sciendo

Rules as Code in Telecommunication Industry: Routing in Fiber Optics Networks

Mihnea-Alexandru VĂDUVA*
Universitatea Națională de Știință și Tehnologie Politehnica București, București, Romania
**Corresponding author, mihnea.a.vaduva@gmail.com*

Ionel-Bujorel PĂVĂLOIU
Universitatea Națională de Știință și Tehnologie POLITEHNICA BUCUREȘTI, București, Romania
bujor.pavaloiu@upb.ro

Abstract. *Rules as Code refers to the idea of creating and ratifying laws which can be easily encoded and accepted by computing systems, ensuring a truly digital mode of governance. Through this methodology of integrating machine-readable legislation into the governance process, all systems that involve the usage of laws can be transfigured into more agile forms, eliminating the degrees of separation that appear when normal legislation must be adapted into serviceable formats for various industries. In the context of engineering, the need to translate laws into actionable instructions is enhanced, especially with the advent of AI-tools, machine learning and large language models, which require proper, concise and relevant input data to ensure the output comes out as requested. The concept is extremely new - its research started a few years ago and currently; a number of states and universities are exploring methodologies to employ the concept of Rules as Code in both the lawmaking and project-making processes. In this scientific paper we endeavor to study the case of applying Rules as Code in the field of fiber-optic network design, in particular looking at the legislation which governs this process in Romania, and to interpret it through the aforementioned Rules as Code lens. Special interest will be given to practical implementations of the concept in this field, as the constraints that can be extracted through the implementation have an important impact in how network projects are developed. The results can lead to improved efficiency in the development of projects, considering the fact that interpreting the legislation and evaluating the network in regards to legislation compliance is one the most time and resource consuming parts of the overall process. The progress of Rules as Code ensures digital compatibility for citizen-centered services, governance and jurisdiction, being an essential step in the Digital Transformation.*

Keywords: Rules-as-Code, Legislation, Project Management, Fiber Optics Networks, Digitalization, Digital Transformation.

Introduction

The idea of Rules as Code (RaC) is currently still in its infancy, with proponents currently analyzing the possibilities and results that can be obtained. First conceived as a terminology to encompass the conceptual findings presented by the Service Innovation Lab in New Zealand in their *Better Rules for Government Discovery Report* (GNZ 2018,2019), the ideas presented have taken root in the legislative zeitgeist, with research being spearheaded by the *Observatory of Public Sector Innovation* (Mohun&Roberts, 2020), as well as several independent authors. The consequences of this development are of particular note for the engineering market, as navigating the constraints imposed by laws and standards is a time and resource intensive task. As such, any

DOI: 10.2478/picbe-2024-0290

discovery that can lead to an increase in the efficiency of this part of the project management process deserves intense scrutiny.

The question this article wishes to tackle is whether or not the concept of Rules-As-Code can be successfully applied to technological standards, such that the time required to extract the relevant information for a particular project can be decreased. Furthermore, by applying the aforementioned concepts, a common ground can more easily be found between management and engineering teams, as certain linguistic problems can be avoided. Lastly, in the context of digitalization, if Rules-as-Code can be successfully applied to engineering legislative documents such as technical regulations, the entire project management process can be transformed, as automation tools can be far more easily employed. With digitalization being at the forefront of the development of many states, chief among them being the Digital Decade initiative proposed by the European Union, the need to apply Rules-as-Code in as many domains as possible is exacerbated. With a proper encoding of legislative documents, large language models as well as simpler programming languages can be employed to enhance the process. Considering the fast pace of our current world, it is necessary to achieve a digital form of legislation, such that it can be more easily be used by all those that require it.

Through the case study presented, we endeavor to see the effect that digitizing regulations can have on an engineering project, in this case the design of a small fiber-optics network. The main hypothesis is that encoding the legislation the governs the construction of fiber-optics networks in Romania (RTC 5/2022) can improve the overall project management process for this field. The terms of this key document will be presented in English through the paper, even if our research is working on Romanian laws. For the exact interpretation, one has to check the original Romanian document.

Literature review

The main point of inception for the concept of Rules-as-Code is the work of the aforementioned New Zealand Service Innovation Lab, namely the *Better Rules for Government Discovery Report* (GNZ 2018,2019), which postulates that with the advent of new digital technologies, new avenues for the transformation of the way that government data is used need to be explored. Considering the importance of software in our current world, legislation is in dire need of transfiguration, such that it may be more easily consumed by machines and the industries surrounding them. Taking into account the fact that one of the main problems that RaC wishes to tackle is that of the inefficiency of rule delivery in business systems (GNZ 2018,2019, p.7). The time wasted manually inputting data from the legislative document as well as cross-referencing it through the various parts of a fiber optics network project is a textbook example of the inefficiency mentioned.

The digitalization of the administrative act is of utmost importance for a number of states. Considering the Digital Decade initiative of the European Union has nominated access to online administrative resources as one of their main KPIs in their *Commission Implementing Decision 2023/1353* (COM 2023/1353), the need to transform legislation becomes obvious.

In the aftermath of the findings from the New Zealand Service Innovation Lab, a practical workshop manual was released, *The Practical Better Rules Workshop Manual* (Fraser 2018,2019), which is of particular interest for this paper, as it lays out the way in which the authors of the original work on RAC believe the concept should be employed in a real-life scenario. On the subject of practical applications and digitization, of particular note is *Rules as code -Seven levels of digitization* (Wong, 2020) which proposes as the name suggests seven different degrees of digitization when it comes to legislation and regulation. Furthermore, it clearly defines differences between degrees of digitization.

In terms of legislative applications, of particular note are the works of Matthew Waddington, specifically *Rules as Code* (Waddington, 2020) and *Rules As Code: Drawing Out the Logic of Legislation for Drafters and Computers* (Waddington, 2022) which further develop the ideas at the base of the concept, with respect to present legislative applicability and particularly distinctive aspects. Furthermore, these works serve to dispel some of the misconceptions that the term may bring about, such as the idea that Rules as Code just means handing off the entire legislative apparatus to machines, removing the human element which is so intrinsic to laws and their applicability. Waddington champions the point that RaC offers the possibility to digitalize legislation from the drafting stage, before it is even enacted, thus ensuring proper communication between drafter and policy owner. It must be stated that RaC is not intended as a silver bullet that replaces laws and bypasses courts of law, merely a tool for better understanding between all parties involved. (Waddington,2022, p.2,3) Having said this, the novel concept is still ripe for various interpretations, such as the one presented in this paper.

On the topic of applicability, another important set of works for this article are *Blawx: Rules as Code Demonstration* (Morris, 2020) and *Blawx: Web-based User-Friendly Rules as Code* (Morris, 2022), which offer a clear and concise use case of Rules as Code in a software environment, proving the utility of the concept and how it can be applied in real life. This further reinforces the hypothesis that RAC can be used to great effect in regards to increasing the efficiency of various processes which depend on legislation. As a tool used to help lawyers with no programming experience tackle legal reasoning and ontology creation, Blawx is a perfect example of a successful RAC implementation in real life.

For further clarification of the term *ontology*, in the context of this paper, it refers to a set of relations between different concepts, which are defined by a user.

The OECD Working Paper *Cracking the code: Rulemaking for humans and machines* (Mohun&Roberts,2020) further underlines the importance of RAC being used to create optimized legislation that can tackle the reality of just how fast-paced and digital our world has become. The primer also offers actionable and concise advice on how Rules as Code can be applied in various contexts. Furthermore, it underlines the importance of RaC in the odyssey to a transformed, digital government, with all facets being available to the end-users, meaning the citizens.

The field of fiber optic network design is one that is very much dependent on both software and legislation. Works such as *Optical network design and planning* (Simmons, 2014) and *Optical network design and implementation* (Alwayn, 2004) have acted as guiding posts for this domain, offering plenty of advice and best-practices as to how networks should be built, both cost-wise and in terms of efficiency. On the topic of costs and efficiency, the *FTTH Business Guide* (FTTH Council, 2016), published by the Fiber To The Home Council Europe, offers pertinent information about the project planning and overall business side of the field, and thus is of particular relevance for our paper.

Finally, the subject of the case study, *RTC 5/2022* is the technical regulation which defines the proper way in which fiber optic channels should be designed, constructed and utilized, as well as the materials that should be used and other such technical information. This document is the basis for all fiber optic network projects in Romania, and as such, must be easily understood and used by experts in the domain.

As of the moment of writing, there has been no study published in regards to the impact of RAC when applied to fiber optic technical regulations. Furthermore, the findings are of interest for the telecommunication industry as a whole, with increased efficiency and lessened costs being constant needs in this field.

Methodology

The chosen research methodology is that of the case study, due to the fact that the field of Rules as Code is currently lacking in enough practical applications and demonstrations of the concept, much of the current literature being based around conceptualization, with certain outliers (Morris, 2020, 2022; Wong, 2020; Fraser 2018,2019). Furthermore, as an engineer currently working in the field of fiber optic network development in Romania, I can safely say that it is one that is based around both software and legislation, thus a perfect subject for study.

The main hypothesis is that encoding RTC 5/2022, the technical regulation which governs the development, deployment and usage of fiber optic network projects, through the usage of the RAC methodology outlined in the literature cited, will lead to an overall improvement in the field. This can be measured in the way the resulting encoded legislation can then be implemented in the various software components that are used in the industry.

To this end, we shall endeavor to transform the legislative information into usable pseudo-code which can then be implemented in various programs. One such piece of software will be QGIS, an open-source geographic information system which is used to process data and create models of the fiber optics network. This is an integral part of the process to create a fiber optic network, and usually requires constant oversight from human operators. Furthermore, the resulting projects must be verified by experts such that the regulations are followed to the letter and the network can indeed be legally built. Thus, if the verification can be nestled in the creation process, time and resources can be successfully conserved.

We shall follow the processes presented in *The Practical Better Rules Workshop Manual*, as well as the "*manual coding, multi-disciplinary*" team approach used by New Zealand's Better Rules laboratory, presented in the OECD's working paper. (Mohun&Roberts,2020, p.63). The resulting pseudocode can be consumed by the aforementioned software, while still being easy to adapt for further processes.

Results and discussions

In the beginning, the regulation (RTC 5/2022) was analyzed to comprehend its complexities and understand exactly which parts have the most importance in the creation and validation of a fiber-optics network project. The documentation is freely available, and is structured in 11 chapters. By the definitions presented in Wong's *Seven Levels of Digitisation,* the technical regulation is at level 1(Wong,2020, p.4), meaning that it is freely published in a digital format by the legislating body, but it does not have any underlying encoding. The legislation is presented as text only, a simple html page, and has no other intrinsic properties. For it to be used in software applications, the language used must be transformed into a set of standardized rules, the aforementioned pseudocode statements, thus taking it from a level 1 RAC implementation to a level 3 one (Wong,2020,p.11). Considering the importance of improved digitalization outlined in the EU's KPIs (COM/2023/4288, p.2), it is obvious how the use of RaC can be beneficial.

To achieve this goal, the chapters which are of most interest for the process of planning and verifying a fiber optics network were selected. As such, chapter 6, "*Design of Telecommunication Channels"* became the main focus of the case study, as it offered the most pertinent information for both the design and the validation, and thus, the most examples of statements being turned into code. Furthermore, several tables in the technical regulation contain pertinent information that can be used in a RaC implementation, as they provide easy to quantify data for future models.

Part of the road	Refference point	Distance[m]
roadway	Edge of the road	0,5
verge	Edge of the road	0,5
separators	Edge of the road	1,0
gutter	Edge of the road	0,5
extension of the gutter	Edge of the gutter	0,5
trees along the roadway	Side of a tree trunk	2,0

Source: RTC 5/2022, chapter 5.

Having selected the sample data, the suitability of RaC was then verified. In the *Better Rules for Government Discovery Report*, several points of inflections were found in the process of translating a policy into a business system (GNZ 2018,2019, p.11). When analyzing RTC 5/2022, one of the first discoveries is that, as a technical regulation, this policy is uniquely suited for implementation into a software system, as the language and data presented is inherently technical. Cross-referencing with seminal works in the field (Simmons,2014) (Almayn, 2004), we can see that the document thoroughly covers the three most important steps in the development of a network, namely design, construction and validation, while also integrating recommendations from European experts (FTTH Council, 2016, p. 47-51, 72-73).

Once more referring to the findings of the discovery report, the contents of the document satisfy several prerequisites for machine consumption, namely the fact that it contains factual information, data about repeatable processes, and compliance processes (GNZ 2018,2019, p.27). With this in mind, one underlying part of our hypothesis is thusly confirmed, namely that the technical regulation is suited for RaC implementation.

Having clarified that RTC 5/2022 is suitable for the purpose of a RaC implementation, we turned to *The Practical Better Rules Workshop Manual* to see how the instructions within apply in our particular context. Once more technical regulations proved uniquely compatible with Rules-as-Code, as much of the data selected is presented in the form of business rule statements, which are one of the base requirements presented in the manual (Fraser, 2018,2019). Furthermore, due to the nature of a technical regulation being uniquely connected to engineering domains, much of the effort that goes into developing conceptual models is circumvented, since the main goal is to obtain business-statements that can be easily fed to a machine.

Coming back to the levels of digitalization discussed in the beginning of this section, the issue of code and pseudocode has to be raised. Waddington raises an important point, namely that *"Ultimately a court, using a natural language, will "interpret" all the relevant words of a statute when applying a set of facts – interpretation is not just about ambiguous words"* (Waddington, 2020, p.185). While a court is not involved in the proceedings of this case study, pseudocode is a language rife with interpretation, as it needs to be translated into higher level languages to actually be used in industry. Pseudocode itself is very useful in the drafting and validation process of a fiber-optics project, as it allows the user to quickly check his work against the proper way of doing things, but of course for a higher level of digitalization, said pseudocode must be transfigured to a language that allows more or less automated, instant validation. Still, for the purpose of a first application of the concept in this particular environment, pseudocode is enough.

After this preparatory validation was done, the main implementation process begins. To verify our hypothesis, we began by analyzing an example of a successful RaC application, the open-source software *Blawx*. As a web application purpose-built for encoding rules, it is a perfect example of using RaC to solve a business problem, namely the need for easy-to-use declarative logic programming tools. (Morris, 2020, p.7). The way it included RaC is by offering the user the ability to clearly define the relationships between rules, with the help of an easy to use interface. Morris tells us that "*The intent is that by reading this code you would have a clear understanding of its meaning*" (Morris, 2020, p.9). This is a concept that stands at the basis of our hypothesis as well, and furthermore it is easier to put in practice, as the nature RTC 5/2022 being a technical regulation means that the information presented is already shaped in such a way that it is easy to understand. Thusly, the task of transfiguring the legislative information into code is a simple one, the starting point being simple "*if* "statements, which can then be given more complexity by inserting them in higher level programming languages, instead of pseudocode.

Following the manual coding approach used by the Better Rules team, we started by taking the rules and data presented in the three chosen chapters, and breaking them down into the specific, useable and concrete data points. For example, for chapter 6, much like in any other programming project, we began by defining the variables that will be used. The very first subsection, 6.1, *"Classifying and symbolizing CTc elements"* (RTC5/2022, c..6.1.) can be used as the blueprint for this process in this section, as it defines all the different types of elements which shall be used in the language of the following sections and their meanings. These elements are of particular importance when creating a project, as they are the very building blocks of the entire process.

Once the definition of these terms is given, and thus, the variables of the code are extracted, we can move on to analysing and translating statements. The term *"translation"* is apt here, as what we endeavour to do is go from natural language to one that is more palatable to machine implementations. Let us look at an example to better define this concept. In section 6.2, *"CTc design principles"*-where the main principles behind the proper construction of fiber optic channels are presented - subsection 6.2.1, Paragraph 9 describes the proper positioning of telecommunication infrastructure in regards to different types of roads. The Romanian text reads as follows: "*A CTc may be built on only one side of roads belonging to the classes of internal road and local road-secondary rural street, regardless of building placement".* Translating and removing abbreviations, we understand that we can only install fiber optics channels on one side of a road that belongs to a certain class, regardless of the placement of buildings. With this in mind, by applying RaC, we can surmise that we have one main variable that determines the placement of our infrastructure – the classification of the road, henceforth defined through the notation *class*. For the sake of writing our code, we shall use the same notation *CTc* to describe the telecommunication infrastructure. From this point, we can transform this paragraph into the following pseudocode statement, where "drum_intern" is "internal road" and "drum_local" is "local road":

IF class == drum_intern OR class == drum_local
CTc=ONLY ONE SIDE OF THE ROAD

On its own, there is still ambiguity contained in the above statement, as we could raise the question as to what happens if the *class* attribute is not one of the ones mentioned in the statement, or if the final four words of the statement, "*regardless of building placement"*, should be ascribed a variable in the code. But as a part of a much bigger whole, this statement helps define a set of rules that can be afterwards input into another program, or a higher-level programming language, and thus be more easily become a part of the validation process for the fiber optics project and its documentation. For example, such statements can act as filters for geographic information systems such as QGIS, which are already employed in the creation process of the aforementioned projects, and thus be used to verify the data the moment it is inputted.

Moving on, looking at Paragraph 32, we can obtain a more abstract form of pseudocode. In this case, we have two main variables defined, namely the method that needs to be used in the design of the network, (henceforth *method)* and the coordinate system that must be employed (henceforth *CRS).* Furthermore, we are given a recommendation in regards to how often to specify the depth at which the infrastructure is installed (henceforth *depth occurrence)*. In terms of pseudocode, we can just present this statement as:

method = CAD
CRS = Stereo 70 || WGS84
depth occurrence !=0

This is an example of a paragraph which is of more importance to the validation part of the project, as this code is one that is more readily employed in a tool like the aforementioned *Blawx* to perform an analysis. The lack of hard data-points, like specific numbers of depths, lead to an interpretation that is more in line with natural language rather than machine language.

With such pseudocode statements defined and in hand, the digitalisation process is close to complete. By inserting these resulting data points into suitable programs, the design and validation process can now begin to be automated. In terms of computer aided design, statements about depth, distance and other such hard factors can be easily encoded into strict filters and limitations for the placement of design elements. Once this process is finished and the design submitted for validation, we can already see an improvement in efficiency, as all that is left for a validation specialist is to input the pseudocode into a program such as *Blawx* and enter statements in natural language regarding the design document, which shall be verified against the code of laws encoded through the statements described in the pseudocode.

Conclusion

Analyzing the results, we can come to the conclusion that the concept of Rules as Code can be successfully applied to technical regulations, even beyond the drafting level. Applying the ideas presented by the Better Rules team (GNZ, 2018,2019; Mohun&Roberts,2020), namely the retroactive analysis of legislations, we have found that technical regulations such as RTC 5/2022 are uniquely compatible with RaC applications. The combination of hard data points with natural language explanations allows us to write pseudocode that can be then employed in a large amount of software solutions. As such, the overall project management process for the field of fiber optic network design can be improved by applying the precepts of RaC, as both the design phase and the validation phase can consume the pseudocode produced by a team employing the concepts mentioned.

The findings presented can be extended to other forms of technical regulations, as the concept of Rules as Code seems to have no particular limitation when it comes to the type of legislative document it is tackling, as long as the person or team employing it understands the underlying principles. Considering the needs of state and private actors to further digitalize their products and services, it is easy to see how RaC proves to be attractive.

In terms of practical applications of the findings, the pseudocode that was and can be produced from analyzing RTC 5/2022 can be translated to filters and rules for computer assisted design programs such as geographic information systems. By doing this, the time to produce a valid design for a network project is reduced, since the user employing these systems is not forced into doing constant checks in regards to how they are producing their work.

A particular pressing limitation for the application of RaC in regards to technical regulations is that, while the created pseudocode is very useful for a variety of applications, it must still be translated to different programming languages if it is to be properly employed. The process may end up more time consuming than a project manager is comfortable with, and most likely employ more than one programming language to completely integrate the results from the RaC implementation. Furthermore, an interdisciplinary team is required to ensure that there are no gaps in the process of transforming natural language into pseudocode. The scope of our research is not just concentrated on applying RaC to routing in fiber optics networks, but rather on searching for flexible and scalable solutions for the industry as a whole.

Nevertheless, Rules-as-Code offers actors in both the public and private sector a tantalizing opportunity to increase their efficiency and thus their overall profit margins. It is the onus of governments across the globe to understand what this has to offer in terms of digitalization opportunities, and how the findings can be employed to great success.

References

Alwayn, V. (2004). Optical network design and implementation. Cisco Press.

Commission Implementing Decision (EU) 2023/1353 of 30 June 2023 setting out key performance indicators to measure the progress towards the digital targets established by Article 4(1) of Decision (EU) 2022/2481 of the European Parliament and of the Council. (2023). Official Journal, L 168, 48-52. Retrieved January 3, 2024 from https://op.europa.eu/en/publication-detail/-/publication/85c5aa00-193c-11ee-806b-01aa75ed71a1/language-en/format-PDF/source-301354449

Council, F. T. T. H. (2016). FTTH business guide. Fiber to the Home Council Europe Tech. Rep. D/2016/12.345/2

Digital.Govt.NZ (2018,2019). Better Rules for Government Discovery Report. Retrieved January 3, 2024 from https://www.digital.govt.nz/dmsdocument/95-better-rules-for-government-discovery-report/html

Fraser, H (2018,2019). The Practical Better Rules Workshop Manual. Retrieved January 3, 2024 from https://betterrules.nz/workshop-manual.html

Mohun, J., & Roberts, A. (2020). Cracking the code: Rulemaking for humans and machines, ECD Working Papers on Public Governance, No. 42, OECD Publishing, Paris, Retrieved January 3, 2024 from https://doi.org/10.1787/3afe6ba5-en.

Morris, J. (2020). Blawx: rules as code demonstration. MIT Computational Law Report. Retrieved January 3, 2024 from https://law.mit.edu/pub/blawxrulesascodedemonstration

Morris, J. (2022). Blawx: Web-based User-Friendly Rules as Code. In GDEASP’22: Workshop on Goal-Directed Execution of Answer Set Programs.

Simmons, J. M. (2014). Optical network design and planning. Springer.

Technical regulation "Canalizaţii de telecomunicaţii (CTc). Fibră optică. Proiectare, execuţie, utilizare, întreţinere şi verificare, indicativ RTC 5-2022", din 09.09.2022

Waddington, M. (2020). Rules as code. Law in Context, 37(1), p.179-186.

Waddington, M. (2022). Rules as Code: Drawing out the logic of legislation for drafters and computers. Modern Legislative Drafting-A Research Companion, Constantin Stefanou (ed.) (Routledge).

Wong, M. W. (2020). Rules as code: Seven levels of digitisation, Singapore Management University, 7(1), 93-110.