

Faculdade de Engenharia da Universidade do Porto



# Software Systems Architecture

Homework #03 - Ambiguity and Architectural Questions

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# Introduction

In terms of software architecture, it is essential to ask the appropriate questions about a proposed product, not only to eliminate any ambiguity that may exist, but also to guarantee that the user needs are addressed and there's harmony between the users and developers.

This report aims to offer a collection of clarification questions regarding the specifications of a traffic signal control system with the purpose of optimizing the traffic flow, saving time and fuel, and reducing emissions as well. These questions are then organized on a spiderweb according to grouping topics and timeline and finally, the five most important questions are highlighted and the significance of each one is thoroughly justified.

## Requirements Clarification Questions

In order to clarify the needs and requirements related to the proposed traffic signal control system, the following twenty-nine questions were compiled.

1. When is the deadline of the project?
2. Do you have a current solution already working?
3. What specific metrics are we aiming to optimize with this traffic signal control system and the trade-offs between them?
4. What should we know about the infrastructure of the traffic signal system?
5. How are we supposed to deal with different types of vehicles, such as cars, trucks, bicycles, and pedestrians? (impact of different types of vehicles)
6. What information is provided about the entities, including details on gathering and transmitting methods, available devices (such as cameras or speed registers), and potential conflicts among them?
7. Are there any environmental or geographical factors that could influence traffic patterns or the effectiveness of the system?
8. What are the constraints and regulations we need to consider when optimizing traffic flow? Like speed limits, emergency vehicle prioritization
9. How is the coordination between traffic signals going to work/be implemented?
10. How can we connect with the traffic lights?
11. What are we expected to see failing? Who should the system report to?
12. What mechanisms should we use to enforce security?
13. Security wise, what should we consider a threat to the system?
14. Are there some restraining laws we should take into account?
15. Will you provide data about the typical peak hours or periods of heavy traffic within the target area?

16. How will the system handle interactions with public transportation systems?
17. Should the system handle pedestrian buttons?
18. Should there be an emergency button in the case of accidents or traffic restrictions?
19. What level of autonomy or manual intervention is acceptable for the system?
20. What are the criteria for evaluating the success of the system once it's implemented?
21. What geographical area should this particular system cover? Is it intended for a city-wide implementation or focused on a smaller scale, such as a block or neighborhood?
22. Will there be a classification for different zones such as school, construction, workplace, etc, that the system should take into account when optimizing the traffic?
23. How will the system account for special events or occasions that may result in unusual traffic patterns, like parades and festivals?
24. In case of a system failure, should the traditional system be temporarily brought back to function? Is there a protocol to follow?
25. Is there an existing AI model? If so, should we use it/ improve it or implement a new one?
26. What is the desired response time of the system from detecting traffic to changing the signal?
27. Should there be a user interface or control mechanisms required for traffic management personnel to monitor or override the system?
28. How often should we report our progress?
29. By when are you expecting a prototype?

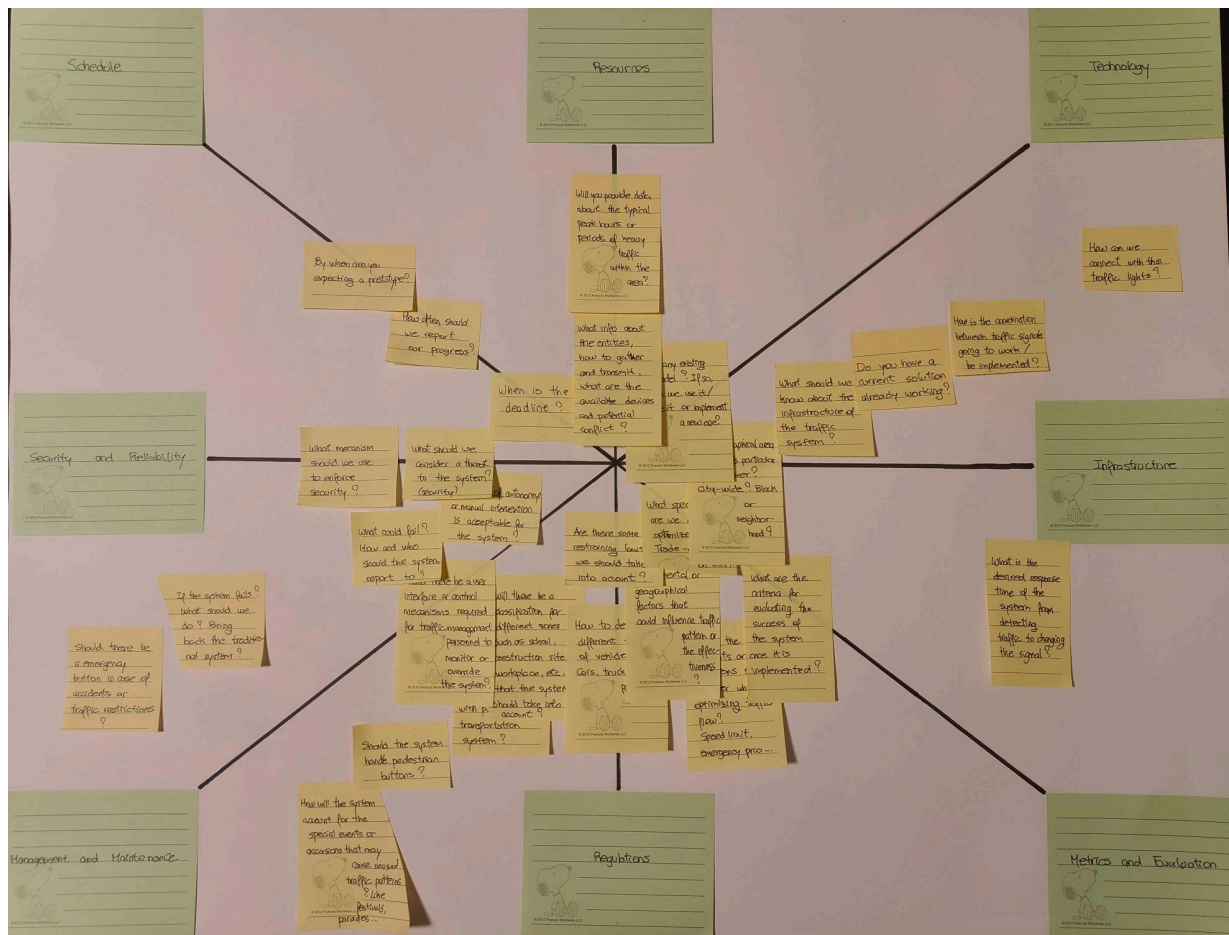
## Questions Topics and Timeline - The Spiderweb

After analyzing the questions and trying to group them in some topics, these were the final results:

- **Schedule:** This topic primarily revolves around the temporal limitations that a project may face, like the project deadline. The responses to such questions have the potential to completely shape the project's execution strategy and ultimately influence its outcomes.
- **Resources:** This topic focuses on the informational and material assets essential for the system's operation. It includes data and hardware necessary for the traffic signal control system. The more resources available, the more accurate and informational the desired result will be.
- **Technology:** This topic addresses the technological aspects crucial for the traffic signal control system. It encompasses questions related to software and hardware selection,

integration and compatibility. Evaluating these factors will inform decisions guiding the solution design and implementation process, ensuring the system achieves its objectives effectively.

- **Infrastructure:** This topic encompasses the physical elements crucial for the traffic signal control system. It includes considerations regarding the layout and structure of the system, as well as the integration of hardware components within various geographical spaces. Assessing the infrastructure involves evaluating the existing layout, identifying potential limitations or gaps, and planning for the implementation of new infrastructure as needed.
- **Metrics and Evaluation:** This topic focuses on the metrics essential for system optimization and quality assessment. Clear and well-defined metrics enable the system to precisely assess its performance, allowing for more informed decisions about optimization tactics.
- **Regulation:** This topic deals with understanding and complying with legal and regulatory requirements relevant to the project. It ensures that the project operates within legal boundaries and fosters a responsible and ethical approach to implementation.
- **Management and Maintenance:** This topic focuses on establishing procedures for managing the project while its running and maintaining system functionality in the case of failures. Effective management and maintenance practices help sustain the project's performance over time, ensuring its continued success and longevity.
- **Security and Reliability:** This topic addresses the need to protect the project's infrastructure against potential threats and vulnerabilities. It involves implementing robust security measures and reliability protocols to maintain system integrity, minimize downtime and knowing what to do when something goes wrong.



## The Five Vital Questions

Developing an effective and efficient traffic signal control system is not an easy task. It requires a meticulous understanding of various factors and requirements, from traffic patterns and infrastructure to technological capabilities and user expectations. With that in mind, it's imperative to address critical questions that shape the project's direction, functionality, and impact. After careful consideration about all the possible questions, we chose the five pivotal questions that serve as guideposts for the system's architecture, addressing concerns of efficiency, existent restrictions, technical implementation and scalability.

### What specific metrics are we aiming to optimize with this traffic signal control system and the trade-offs between them?

#### Why is this question important?

In designing a traffic signal control system, one of the fundamental considerations is determining the specific metrics that the system aims to optimize. These metrics will serve as a base for the entire project, defining the objectives and success criteria, which will allow for effective prioritization of system features and design decisions. However, there are often tradeoffs between different metrics, where improving one aspect may come at the expense of another. Therefore, exploring it will provide insights into the complexities of traffic management and ensure a balanced approach to system optimization.

### **Whom does this question impact?**

This question has a big impact on many different groups of people, like everyday commuters, city planners, transportation officials, and even environmental agencies. The traffic signal control is something that takes a role on the life of everyone that uses the road, so the chosen metrics directly affect how easy it is for people to get around, how well traffic flows and how good it is for the environment. With that being said, it's not just about making traffic smoother, but it's also about making sure that citizens find cities nice places to live and work. Additionally, groups concerned with urban planning, transportation policy-making and public safety are also considered stakeholders as they are interested in the decisions made about which metrics to focus on.

### **When can this question be answered?**

Addressing this question should occur in the early stages of the project, ideally during the analysis and planning phases. By doing so, we ensure that the project goals align with the stakeholders expectations and that the system is designed to fulfill its intended purpose effectively. By figuring out the metrics early on, project teams can create a solid plan for how to build and test the system, allowing for an easier and faster development process.

### **How does the answer to this question impact the architecture of the system?**

The answer to this question fundamentally shapes the architecture of the traffic signal control system. Different metrics may require distinct algorithms, data processing capabilities, and communication protocols. For example, optimizing for minimal travel time may necessitate real-time data processing and adaptive signal control algorithms, while prioritizing environmental sustainability may require integration with air quality sensors and emission monitoring systems. Therefore, the chosen metrics directly influence the selection of components, design of algorithms, and overall system architecture, impacting its scalability, adaptability, and effectiveness in managing traffic flow.

### **What are the constraints and regulations we need to consider when optimizing traffic flow? Like speed limits, emergency vehicle prioritization.**

### **Why is this question important?**

Understanding the constraints and regulations is crucial as it shapes the boundaries within which the traffic signal control system operates. These rules ensure that the development complies with legal requirements, safety standards, and societal norms, thereby safeguarding the well-being of road users and the surrounding community. Moreover, paying attention to these constraints helps in designing a system that not only optimizes traffic flow but also prioritizes safety and emergency response.

### **Whom does this question impact?**

This question affects a wide range of stakeholders, including commuters, law enforcement agencies, emergency services and city officials responsible for traffic management. Following the speed limits, making sure emergency vehicles can get through, and sticking to other regulations directly impact how drivers behave and how safe the roads are for

everyone. With that in mind, stakeholders involved in setting and enforcing traffic laws, as well as those responsible for emergency vehicles, are particularly impacted by decisions made regarding these constraints.

### **When can this question be answered?**

Addressing this question is best at the beginning of the project, when still figuring out and planning the development process. Knowing about the constraints and regulations from the start, allows for their integration into the system design, laying a strong foundation for the project. Additionally, it ensures that everything built on top of it stays solid and meets the legal and safety requirements.

### **How does the answer to this question impact the architecture of the system?**

The answer obtained from this question will dictate the design of the system, more specifically, the choice of the features to implement. These features can include speed detection mechanisms, emergency vehicle preemption systems, and compliance monitoring tools. By integrating it into the system architecture, the traffic flow optimization is guaranteed while still staying within the legal and safety guidelines. Additionally, the system architecture may incorporate adaptive algorithms to dynamically adjust traffic signal timings based on the real-time conditions, such as the presence of emergency vehicles or changes in speed limits. Consequently, considering constraints and regulations early on, makes the resulting system robust, compliant and efficient.

### **How is the coordination between traffic signals going to work/be implemented?**

#### **Why is this question important?**

The focus of this question relies on the details about the technical implementation of the system, namely the coordination between traffic signals. This topic holds significant importance because having well-coordinated traffic signals is vital for improving traffic flow and easing congestion. By understanding how coordination will be implemented, we can devise strategies to minimize delays, improve travel times and enhance overall efficiency of managing traffic.

#### **Whom does this question impact?**

This inquiry has broad implications, reaching stakeholders such as city planners, transportation authorities and traffic experts. These entities hold responsibility for implementing and managing traffic infrastructure, making them particularly affected by decisions concerning traffic signal coordination. Consequently, it affects the travel times and overall satisfaction of commuters.

### **When can this question be answered?**

Addressing this question should occur early in the project lifecycle, preferably during the planning and design phases. Developing a clear understanding of how traffic signal coordination will be implemented allows for proper integration within the system architecture and ensures that the resulting system effectively addresses traffic management needs.

### **How does the answer to this question impact the architecture of the system?**

With this question, we are exploring the mechanisms and protocols used for communication and coordination between traffic signals. The chosen approach may involve centralized control, decentralized coordination algorithms, or a combination of both, which will impact the scalability and adaptability of the system. Additionally, the architecture might support real-time data exchange and coordination strategies, backed up by a decision making logic to ensure seamless traffic flow optimization across intersections. Therefore, considering how coordination will be implemented early in the design process is essential for designing a system that effectively manages traffic flow and enhances overall transportation efficiency.

### **What are we expected to see failing? Who should the system report to?**

#### **Why is this question important?**

This question is of great importance as it directly relates to reliability, resilience and sustainability of the traffic system. By identifying potential failure scenarios within the system, we can minimize disruptions, mitigate risks, and enhance the overall performance of the system. Additionally, determining whom the system should report to is essential for effective oversight, timely intervention, and accountability.

#### **Whom does this question impact?**

The impact of this question extends to various stakeholders involved in the planning, implementation, operation, and maintenance of the traffic system. This includes authorities, traffic engineers, maintenance crews, emergency responders, transportation agencies and the general public. Each group relies on the system's reliability and responsiveness to fulfill their respective roles and responsibilities effectively. Failures in the system can lead to traffic congestion, accidents and public dissatisfaction, underscoring the widespread impact of addressing this question.

#### **When can this question be answered?**

This question can be answered at various stages of the project lifecycle, depending on the approach and priorities of the development process. While it is crucial to consider potential failure scenarios and reporting protocols early in the planning phase to inform system design and risk management strategies, it may also be reissued and refined throughout the development and implementation stages. However, this question remains relevant even after the system is operational, as it requires periodic review and refinement to adapt to evolving circumstances and emerging technologies.

### **How does the answer to this question impact the architecture of the system?**

The answer to this question significantly influences the architectural design of the traffic system, particularly in terms of redundancy, fault tolerance, and monitoring capabilities. It may be necessary to implement backup systems, redundancy measures, and automated alerts to detect and respond to failures immediately. Moreover, it informs the design of reporting interfaces and communication channels to ensure that relevant stakeholders receive timely and actionable information. By integrating these considerations into the



system architecture, it becomes more resilient, responsive, and adaptive to potential problems that may occur during its operation.

## **What geographical area should this particular system cover? Is it intended for a city-wide implementation or focused on a smaller scale, such as a block or neighborhood?**

### **Why is this question important?**

The question of geographical coverage holds great importance as it delineates the scope, the scalability, effectiveness, and resource allocation of the traffic signal control system. Understanding the geographical area the system will cover determines not only its extent of impact but also the resources required and the level of complexity involved in its implementation. By defining the system's coverage, we ensure alignment with the specific needs and demands of the target area, whether it encompasses a small neighborhood or extends across an entire city. This understanding is paramount in designing a system that optimally balances traffic flow, minimizes congestion, and enhances safety within the defined boundaries. Moreover, it sets the boundaries for system design and deployment, ensuring alignment with the overarching goals and objectives of the project, while also informing budgeting and project scope considerations.

### **Whom does this question impact?**

This question impacts various stakeholders involved in the planning, development, and usage of the traffic signal control system. Urban planners, city officials, transportation authorities, and traffic engineers are directly affected as they are responsible for defining the geographical boundaries and implementing the system. Additionally, residents, commuters, and businesses within the covered area are also impacted by the system's efficiency and effectiveness in managing traffic flow.

### **When can this question be answered?**

This question needs to be addressed during the initial stages of the project, preferably in the analysis and planning phase. Determining the geographical area to be covered sets the foundation for subsequent decisions regarding system design, infrastructure requirements, and implementation strategies. Addressing this question early ensures that the system is tailored to meet the specific needs of the target area, allowing project teams to allocate resources effectively, and develop appropriate strategies for system implementation and management.

### **How does the answer to this question impact the architecture of the system?**

The answer to this question profoundly impacts the architecture of the traffic signal control system. A city-wide implementation requires a more complex and scalable architecture capable of handling large volumes of traffic data and coordinating signals across extensive networks of intersections. This may necessitate the use of distributed systems, advanced communication protocols, and robust data processing capabilities to ensure real-time responsiveness and reliability.

On the other hand, focusing on a smaller scale, such as a neighborhood or a block, allows for a more localized approach with simplified infrastructure and communication requirements. The system architecture can be more streamlined, leveraging simpler algorithms and communication protocols tailored to the specific needs of the smaller area. Additionally, scalability considerations may differ, with the potential for easier expansion or replication of the system in other neighborhoods or areas as needed.

In summary, the geographical area coverage directly shapes the system's architecture, influencing factors such as scalability, complexity, resource requirements, and overall system performance. Addressing this question early in the project ensures that the system is designed and implemented to effectively meet the unique needs of the target area while optimizing traffic flow and enhancing transportation efficiency.

## Conclusions

In conclusion, the development of a traffic signal control system demands a rigorous understanding of user requirements, technical constraints, regulatory considerations, and scalability factors. The right questions need to be addressed to understand what people need and how to build the system well. In this report we list a lot of questions that we find fundamental about the traffic system, grouping them together and picking out the five most important ones. The identification of five vital questions underscores the critical aspects that shape the system's architecture, functionality, and impact on stakeholders. Through thorough analysis and strategic planning, we aim to develop a robust and efficient traffic management solution that optimizes traffic flow, enhances safety, and promotes sustainability in urban environments. By addressing these questions thoughtfully and proactively, we can ensure the successful implementation of the traffic signal control system, contributing to improved transportation efficiency and quality of life for all road users, helping people get around better and keeping everyone safe.