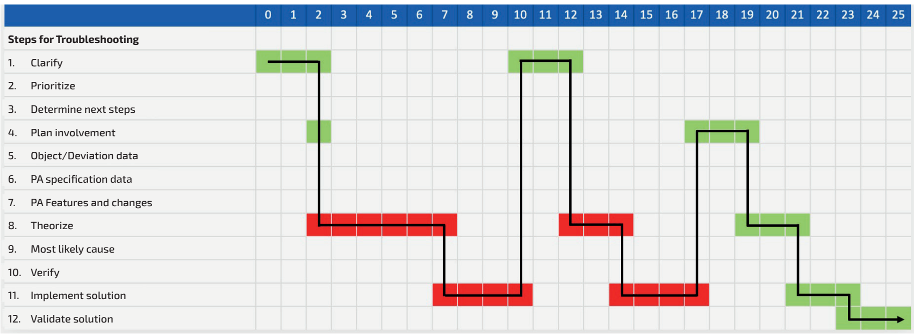

Figure 5: Typical flow of problem-solving.

Tip 4: Beware of the ad hoc trap

The danger of complex problems that are not made visible and receive too little 'conscious thinking' is that there is insufficient structure in the approach. Simply put, the approach becomes very 'ad hoc', although problem solvers often do not realize this. Figure 4 shows the logical high-level structure. This is our model for Problem Analysis and Decision Making; it shows the various thinking steps.

Figure 5 shows what is often seen in practice. Premature conclusions are drawn, and actions are quickly taken. Many actions taken in an attempt to be fast do not work, or even have counterproductive effects. Not only is valuable time lost, but unnecessary energy is invested in efforts that yield nothing.

To successfully solve complex problems, it can be valuable to have a facilitator lead the analysis. He or she can take control, make thinking visible, provide structure, and ask probing questions to get the best out of experts around the table. Nowadays, when problems are increasing in complexity and their impact is greater than ever before, you want to avoid people saying: 'My gut feeling is that...' and then jumping into action without proper consideration. By following a clear, structured approach, you don't leave the solving of complex problems to chance. **Q**

The Kepner-Tregoe methodology provides structure in simple to extremely complex situations and facilitates collaboration within the organization. Silos are broken down: from management teams to the shop floor, everyone speaks the same language. With this approach, it is clear where to start, what to do, and the right questions are asked at the right time.

In the September/October 2022 issue of Kwaliteit in Bedrijf (Quality in Business), Gijs Verrest's article 'How to get a better grip on problems' was published (see www.kwaliteit-in-bedrijf.nl/grip).

About the author

Gijs Verrest is a senior consultant at Kepner-Tregoe and market leader for KT Netherlands. With 25 years of experience as an advisor, trainer, and facilitator, he helps organizations gain better control over their problems. He has worked with many (inter)national clients ranging from aerospace and pharma to semiconductors and ICT.

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