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MOSCONE WEST CENTER
SAN FRANCISCO, CA, USA

100Gbps class in-vehicle Ethernet Switch architecture for next generation autonomous driving car

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AGENDA

1. BACKGROUND

2. ISSUES

1. Issues for Ethernet Switch
2. Issues to be solved

3. SOLUTIONS

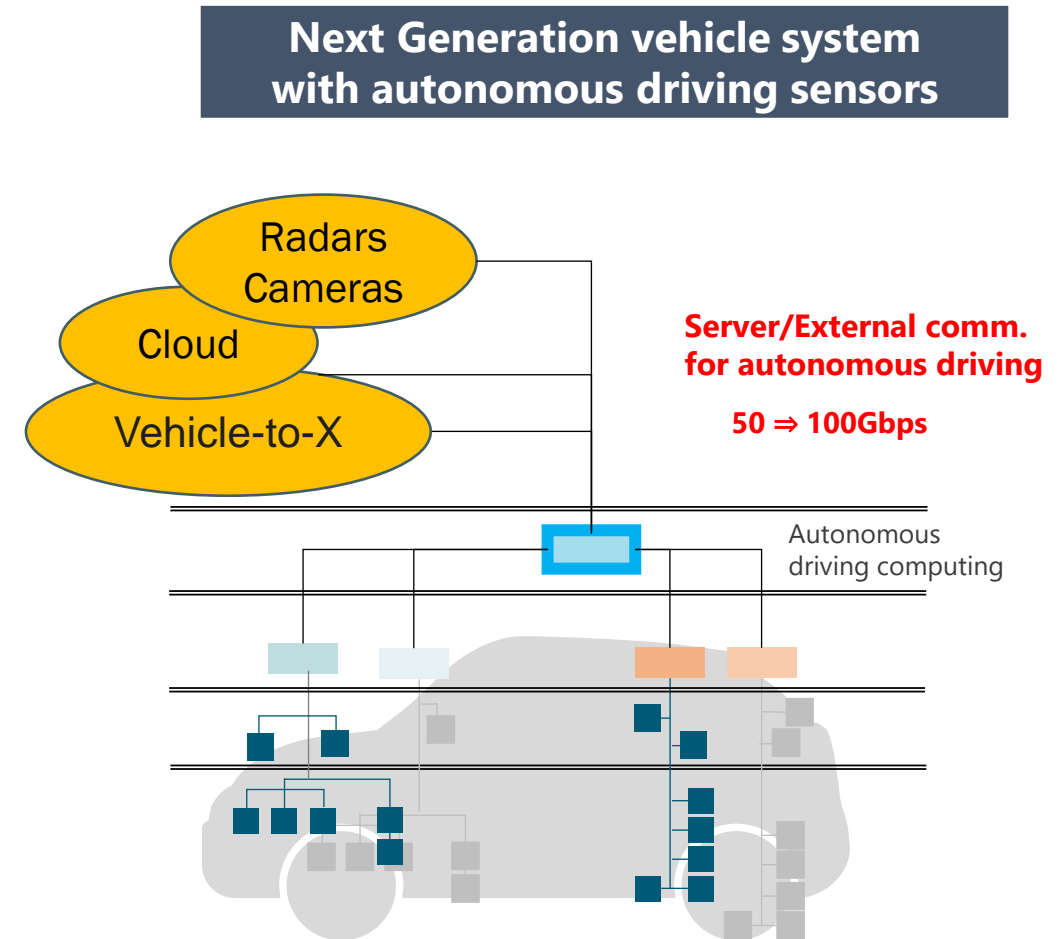
1. Architectural Optimization Overview
2. Pipeline Search Method
3. Phase Shift Search Method

4. EVIDENCE

5. SUMMARY

BACKGROUND

- Current vehicle systems need to process large amount of data from a wide variety of sensors, such as radars and cameras, at high speed and in real time for **autonomous driving**.
- Therefore, **Ethernet Switch** embedded in-vehicle system should communicate with high throughput. Next generation autonomous driving technology is becoming increasingly sophisticated and requires **high throughput of 100Gbps**.
- On the other hands, in-vehicle system requires to consume even **less power** in order to prevent heat generation inside the vehicle.

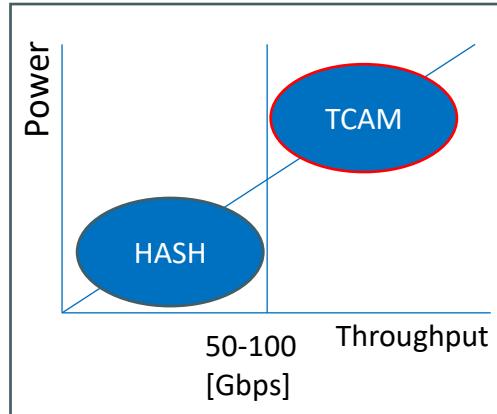


ISSUES

Issues for Ethernet Switch

Performance Requirement

- TCAM is required for **100Gbps throughput**.
- But much higher **power consumption**.



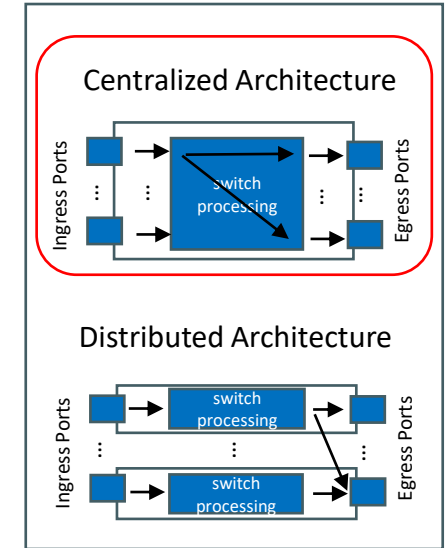
Search Method

	HASH	TCAM (*)
Merit	Smaller area and power	More than 100Gbps throughput More throughput without jitter factor of search cycle
De-Merit	Less than 100G throughput limitation due to jitter factor of search cycle from hash collision.	much Bigger area and power (*) TCAM or CAM. TCAM for Layer3 table CAM for Layer2 table

(*) We express TCAM in the presentation though TCAM is used for L3(IP) table search and CAM is used for L2(MAC) table search.

Power, Area Requirement :

- A centralized architecture is adopted for small size and low power consumption.
- But it has a **throughput bottleneck** due to shared switch processing among **all ports**.



Architecture Type

	Centralized Architecture	Distributed Architecture
Merit	Small area and power because of the shared switch processing block	No throughput bottleneck because each port has its own switch processing
De-Merit	Becomes a throughput bottleneck because all ports shares one switch processing block.	Big area and power because each port has its own switch processing block.

ISSUES

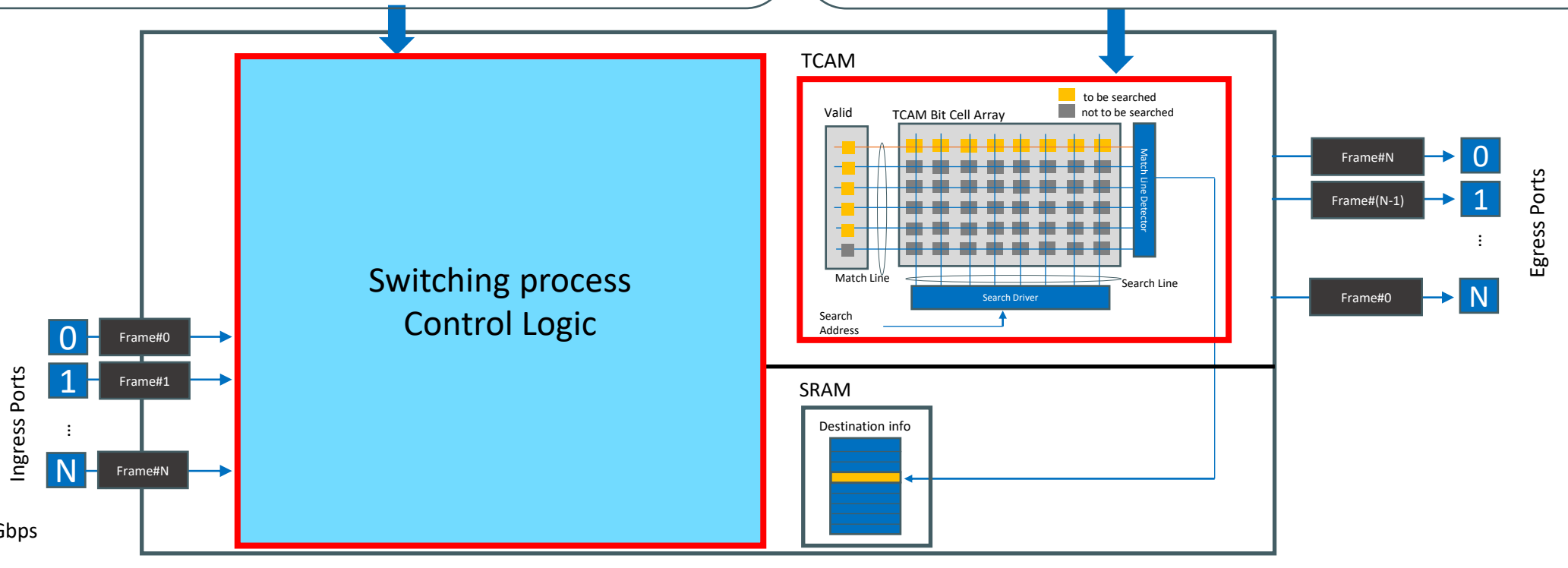
Issues to be solved

Issue (1) 100Gbps Throughput

In a centralized architecture, a single switch processing block processes all received frames from each port at once, becoming a **throughput bottleneck**. Achieving a 100Gbps throughput at low power requires architectural optimization.

Issue (2) Low power consumption

TCAM accounts for the majority of power consumption. In order to reduce power consumption, it is necessary to take measures to reduce power consumption in TCAM.



Total Bandwidth = 100Gbps
Ingress + Egress

SOLUTION

Architectural optimization overview

Solution (1) Pipeline Search Method for 100Gbps Throughput

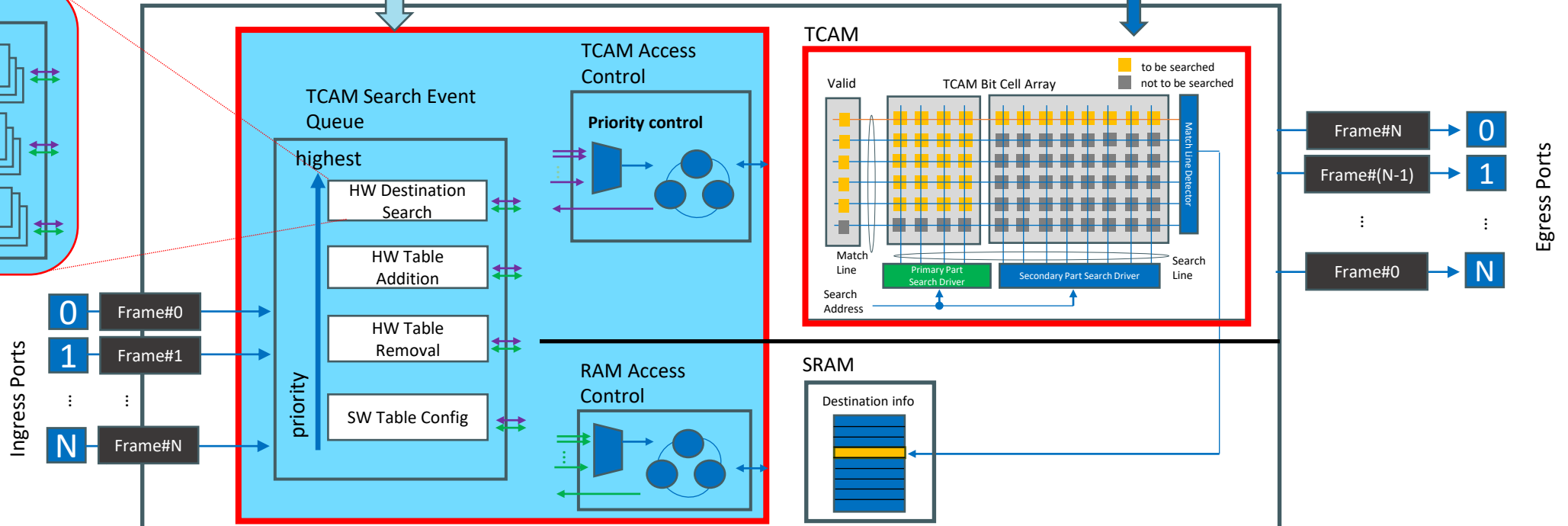
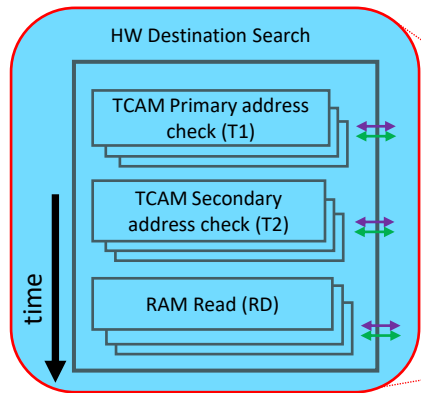
(1) Pipeline

The method optimizes throughput performance by adopting a microstep controlling to shift the process **one cycle at a time as a pipeline**.

(2) Priority control

The method prevents throughput degression by **prioritizing search events over other events**.

Search micro steps
for each TCAM Search events



Solution (2) Phase Shift Search Method for Low power consumption

The method achieves low power consumption by aligning small TCAM cores on an array in two parts instead of one big TCAM and processing comparison sequentially.

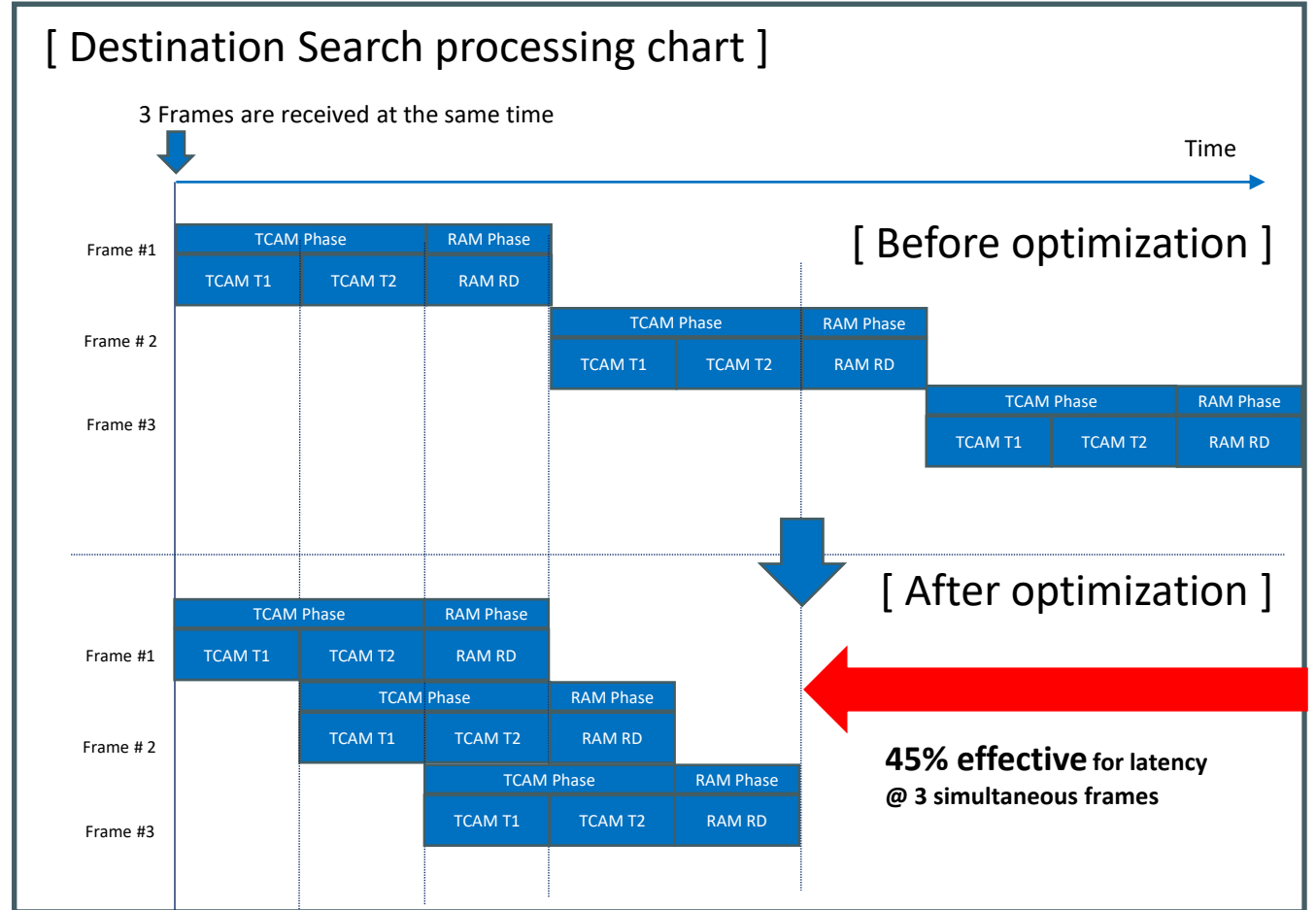
SOLUTION

Pipeline Search Method

Pipeline Search Method

The method optimizes processing performance by shifting the process **one cycle at a time as a pipeline** instead of sequentially processing.

To achieve this, a command queue buffer is provided for each microstep during switch processing, allowing commands to be received in one cycle.



SOLUTION

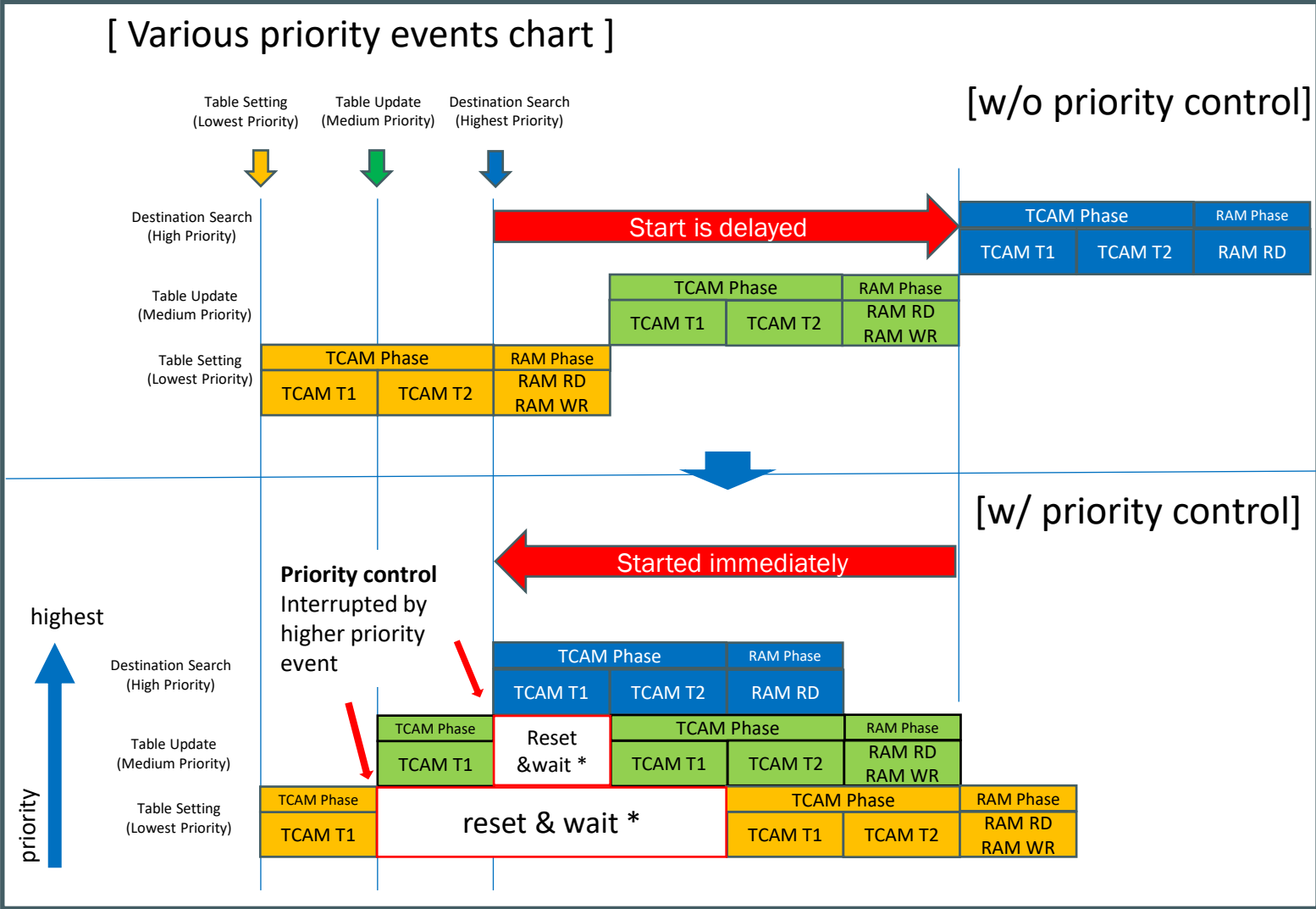
Pipeline Search Method

Pipeline Search Method

The method prevents throughput degradation by **prioritizing search events** over other events and allowing search events to **preempt other lower priority events**.

Lower priority events that are not related to switching performance, such as a table update event, are processing again after the switch processing event completes.

* To keep the contents of TCAM and RAM consistent, lower-level events are initialized and restarted after higher priority events are started.



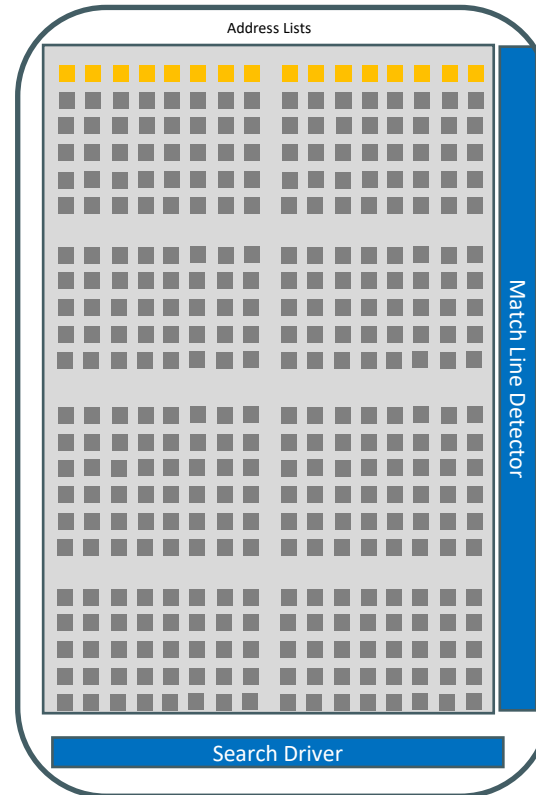
SOLUTION

Phase Shift Search Method

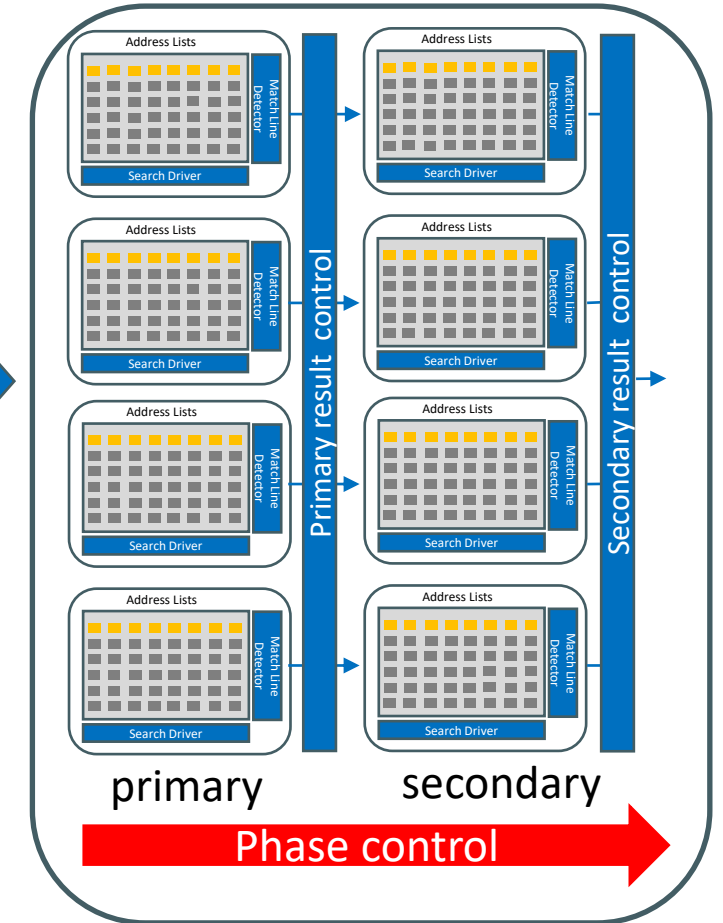
Phase Shift Search Method

The method achieves low power consumption by **aligning small TCAM cores on an array in two parts** instead of one big TCAM and processing comparison sequentially

One Big TCAM structure



Small TCAMs array structure

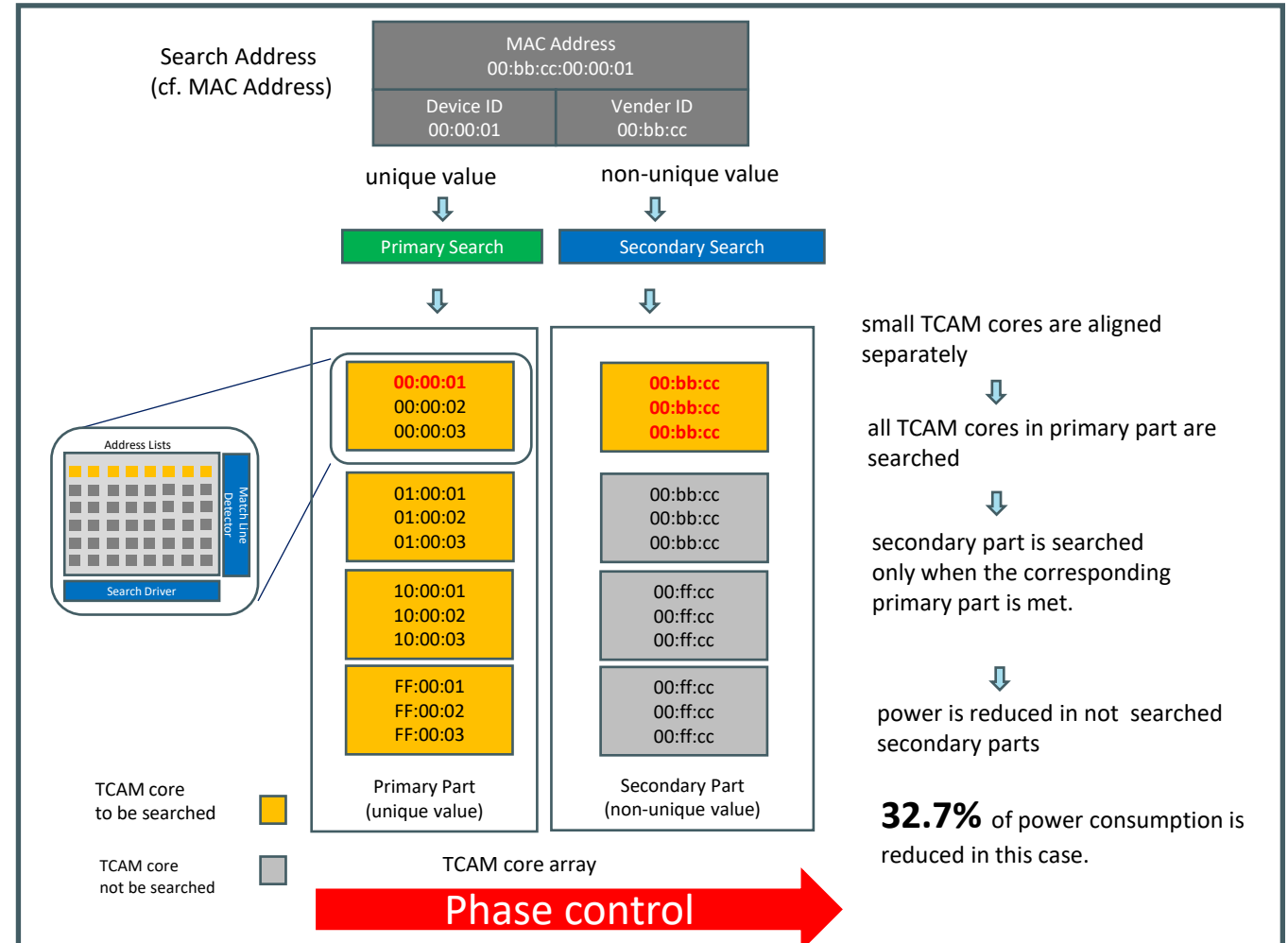


SOLUTION

Phase Shift Search Method

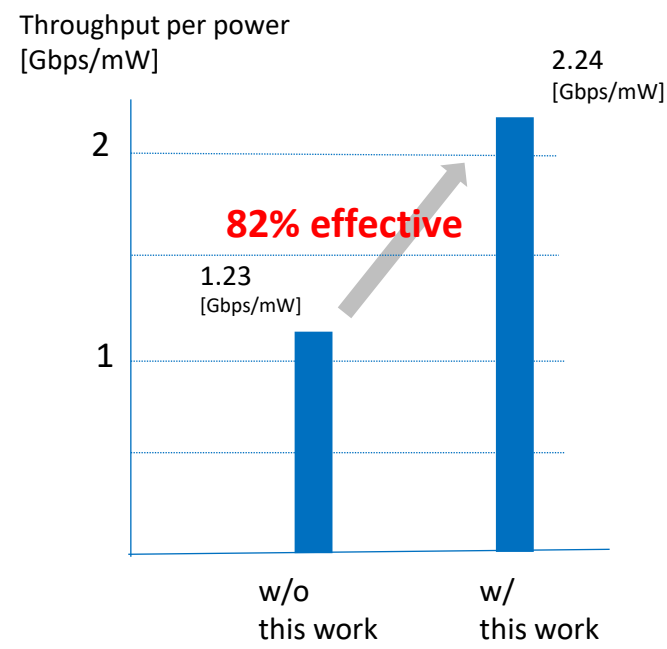
Phase Shift Search Method

The method achieves low power consumption of TCAM by reducing the number of active TCAM cores during comparison, i.e. the secondary part is searched only if the primary part matches.



EVIDENCE

- The Table shows the performance and power results without and with this work.
- The throughput of our Ethernet Switch achieve 100Gbps, a 2x increase compared to the result w/o this work
 - The throughput per power is increased by 82% compared to the result w/o this work.



Throughput and Power Consumption of Ethernet Switch

	w/o this work	w/ this work
Performance (Through)	50Gbps @800MHz	100Gbps @800MHz <u>Achieved 100Gbps</u>
Power	20.37[mW] @50Gbps 800MHz	22.37[mW] @100Gbps 800MHz
Gbps/mW	1.23[Gbps/mW]	2.24[Gbps/mW] <u>82% more effective</u>

SUMMARY

We have realized Ethernet Switch architecture that can achieve high throughput with low power consumption by adopting :

(1) Pipeline search Method

The method optimizes throughput performance by adopting a microstep controller to shift the process one cycle at a time as a pipeline and prevents throughput degression by prioritizing search events over other events.

(2) Phase Shift Search Method

The method achieves low power consumption by aligning small TCAM cores on an array in two parts instead of one big TCAM and processing comparison sequentially.

The throughput of our Ethernet Switch achieves 100Gbps, a 2x increase compared to the result w/o this work.
The throughput per power is increased by 82 % compared to the result w/o this work.

This Ethernet Switch fulfills the requirements of next generation autonomous driving car.