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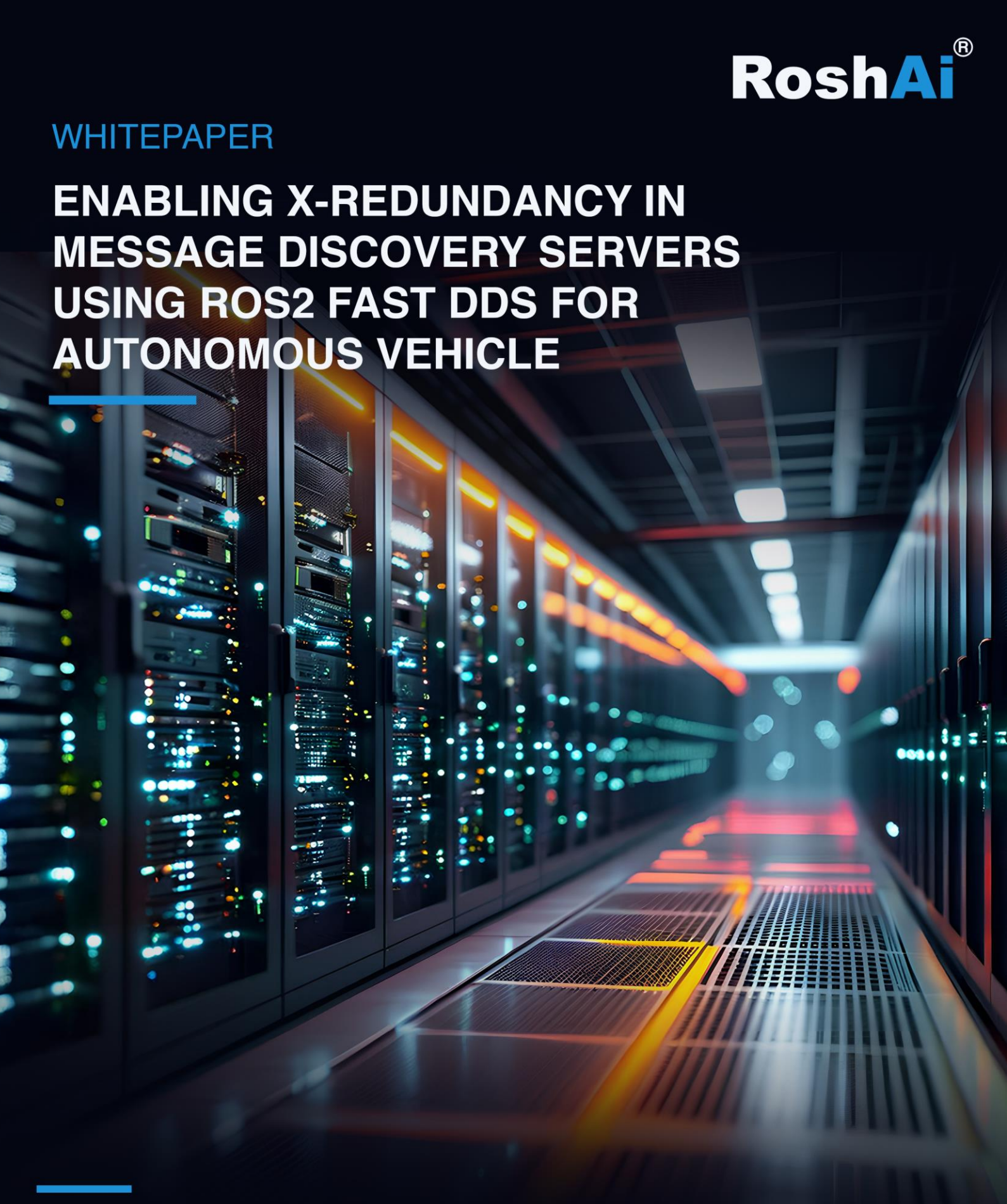
WHITEPAPER

ENABLING X-REDUNDANCY IN MESSAGE DISCOVERY SERVERS USING ROS2 FAST DDS FOR AUTONOMOUS VEHICLE



Abstract : During the concept, design, and subsequent stages of autonomous driving applications, the system must adhere to the regulations of functional safety. To achieve this, architects implement redundancy in all aspects to prevent failures in system functions. As part of the ongoing work on vehicle platform migration to ROS2, redundancy in Data Discovery services is being implemented to avoid message server failures and reduce message traffic across ROS2 nodes. This article shares the details and experiences encountered during the implementation of redundancy in message discovery server protocols, a critical component for autonomous vehicle application development.

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Introduction

This whitepaper examines the limitations of default ROS2 message discovery and presents how Fast DDS Discovery Server architecture enables scalable, fault-tolerant, and low-latency communication essential for safe and reliable autonomous vehicle operations.

In the rapidly evolving domain of autonomous vehicle systems, functional safety and fault tolerance are non-negotiable standards. Automotive regulations demand multiple redundancies across all system components, from sensors to control units, communication networks, and data processing nodes. Among these, the messaging layer, particularly the discovery of participants and message routing, is a critical element requiring robust design.

This whitepaper focuses on enabling redundancy in message discovery protocols using ROS2 Fast DDS (Data Distribution Service), a foundational communication middleware for autonomous systems. It presents a practical approach toward achieving X redundancy in the discovery server mechanism, ensuring resilient message exchange with minimal latency and network traffic in complex autonomous driving platforms.

Terms to be known

Data Writers, Data Listeners & Domain Participants – To understand in detail, request you to refer to the ROS2 foundational documentation

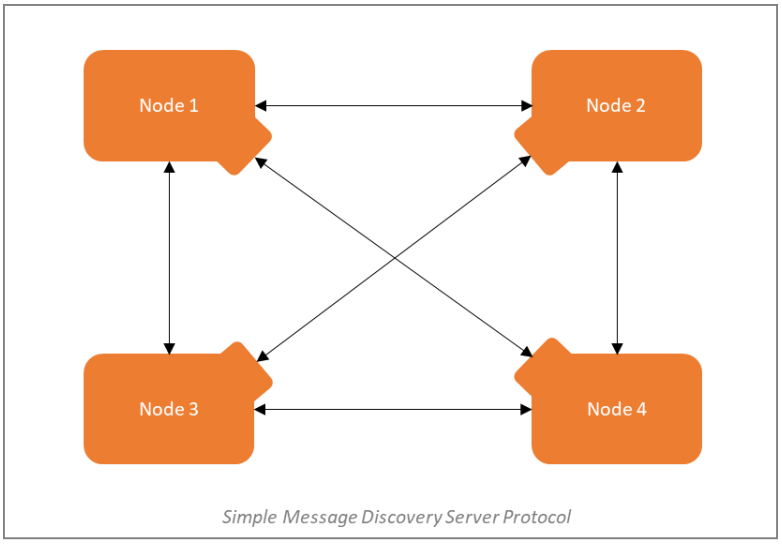
Simple Discovery Server - By Default Option in ROS2

As we are all aware that the ROS2 comes with various DDS services as RMW (ROS2 middleware) frameworks. These frameworks provide the basic services like message discovery protocols and also act as a bridge between the data writers, listeners, and all the domain participants (publishers and subscribers) to enable message handling services to avoid message losses, traffic management, etc. By default, ROS2 provides the simple discovery servers which work as an end to end or peer to peer and also have the following drawbacks

- Lack of dynamic scalability when the packets and nodes increased
- Non-availability of seamless 'multi-casting' capability
- No support for redundancy implementation

The diagram shows the working functionalities and the high-level concept of a simple discovery server available in ROS. As depicted in the below block diagram, various nodes are connected and every node requires a multi-cast capability to share and exchange the information.

As per the above design, there are lots of chances for the data losses and high traffic during the messages exchange.



Simple Message Discovery Server Protocol

The Necessity of Discovery Server

Considering the functional safety of any autonomous driving system, the redundancy, minimal latency, reduced message traffic congestion etc are needed to be adhere to the regulated requirement standards (which is like a few milliseconds of interval to exchange the information) to achieve an efficient and highly responsive and reliable vehicle platform.

The Discovery Server Should be required to enable the efficiency in the following

- Highly Scalable system when the packets and nodes increased
- Efficient multi-casting capability
- Multiple redundancy in Message Servers

To address and comply with regulations, efforts were initiated to implement redundancy in message exchange discovery servers. It was discovered that the ROS2 FastDDS Discovery Server offers the necessary services and appropriate responses to support this requirement.

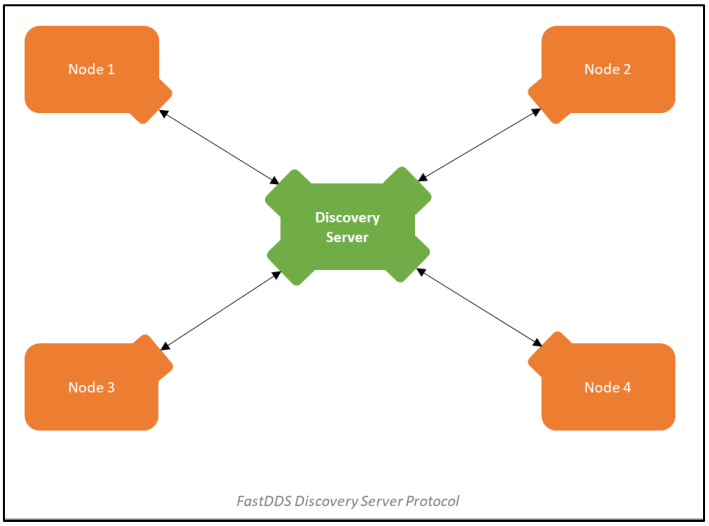
The FastDDS Discovery Server Protocol

The Fast DDS Discovery Server provides a Client-Server Architecture that allows nodes to connect with each other using an intermediate server which is called here as Discover Server. Each node functions as a discovery client, sharing its info with one or more discovery servers and receiving discovery information from it.

The following block diagram depicts the FastDDS Discovery Server Architecture when compared to the simple discovery server.

By Enabling the above Architecture using FastDDS for the Discovery Servers, the following things are achievable:

- Independent Discover Servers
- Duplicated or connected with each other in order to create redundancy over the network
- Avoid having a single point of failure
- Reduces the number of messages sent between the server and clients dramatically



Recommendation

The provided information offers a foundational understanding to initiate work related to Discovery Servers. FastDDS Discovery Servers serve as an effective framework that supports designers and engineers in implementing redundancy within data exchange protocols. For further details on implementation, design, and deeper insights, please refer to the listed resources.

References

1. https://fast-dds.docs.eprosima.com/en/v2.1.0/fastdds/discovery/discovery.html
2. https://fast-dds.docs.eprosima.com/en/v2.1.0/fastdds/discovery/discovery_server.html#discovery-server

Highlights

As autonomous vehicle technologies continue to advance, the demand for high-performance, fail-safe communication architectures becomes increasingly crucial. One of the foundational requirements in building such systems is ensuring robust message discovery and routing across distributed components. With the industry's growing emphasis on functional safety, system architects are mandated to incorporate multiple layers of redundancy—not just in hardware, but also within the communication frameworks that power these intelligent machines.

This whitepaper delves into a practical approach for implementing X-redundancy in message discovery protocols using ROS2 Fast DDS, a widely adopted middleware in the robotics and autonomous vehicle ecosystem. By transitioning from ROS2's default discovery mechanisms to a more resilient Fast DDS Discovery Server model, the solution enhances fault tolerance, minimizes latency, and optimizes traffic across complex vehicle communication networks.