Implementation and Verification of the Slave Elementary Cycle Synchronization Mechanism of the Flexible Time-Triggered Replicated Star for Ethernet

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Tutors

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Supervisor

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- Fault Tolerance for Flexible Time-Triggered Ethernet (FT4FTT).
  - Highly-dependable and flexible communication infraestructure.
- Flexible Time-Triggered Switched Ethernet (FTT-SE) communication protocol.
- Flexible Time-Triggered Replicated Star for Ethernet (FTTRS) architecture.

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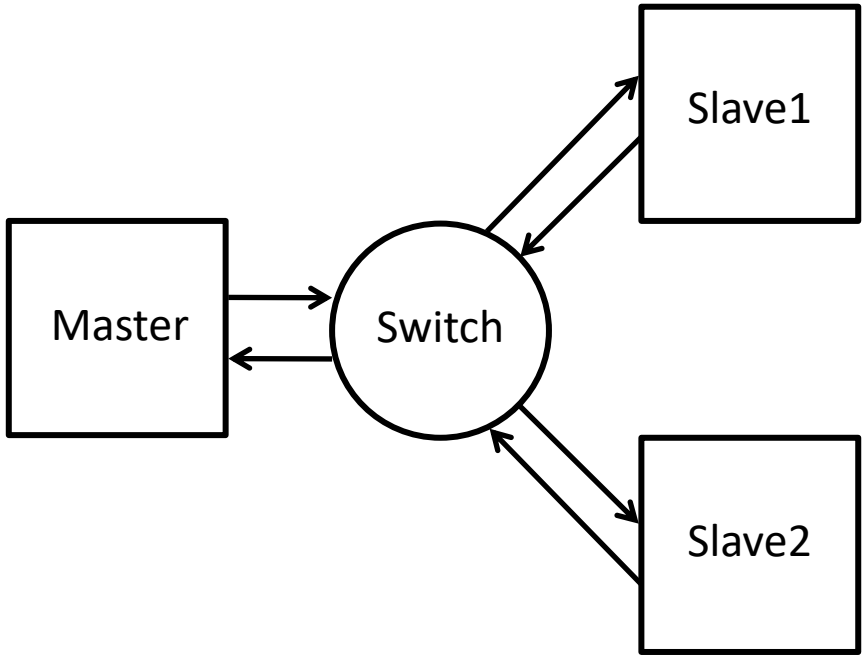
Architecture



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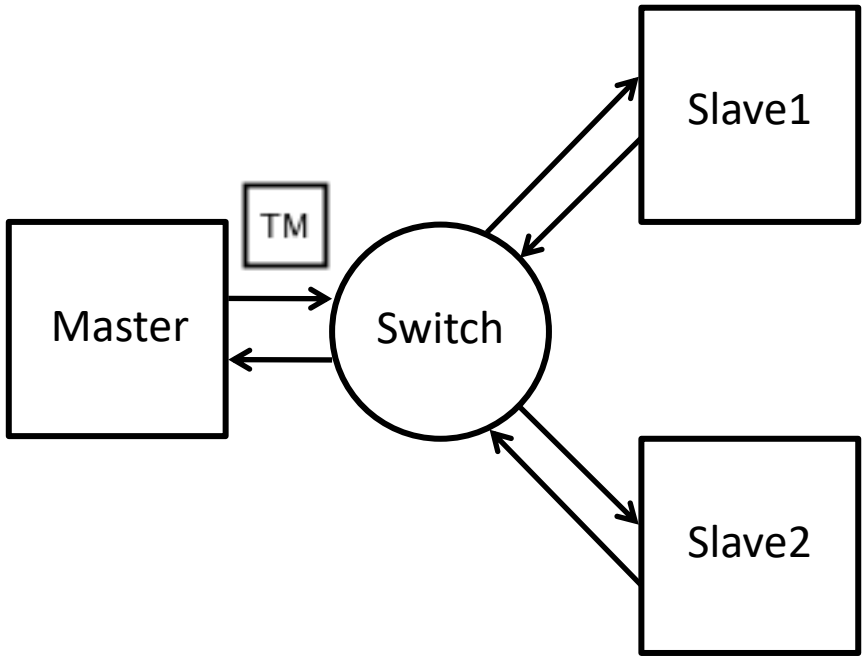

Slaves view

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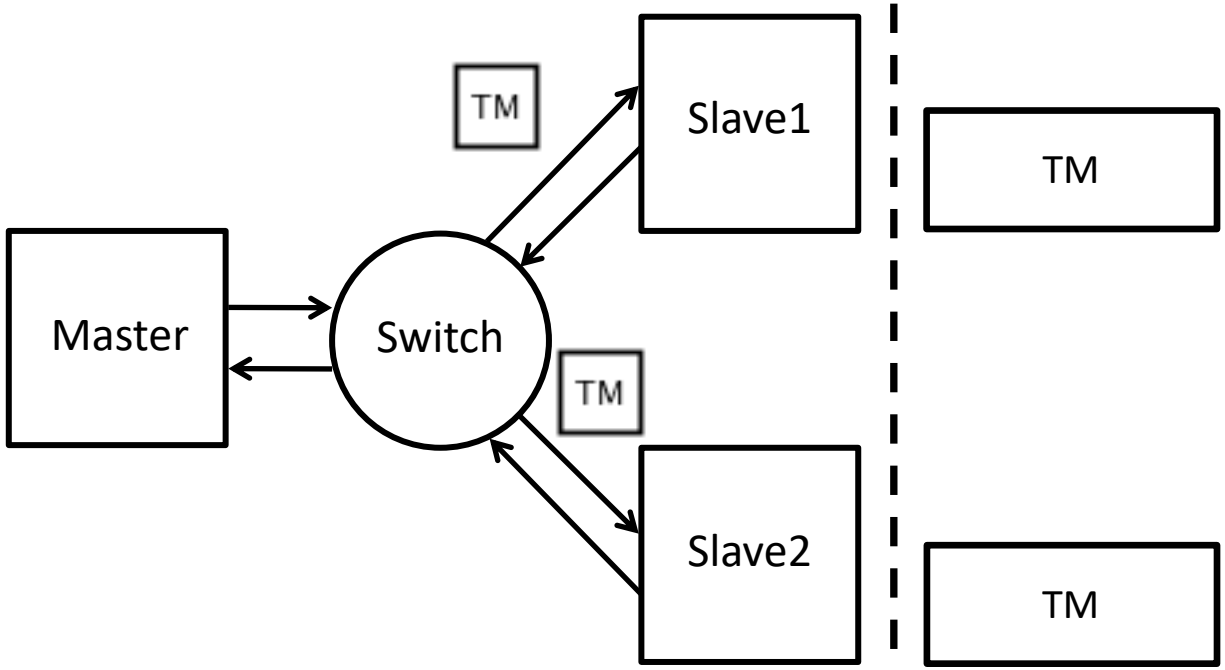

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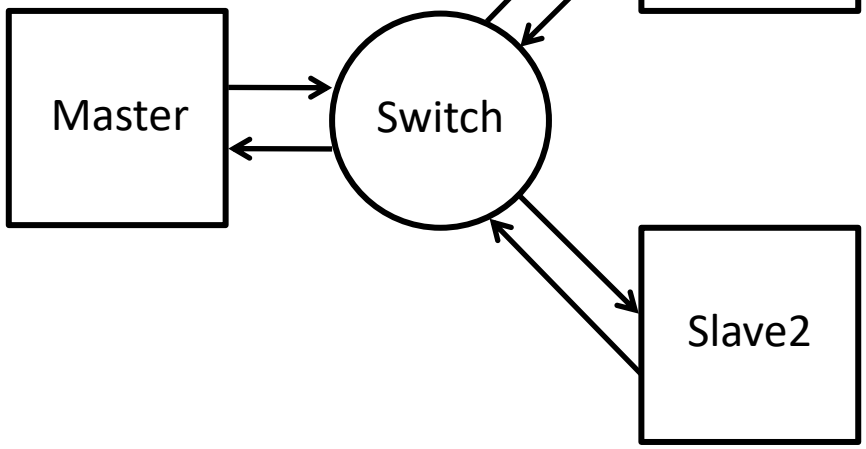

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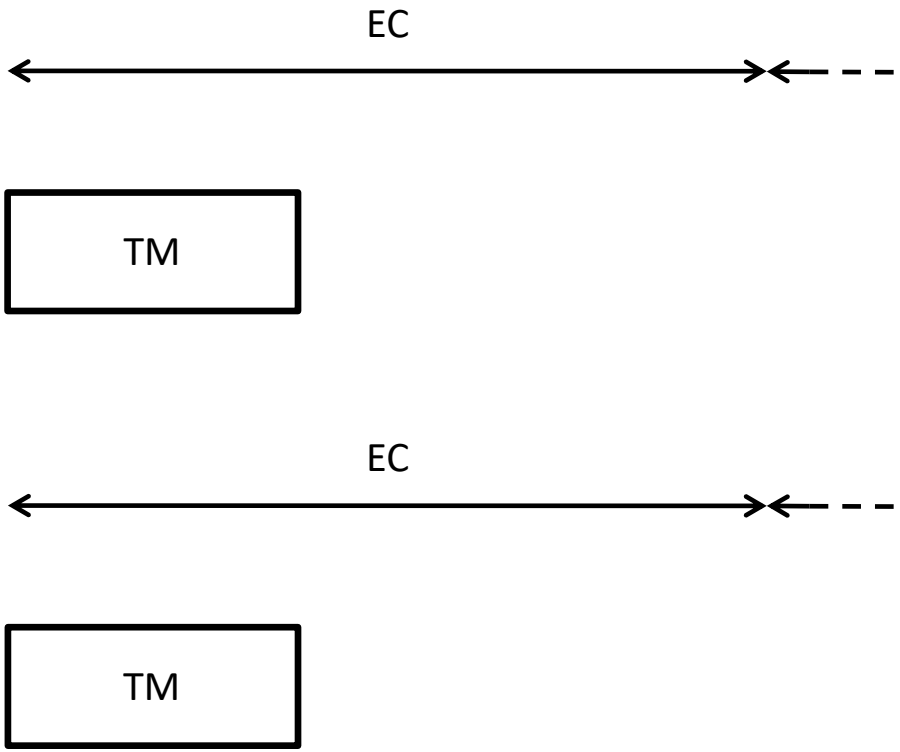

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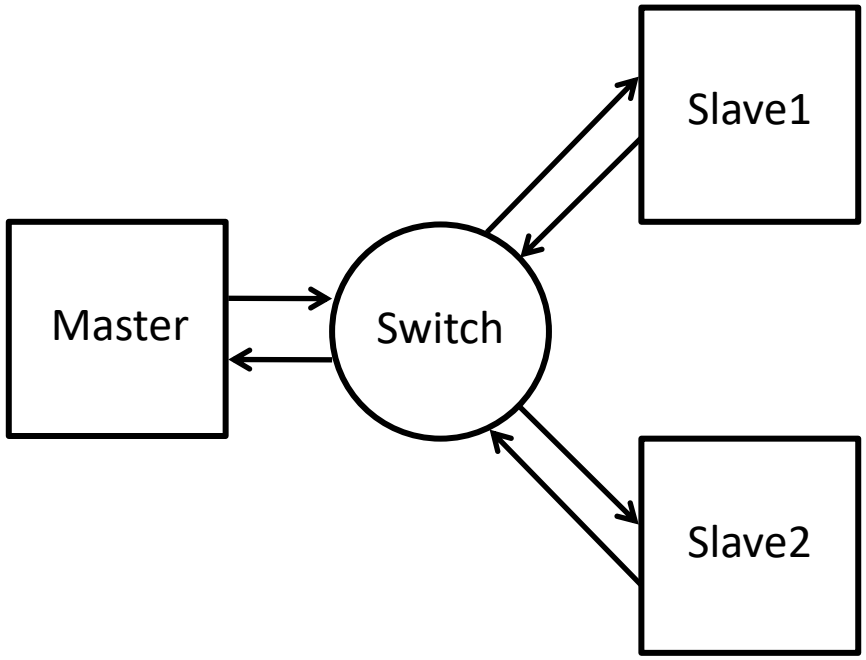

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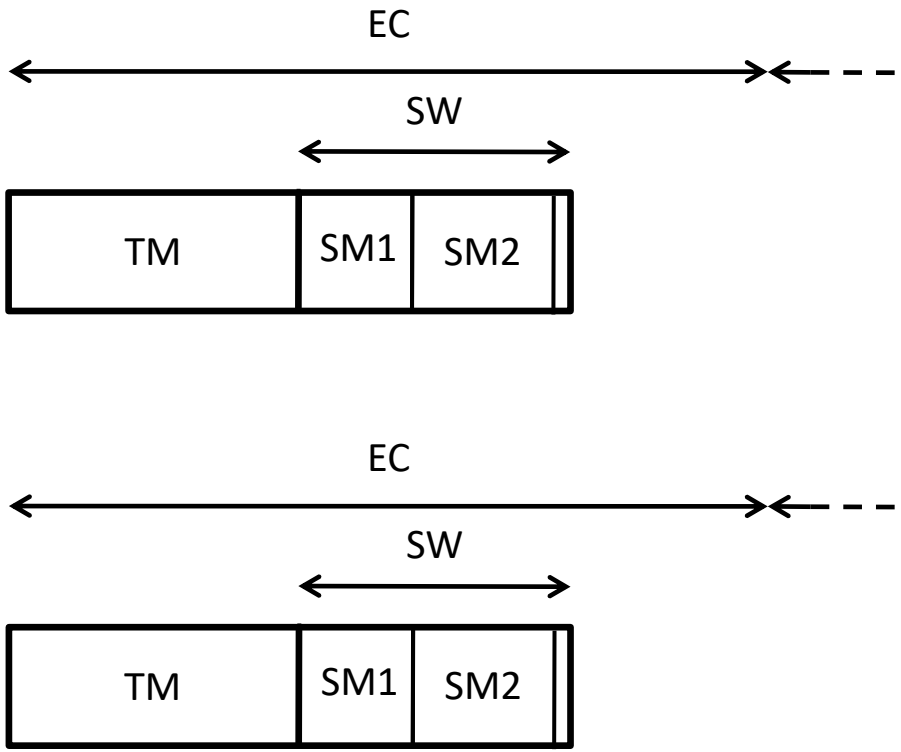

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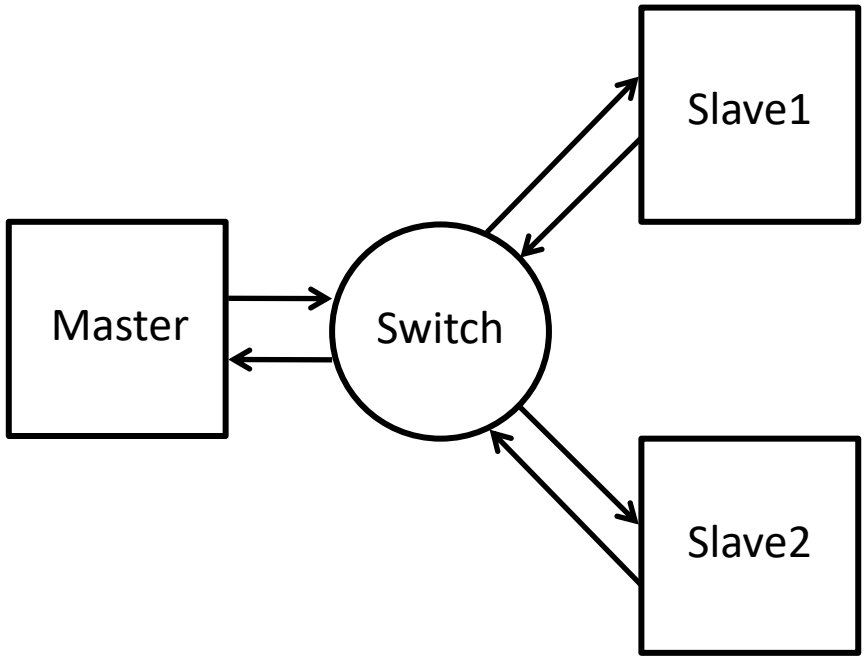

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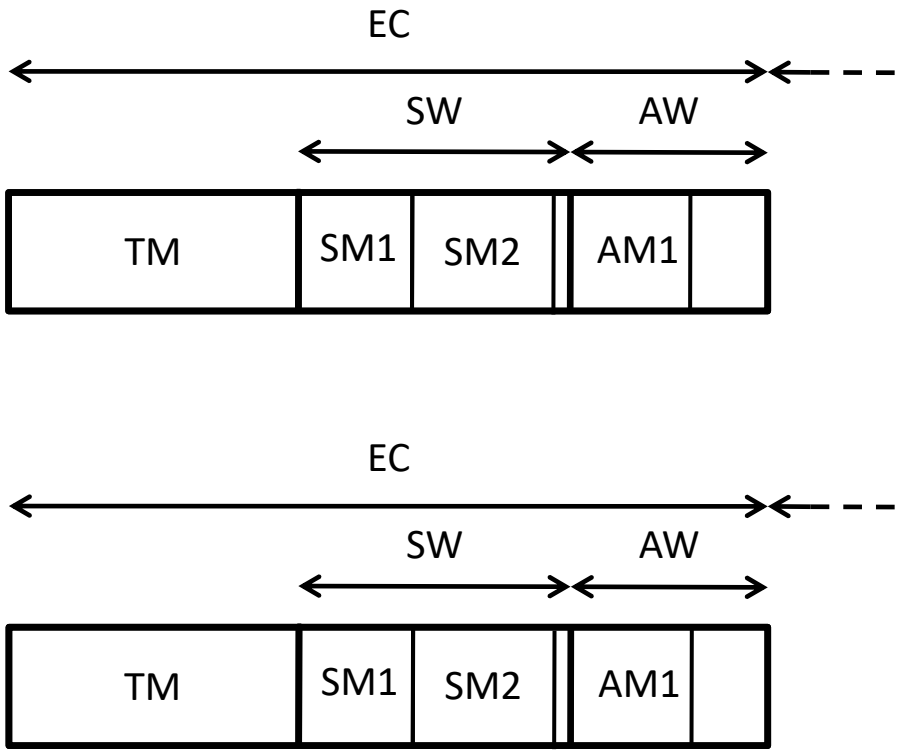

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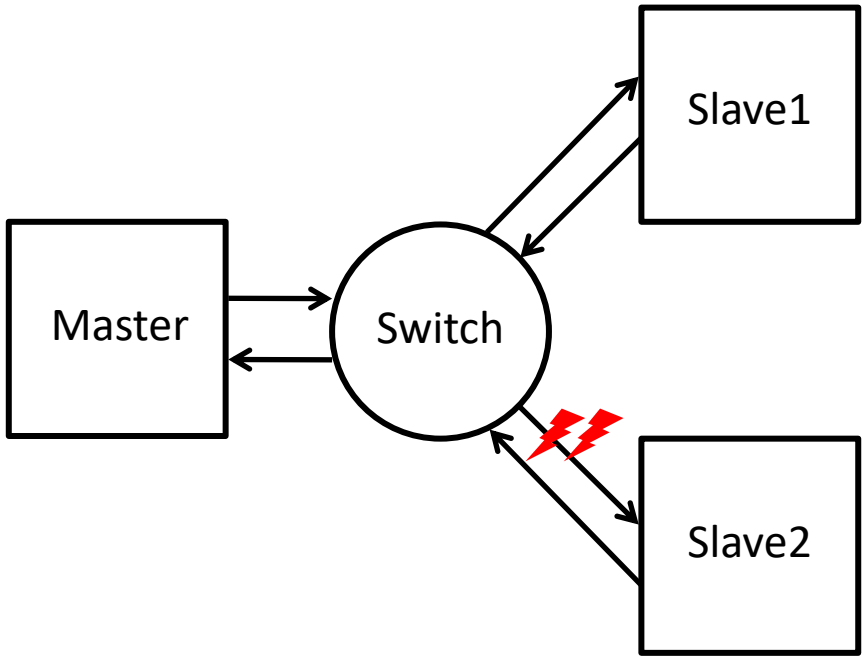

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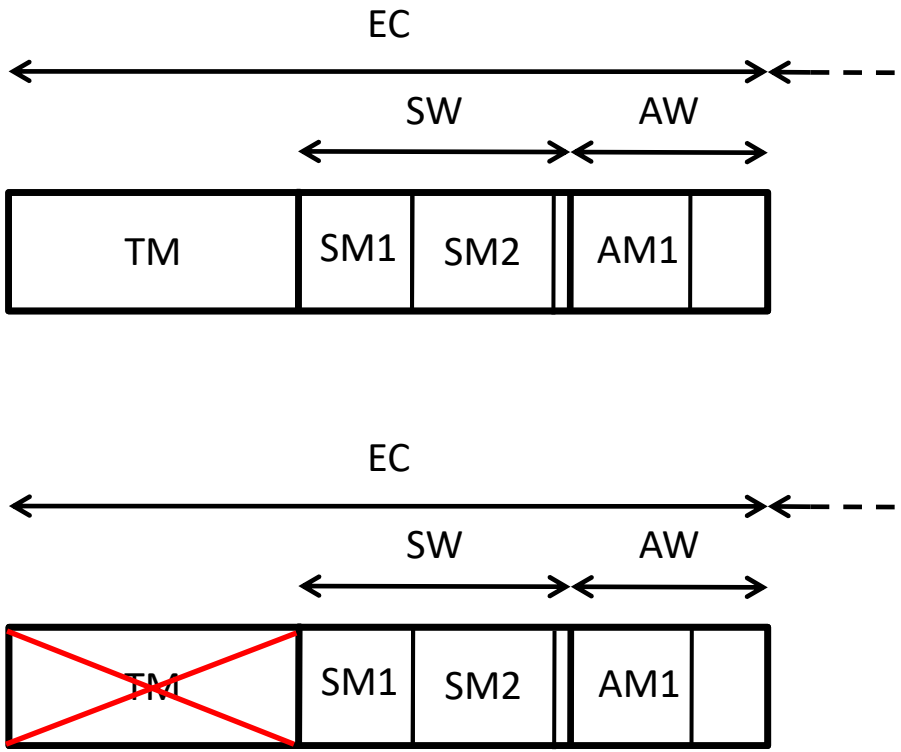

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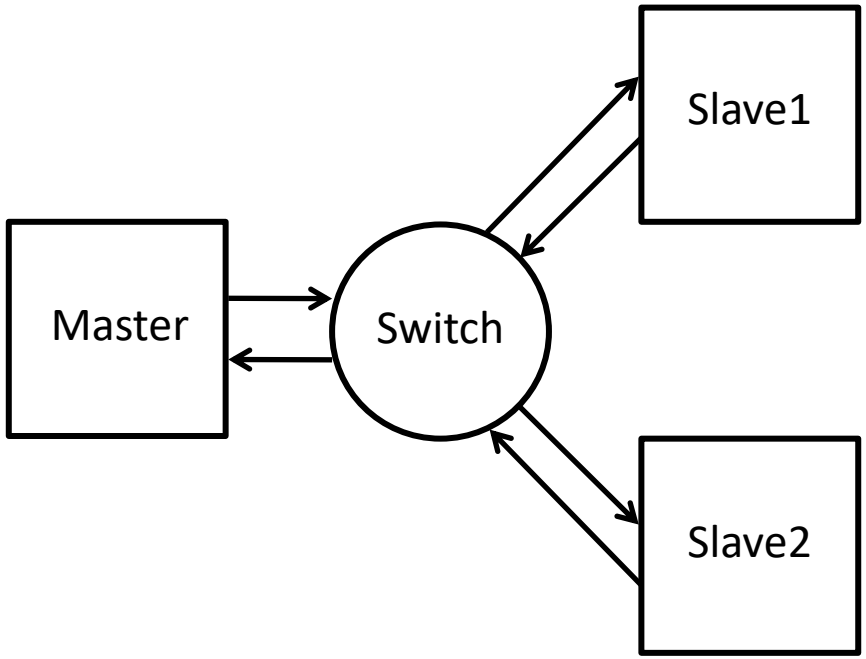

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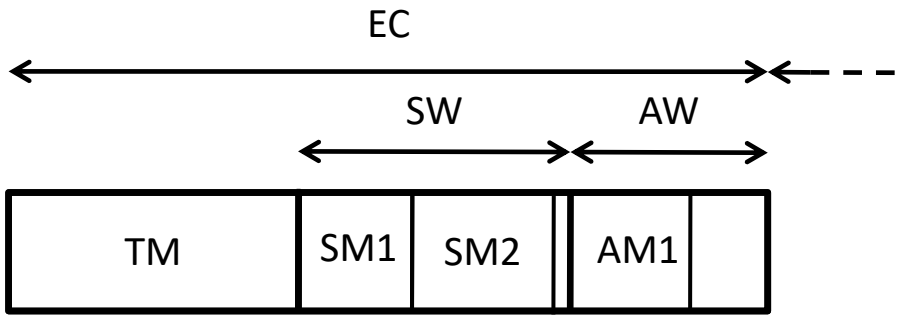

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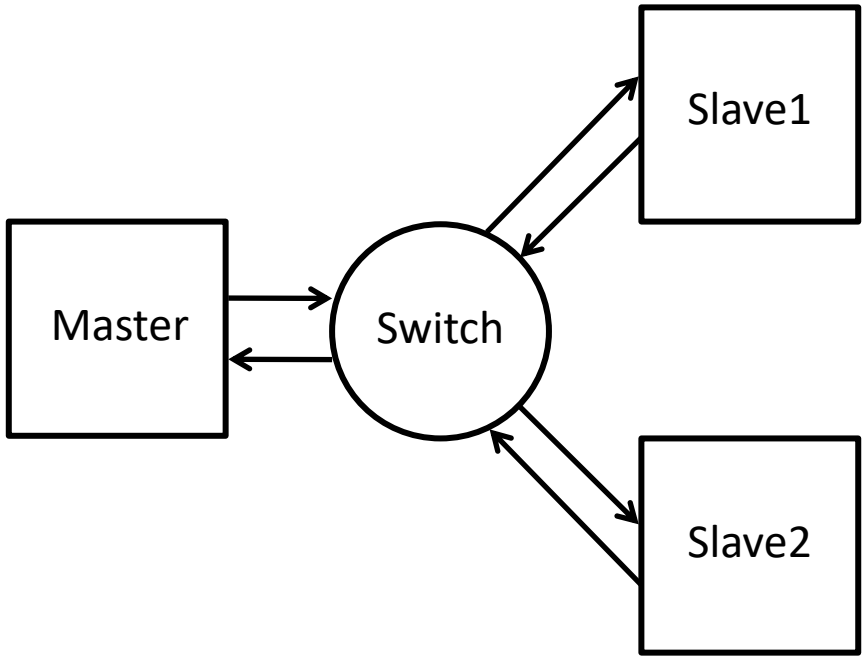

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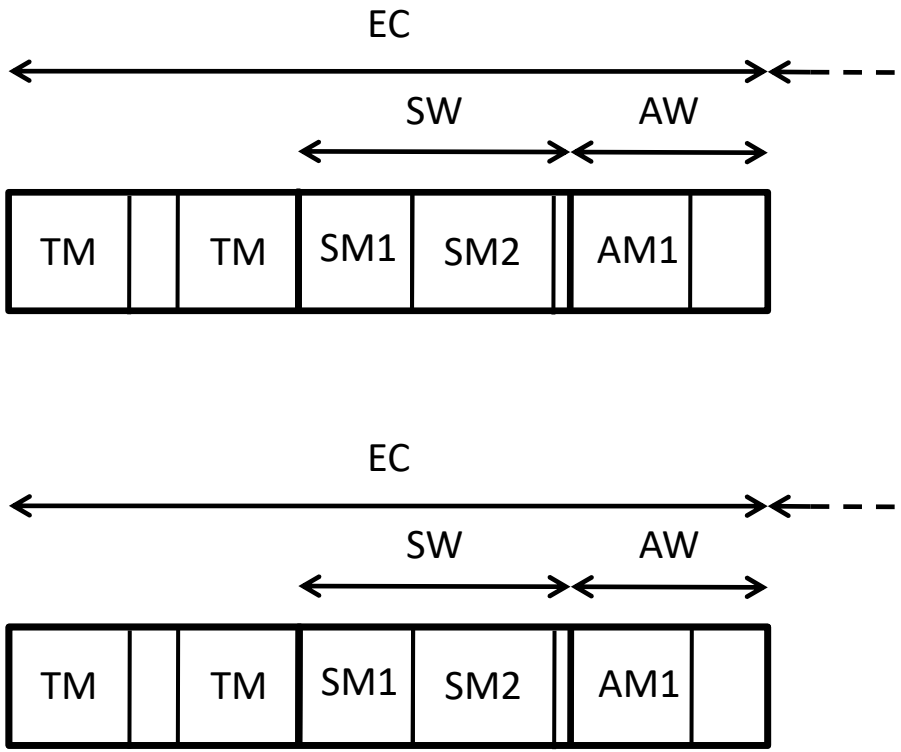

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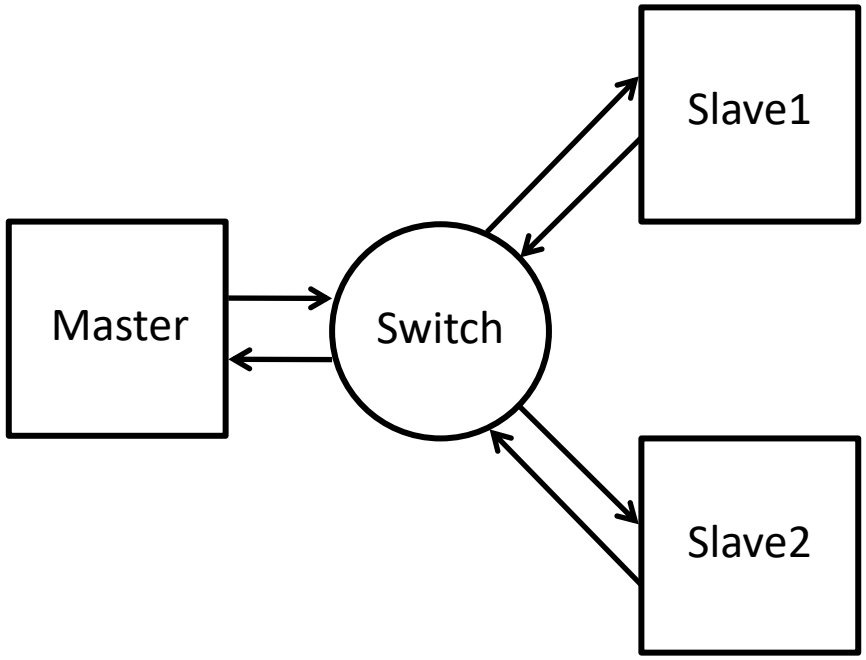

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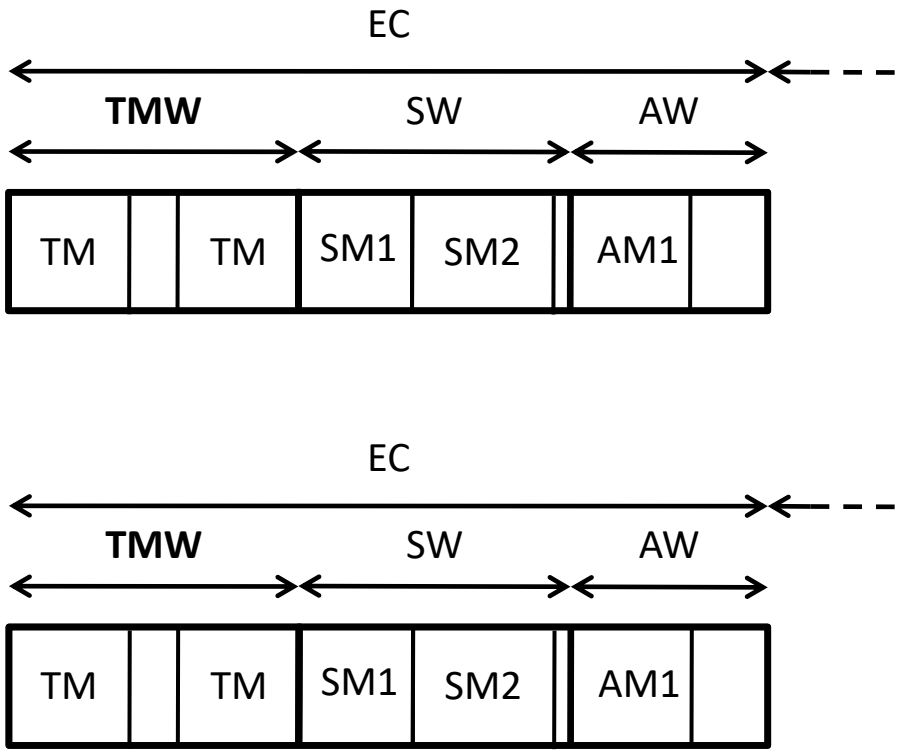

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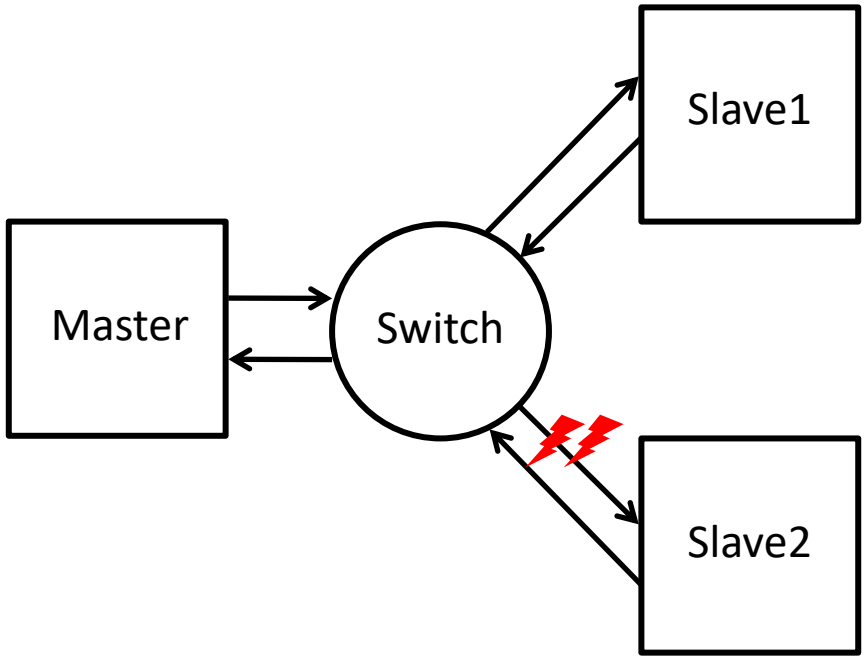

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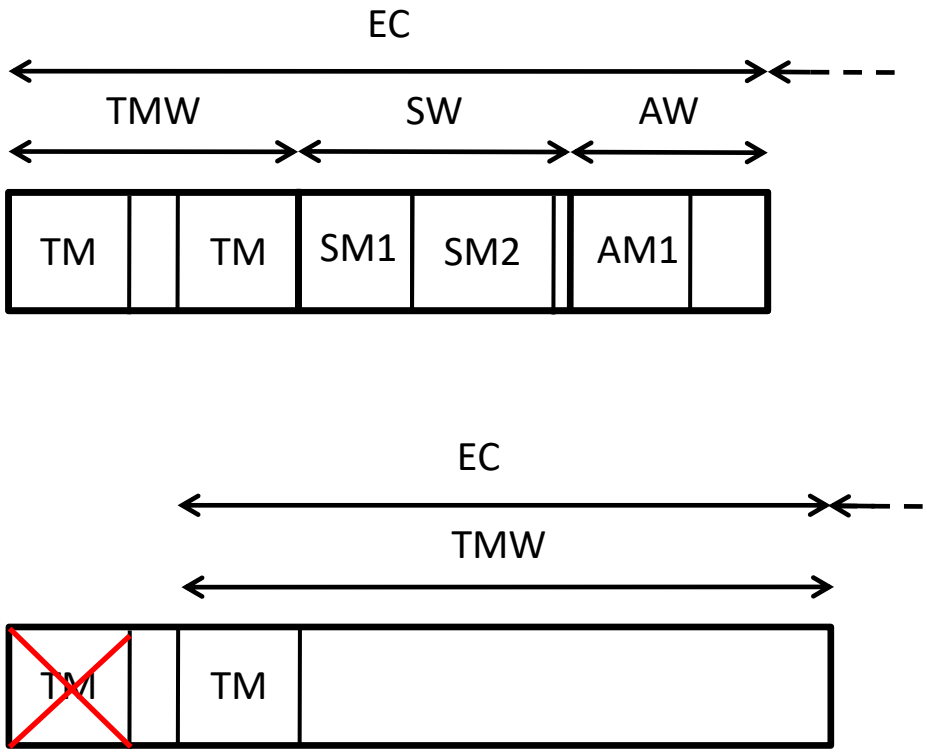

Introduction

Slave Elementary Cycle Synchronization Mechanism (SECSM)

D. Gessner, J. Proenza, and M. Barranco, *A Proposal for Managing the Redundancy Provided by the Flexible Time-Triggered Replicated Star for Ethernet*, in Proc. 10th IEEE Int. Workshop on Factory Communication Systems (WFCS) , Toulouse, France, May 2014.

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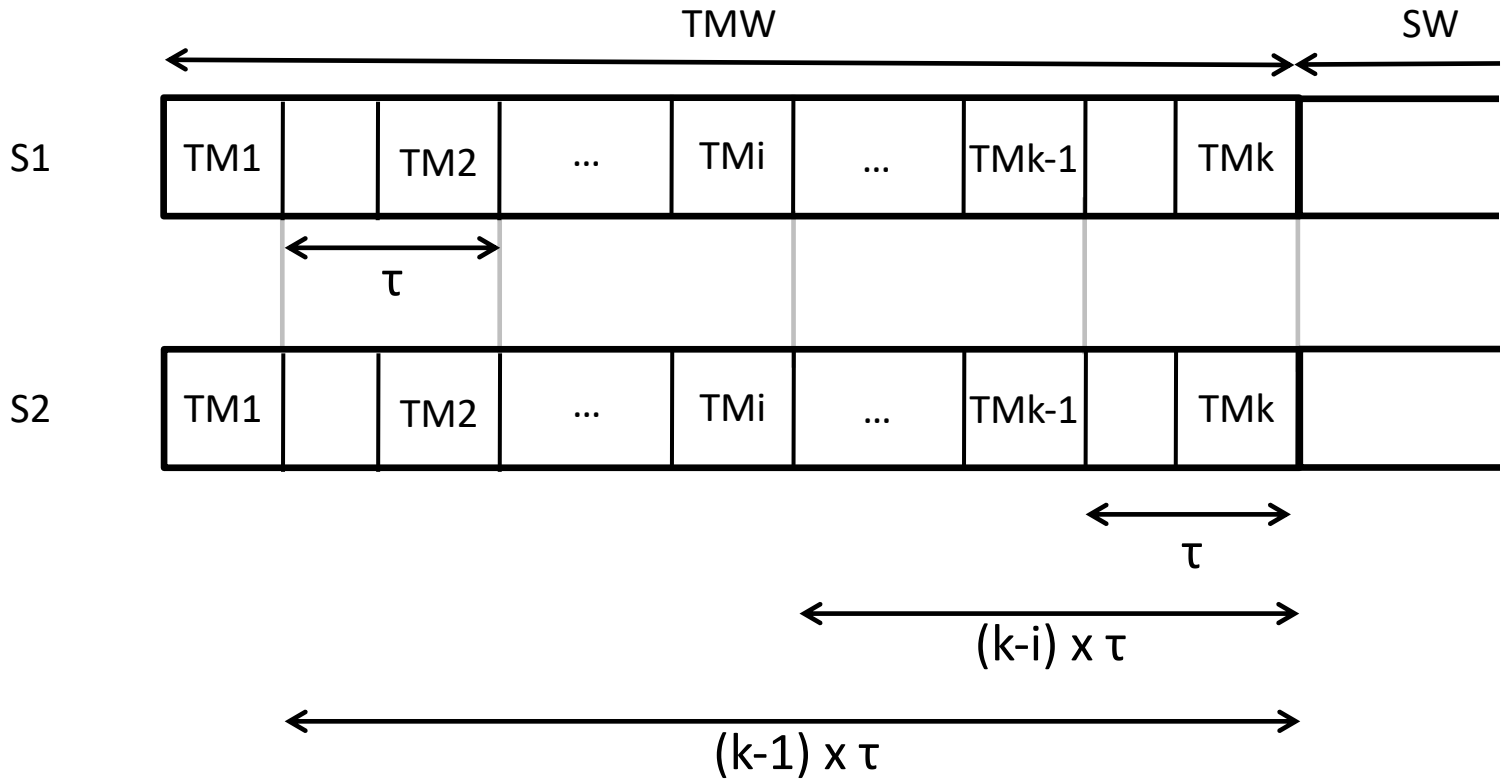
SECSM



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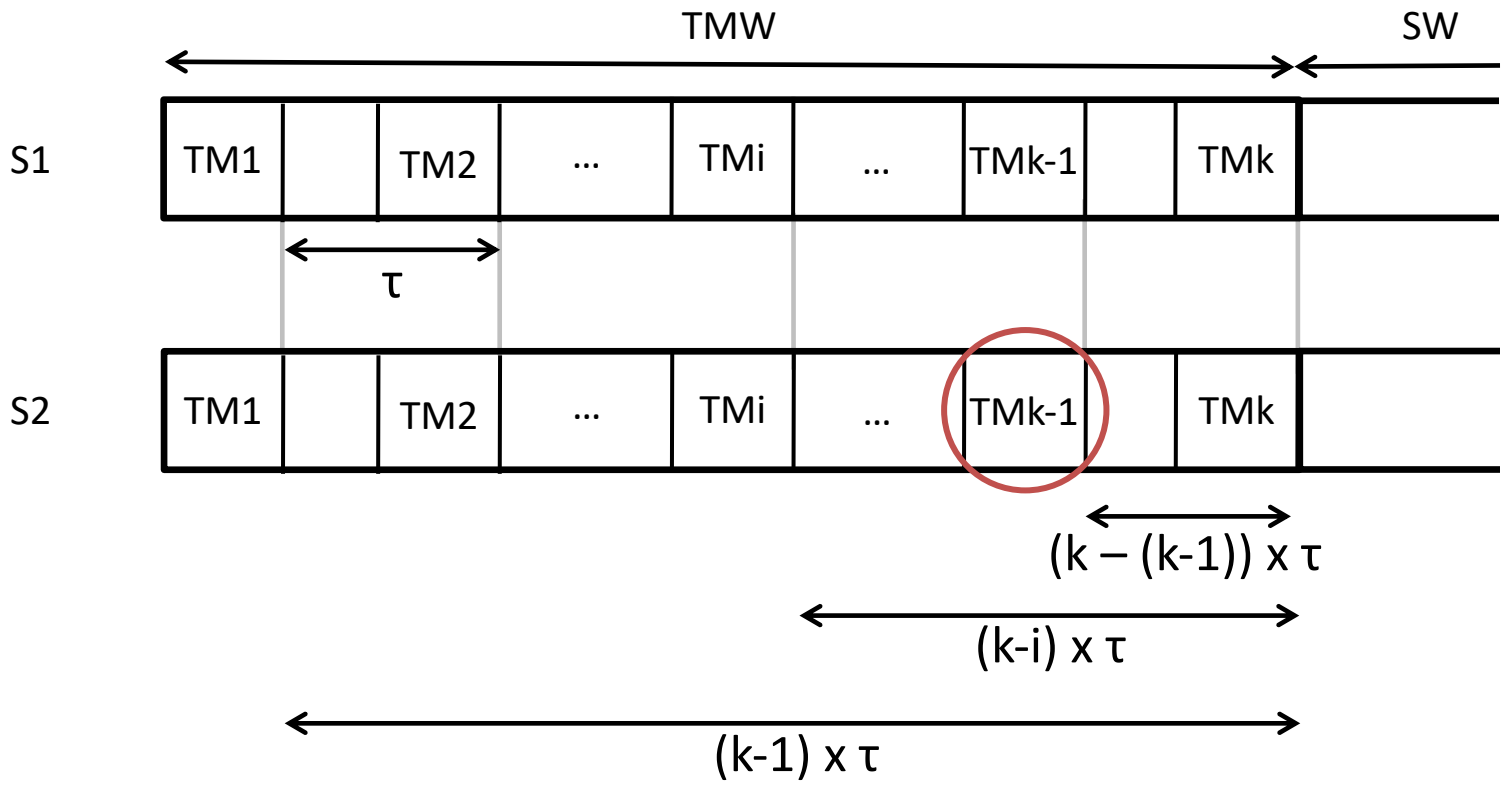
SECSM



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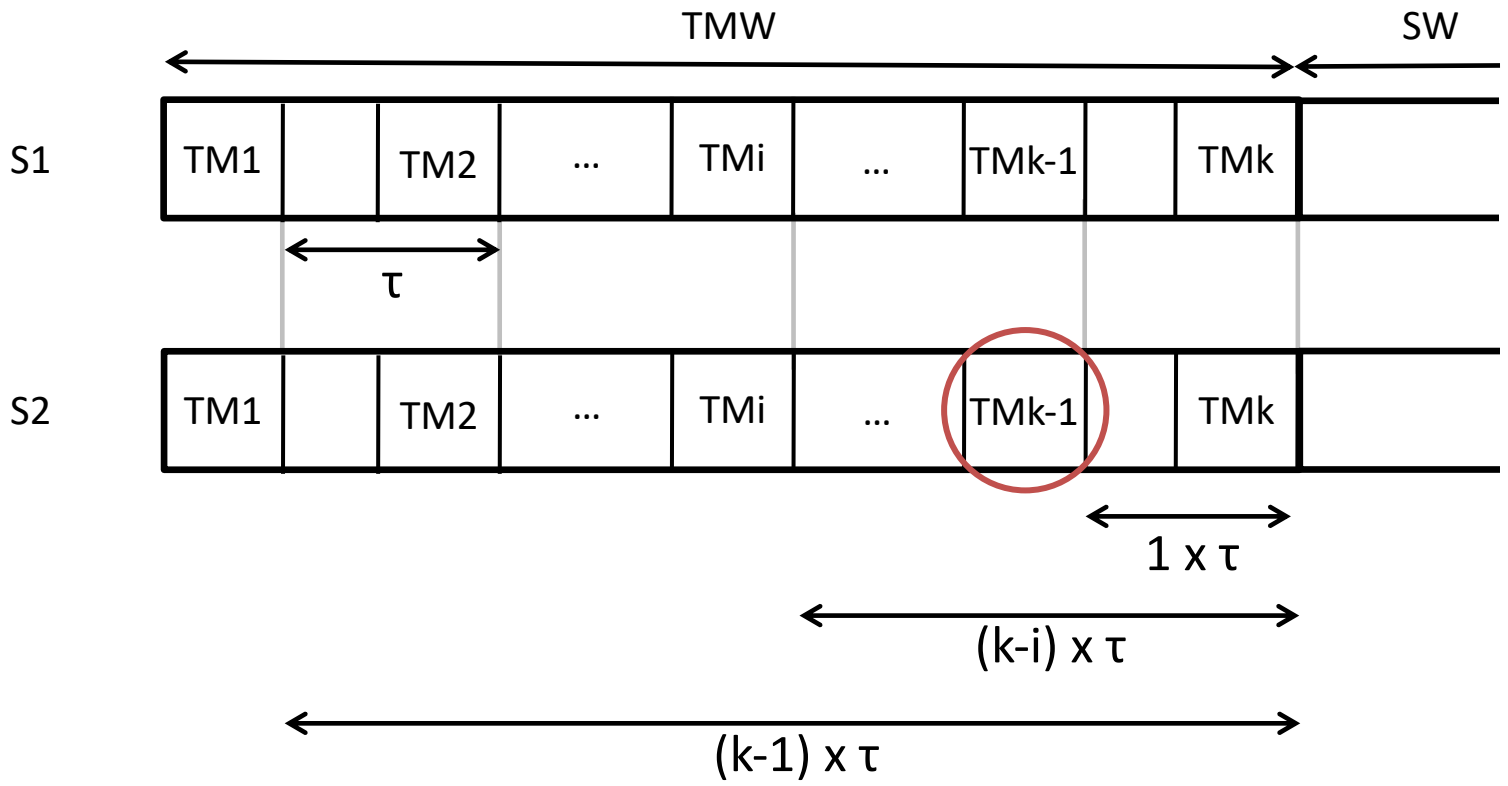

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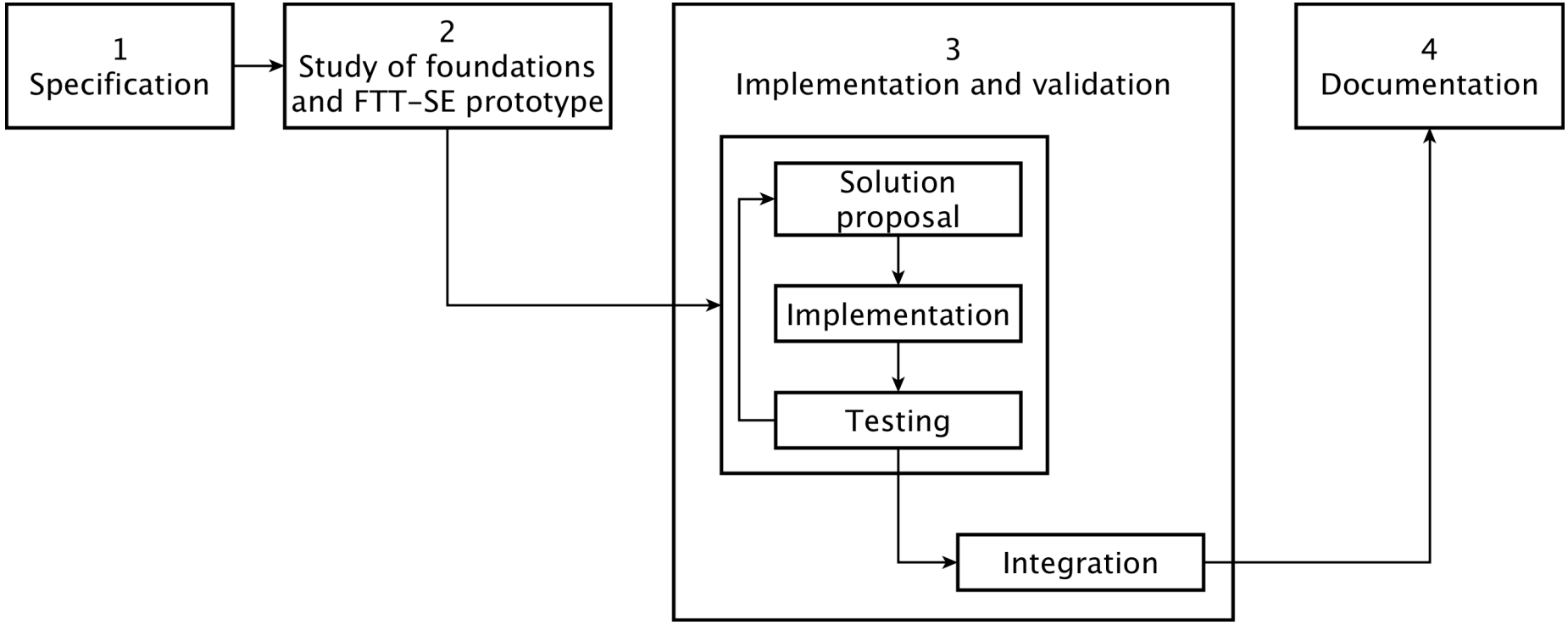

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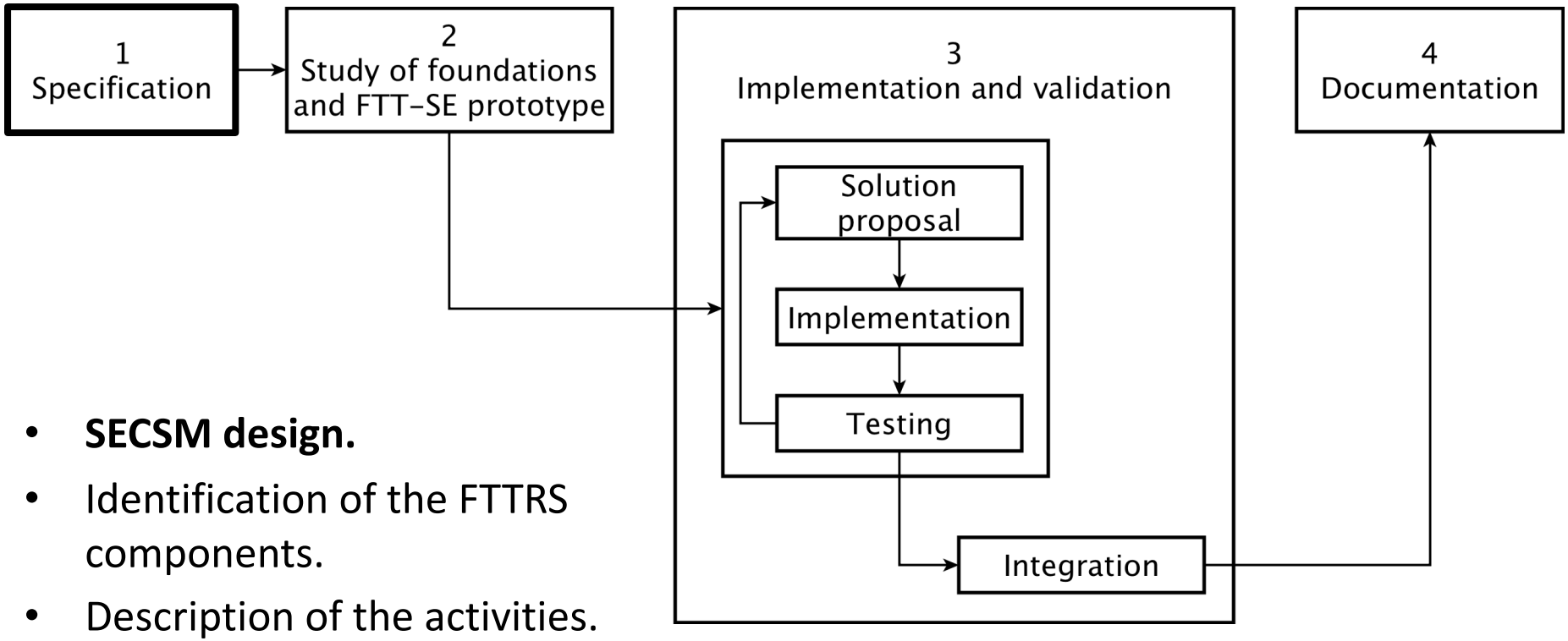
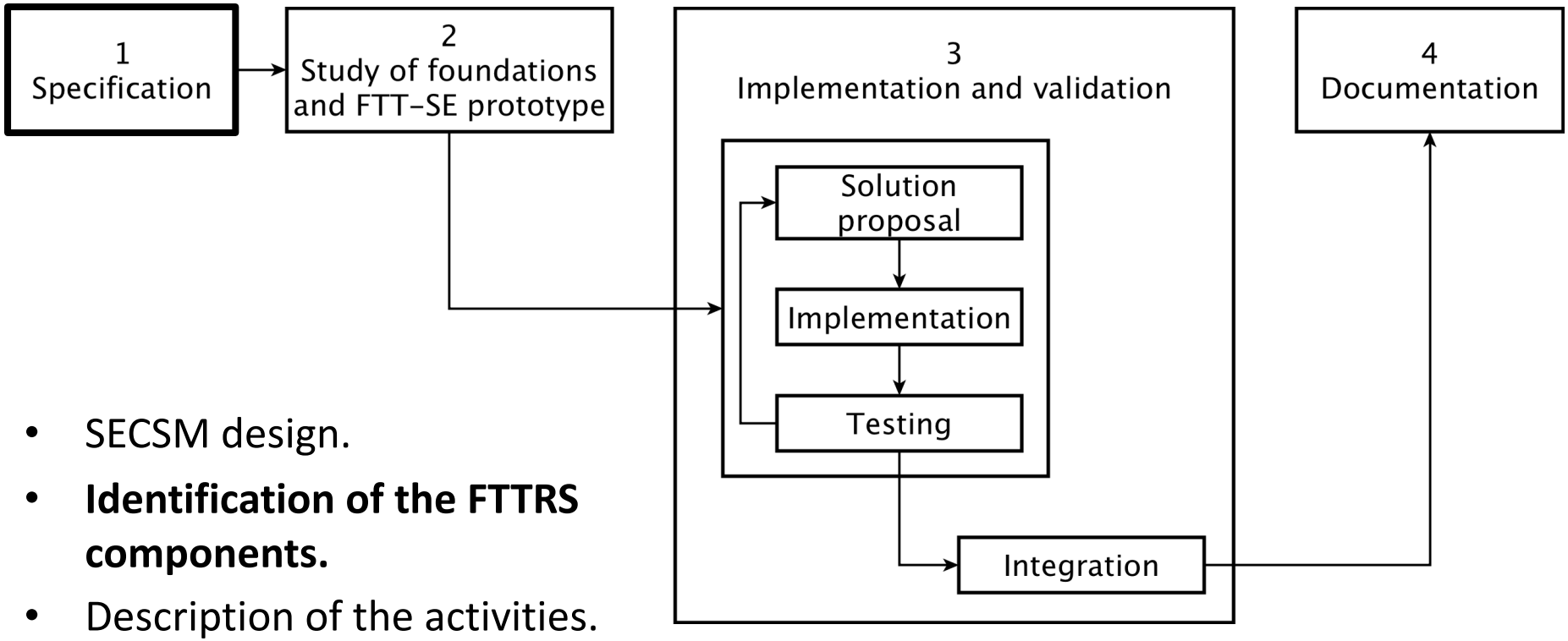


- **SECSM design.**
- Identification of the FTTRS components.
- Description of the activities.

Phases of the project



- SECSM design.
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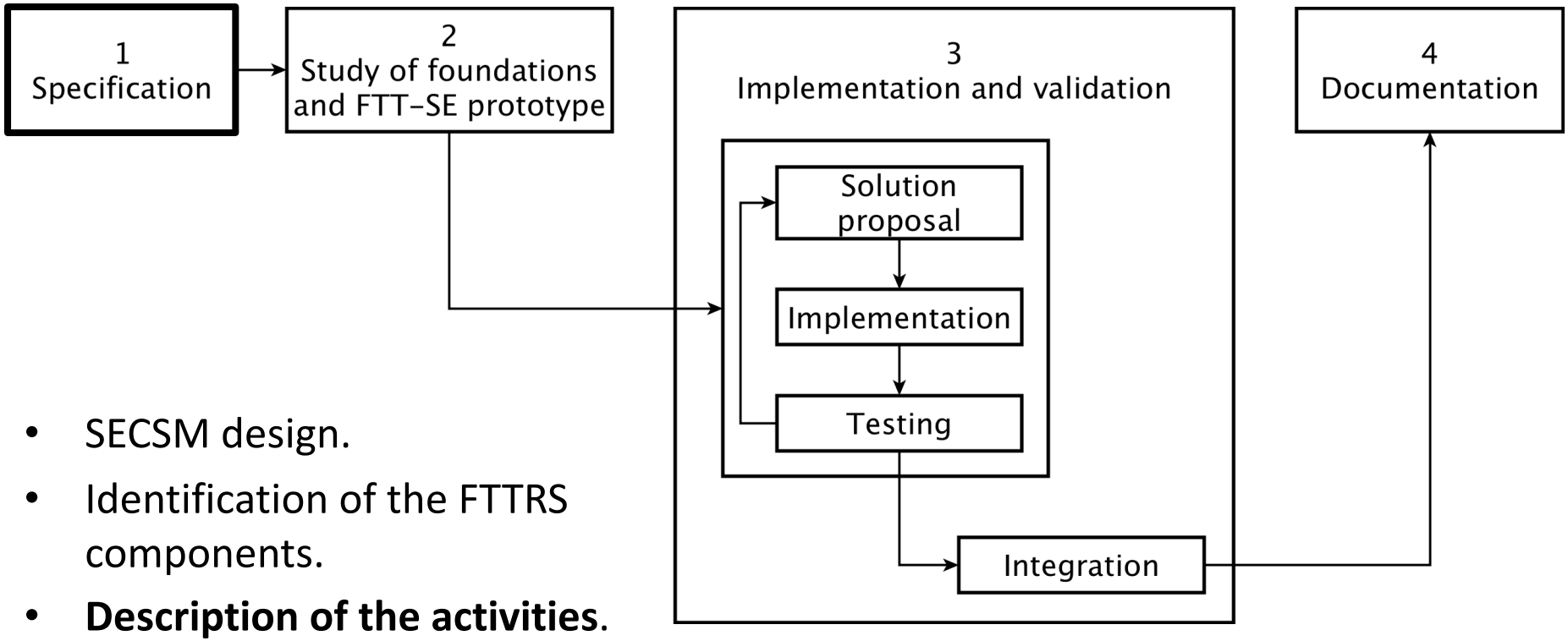
Phases of the project



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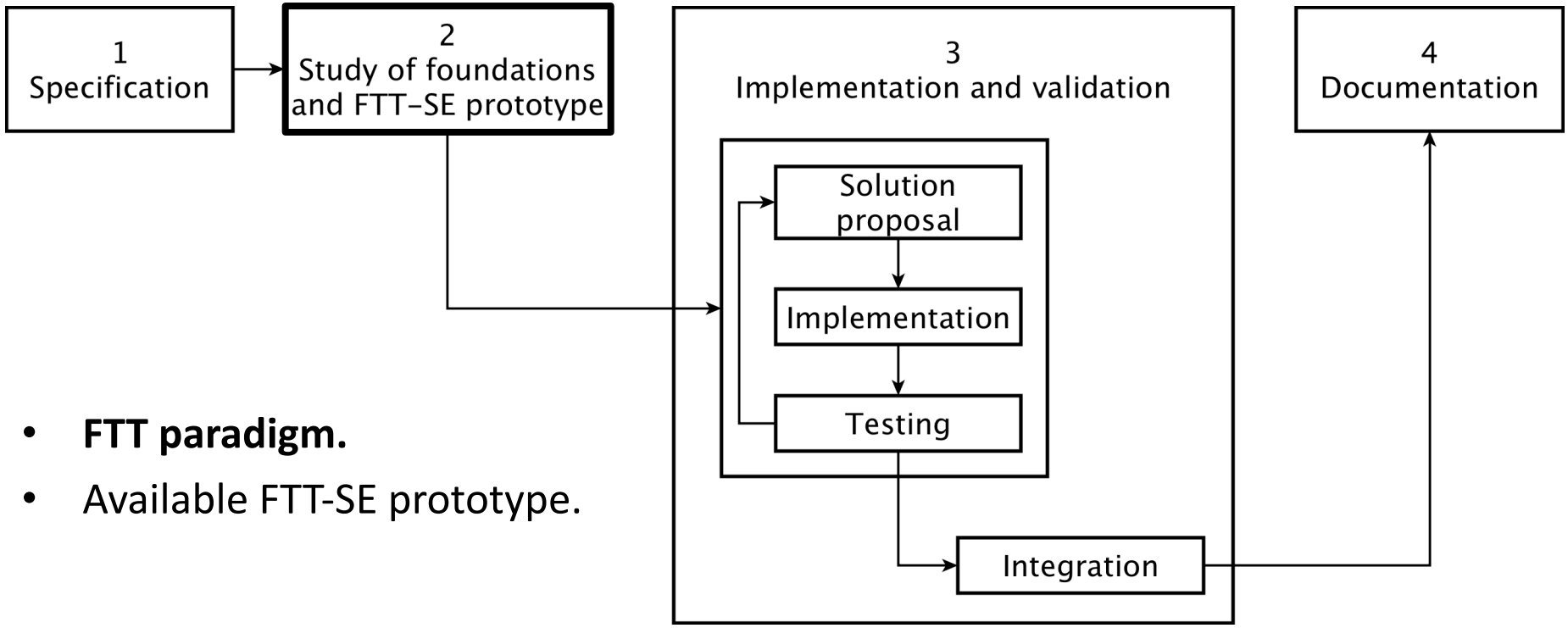
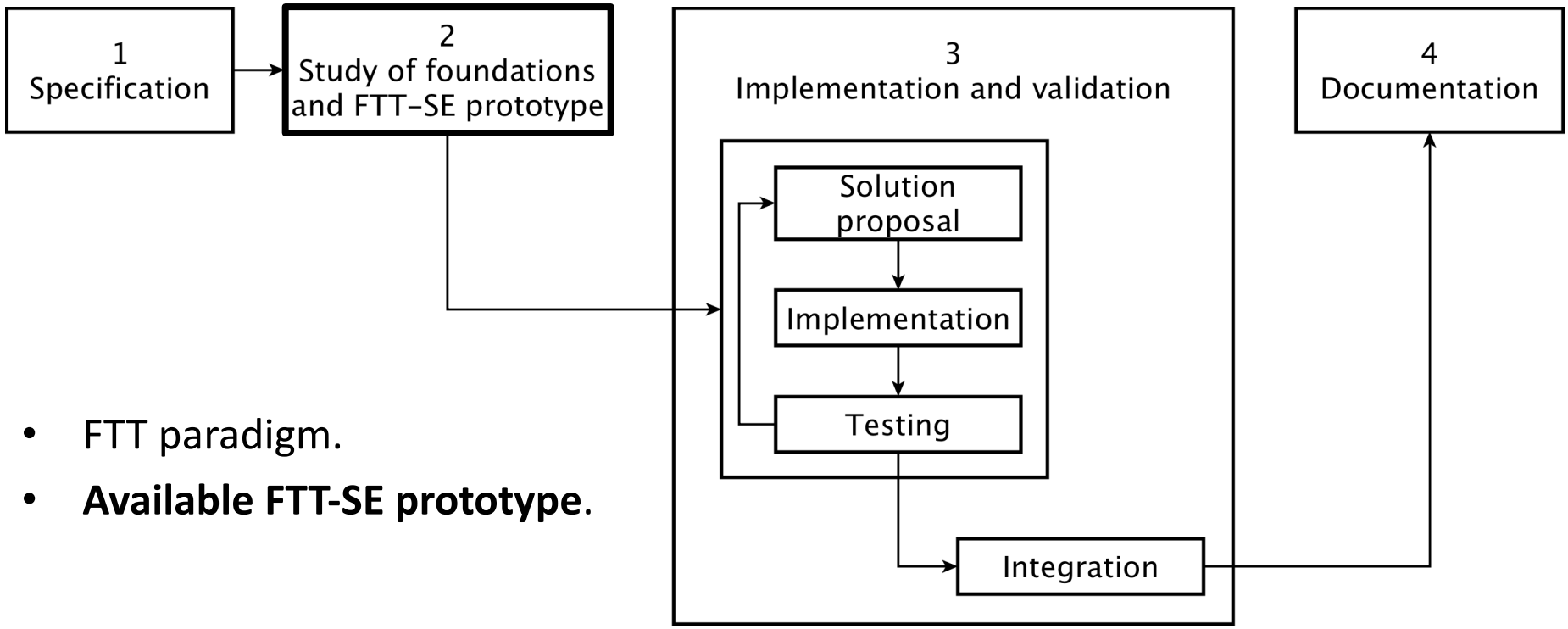


- **FTT paradigm.**
- Available FTT-SE prototype.

Phases of the project



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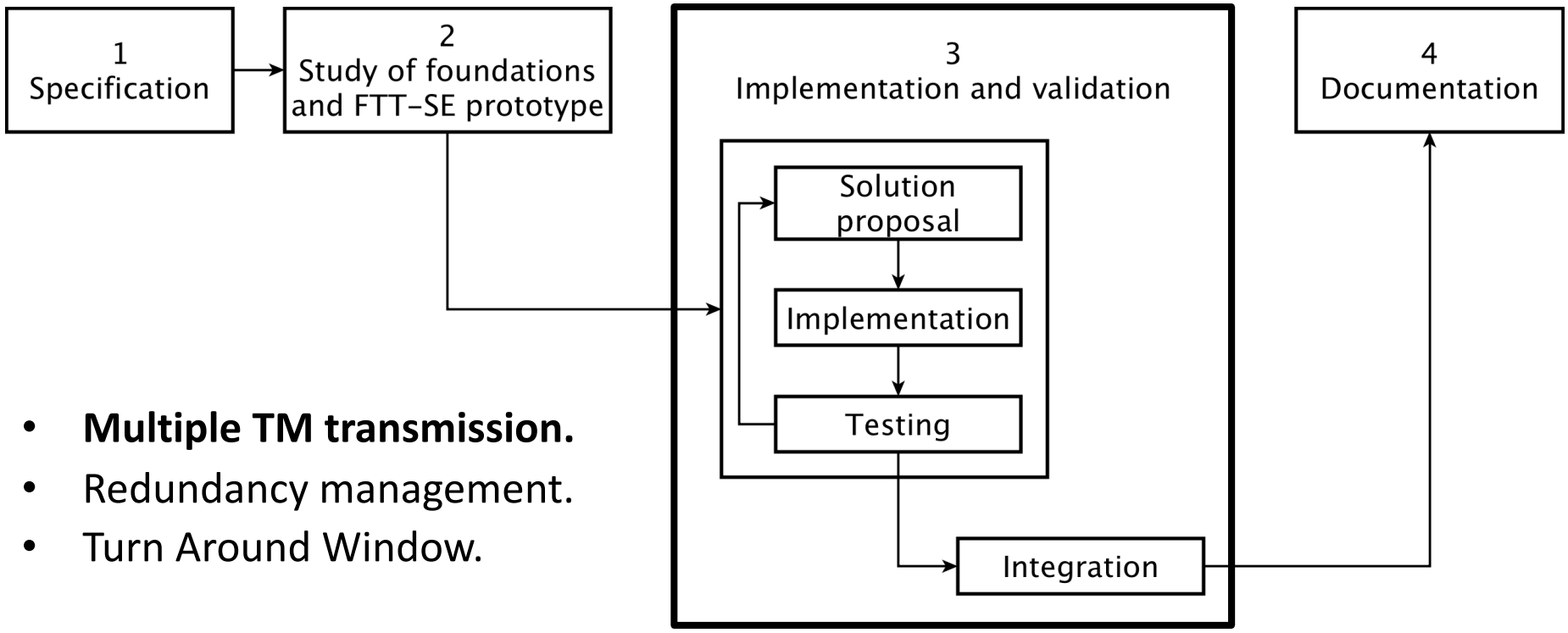
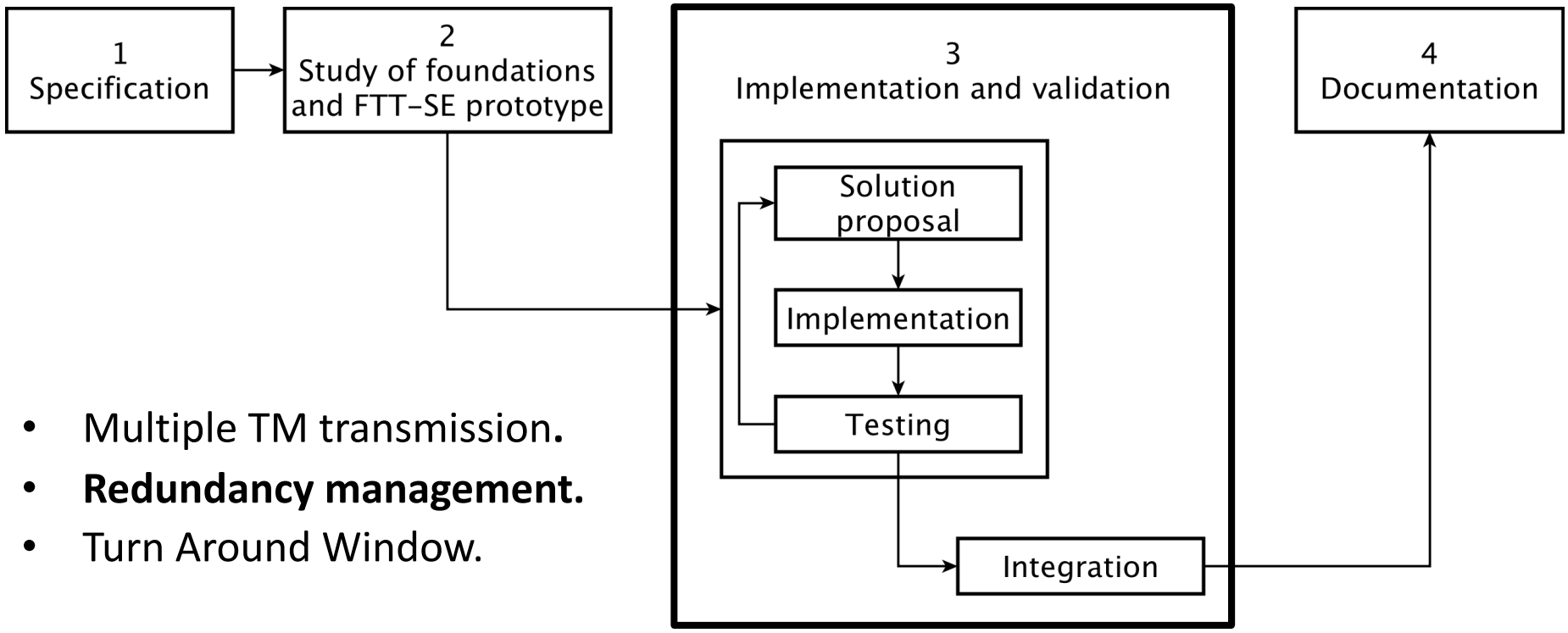


- **Multiple TM transmission.**
- Redundancy management.
- Turn Around Window.

Phases of the project



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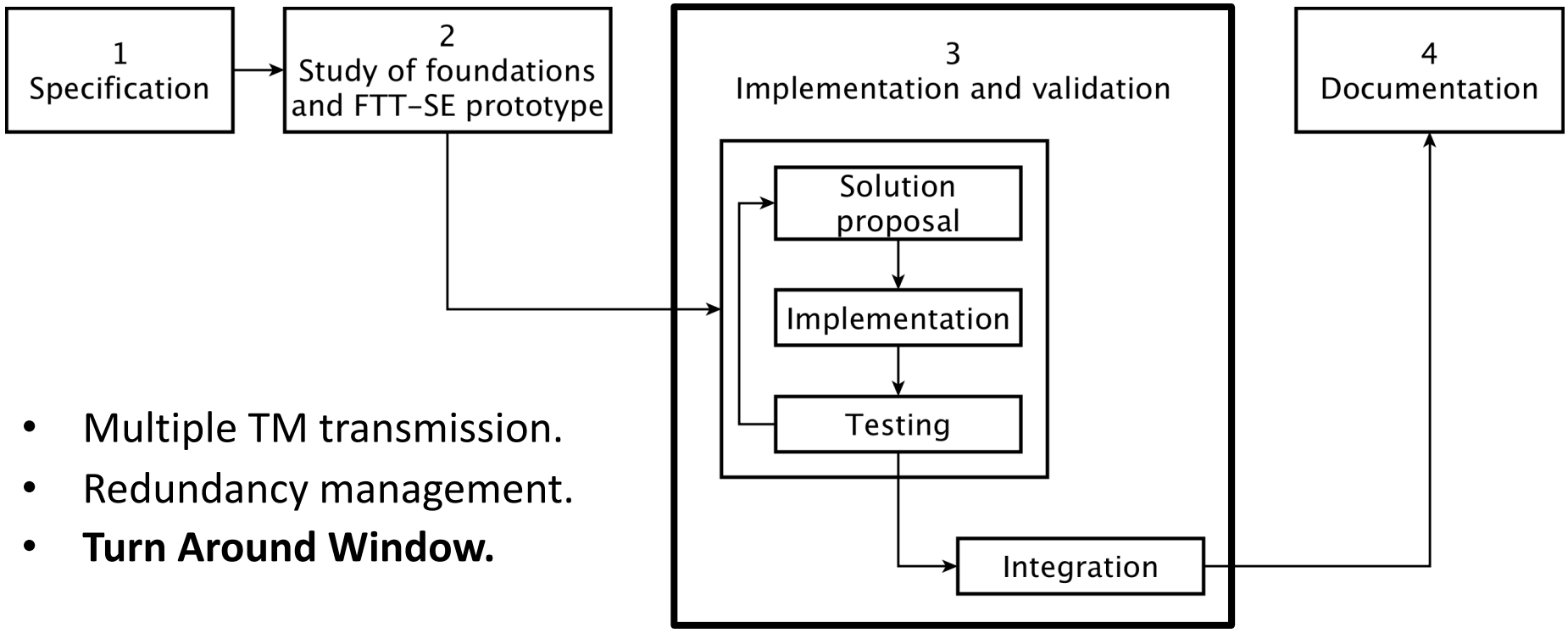

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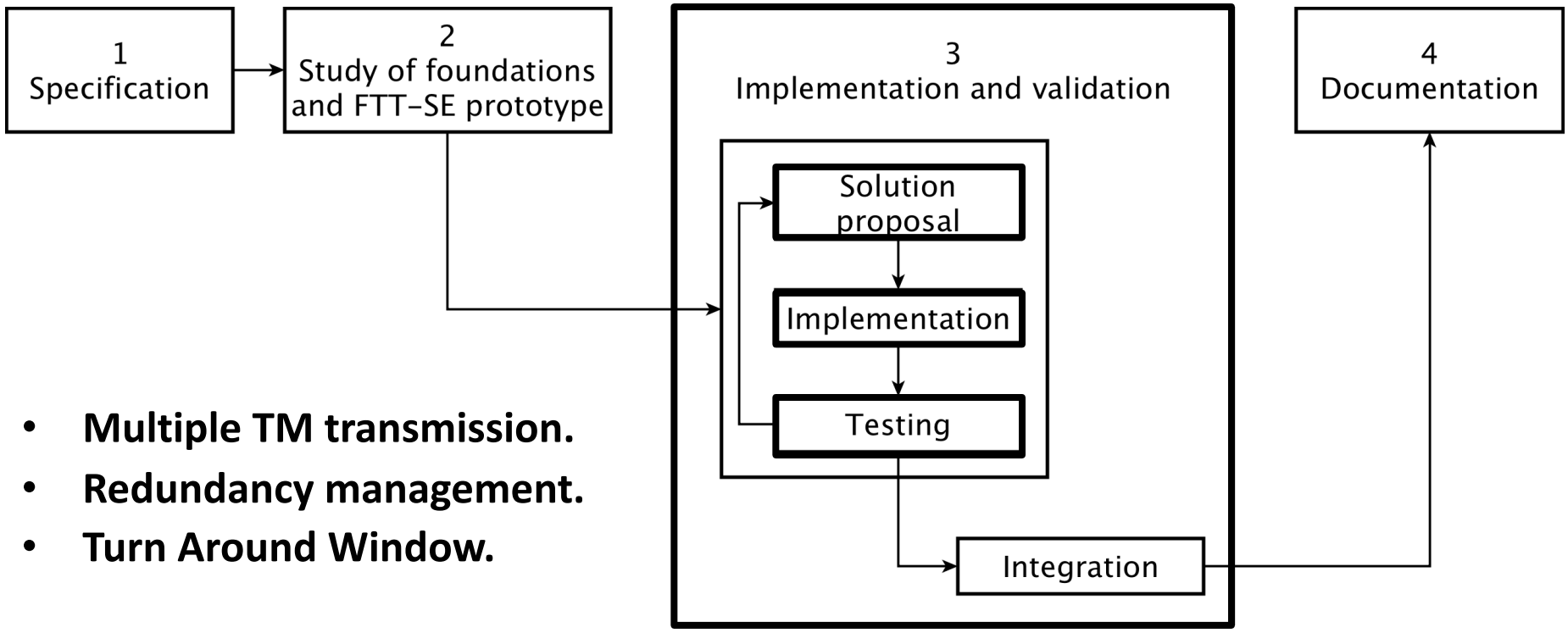

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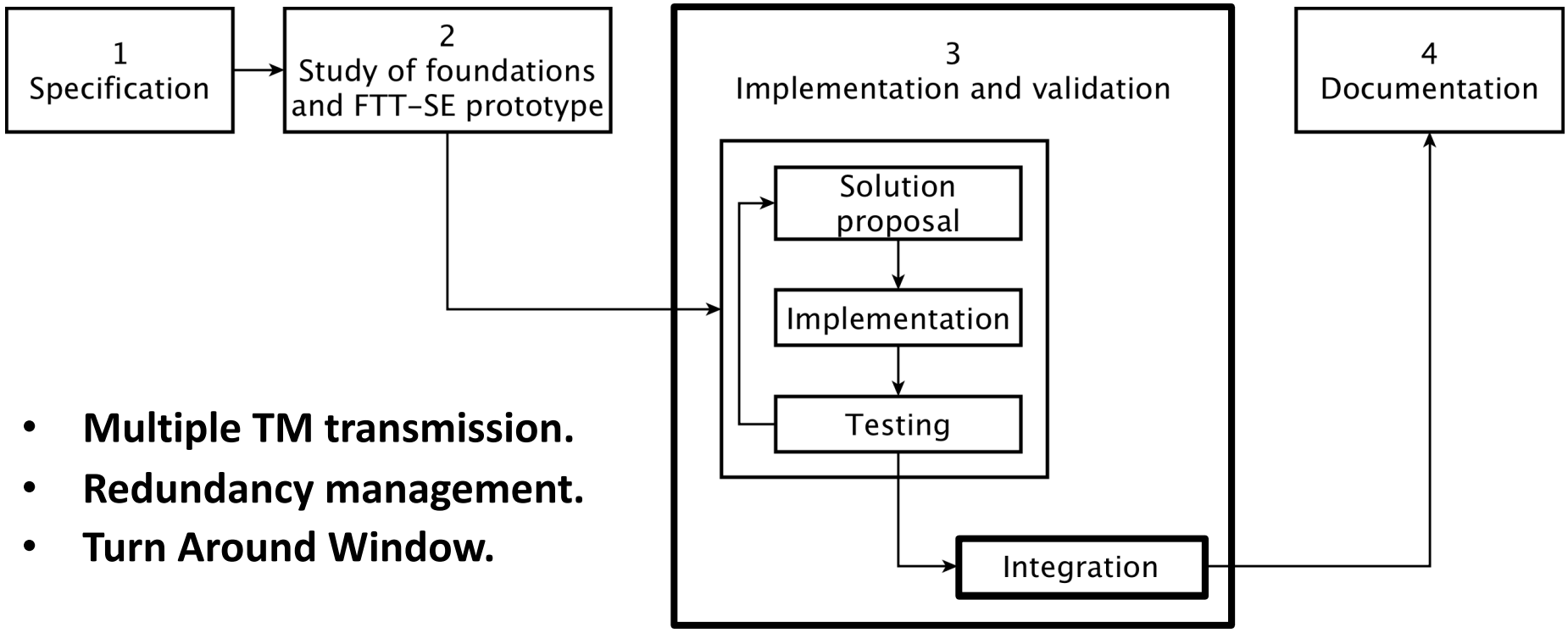

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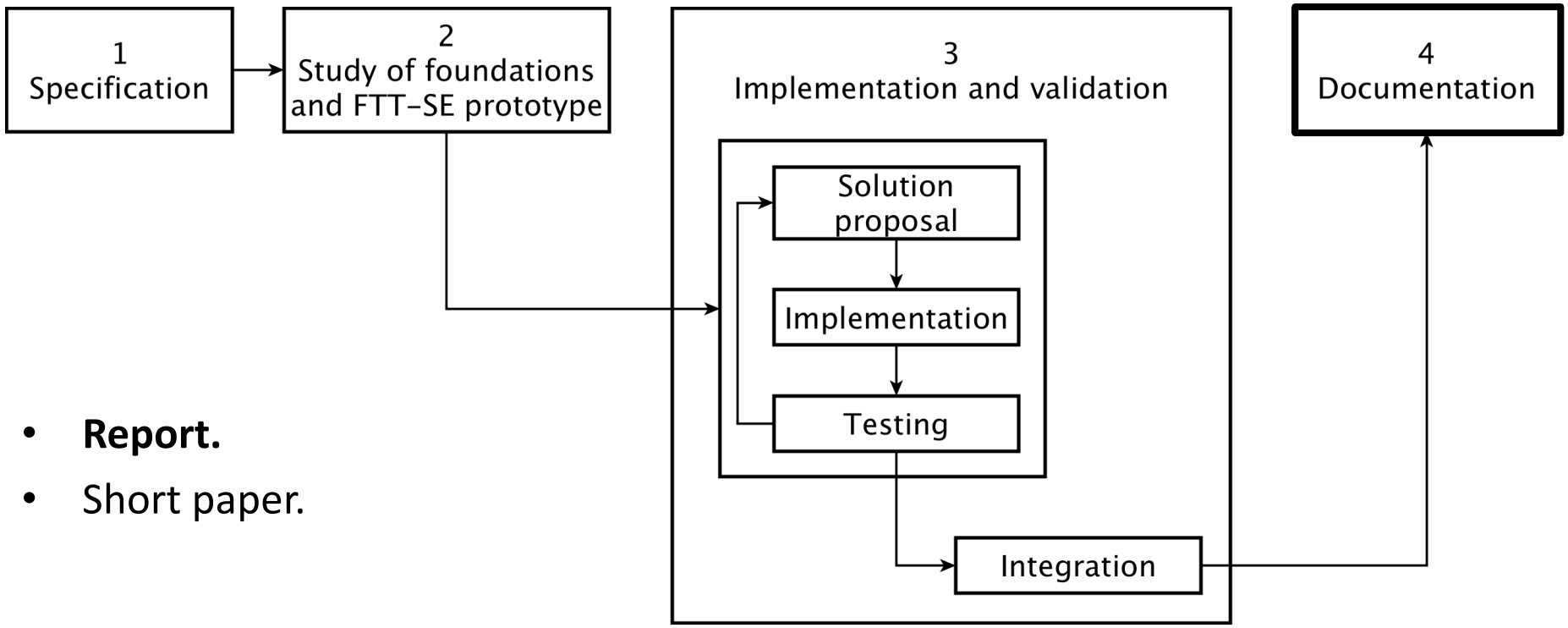
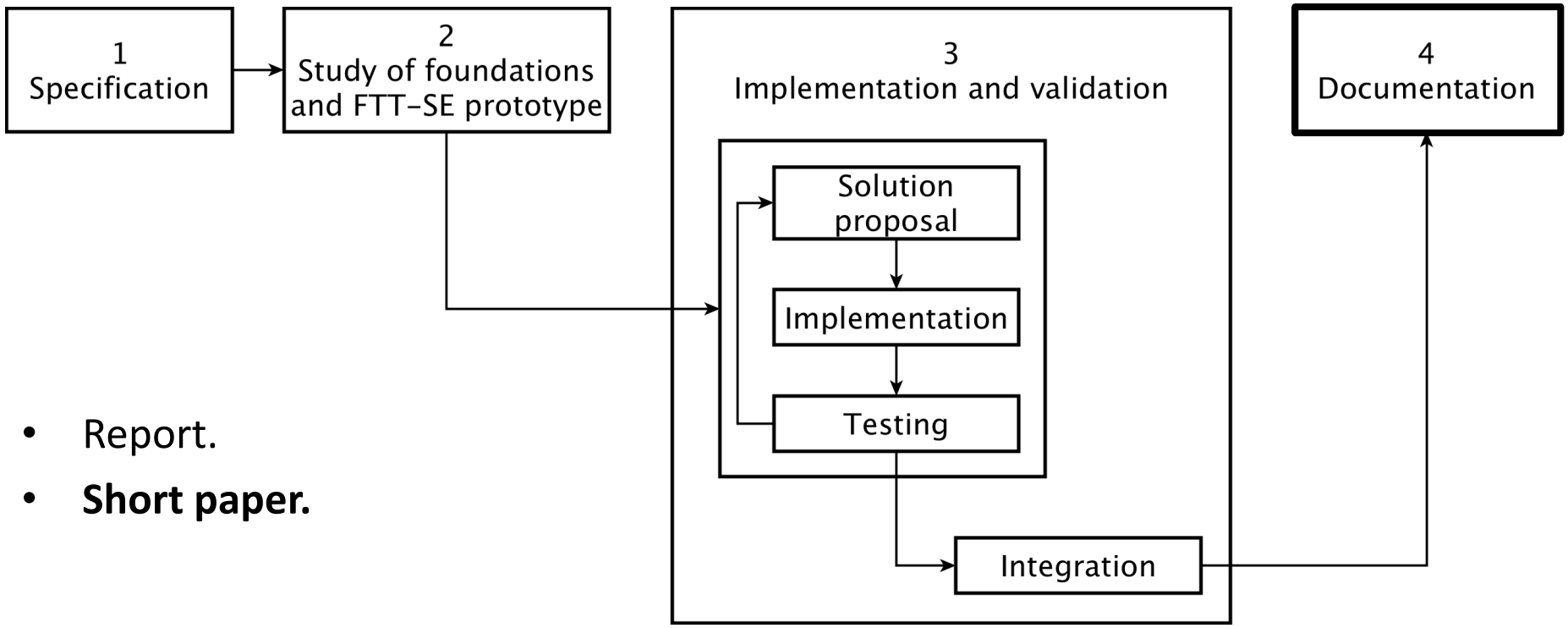


- **Report.**
- Short paper.

Phases of the project



- Report.
- **Short paper.**

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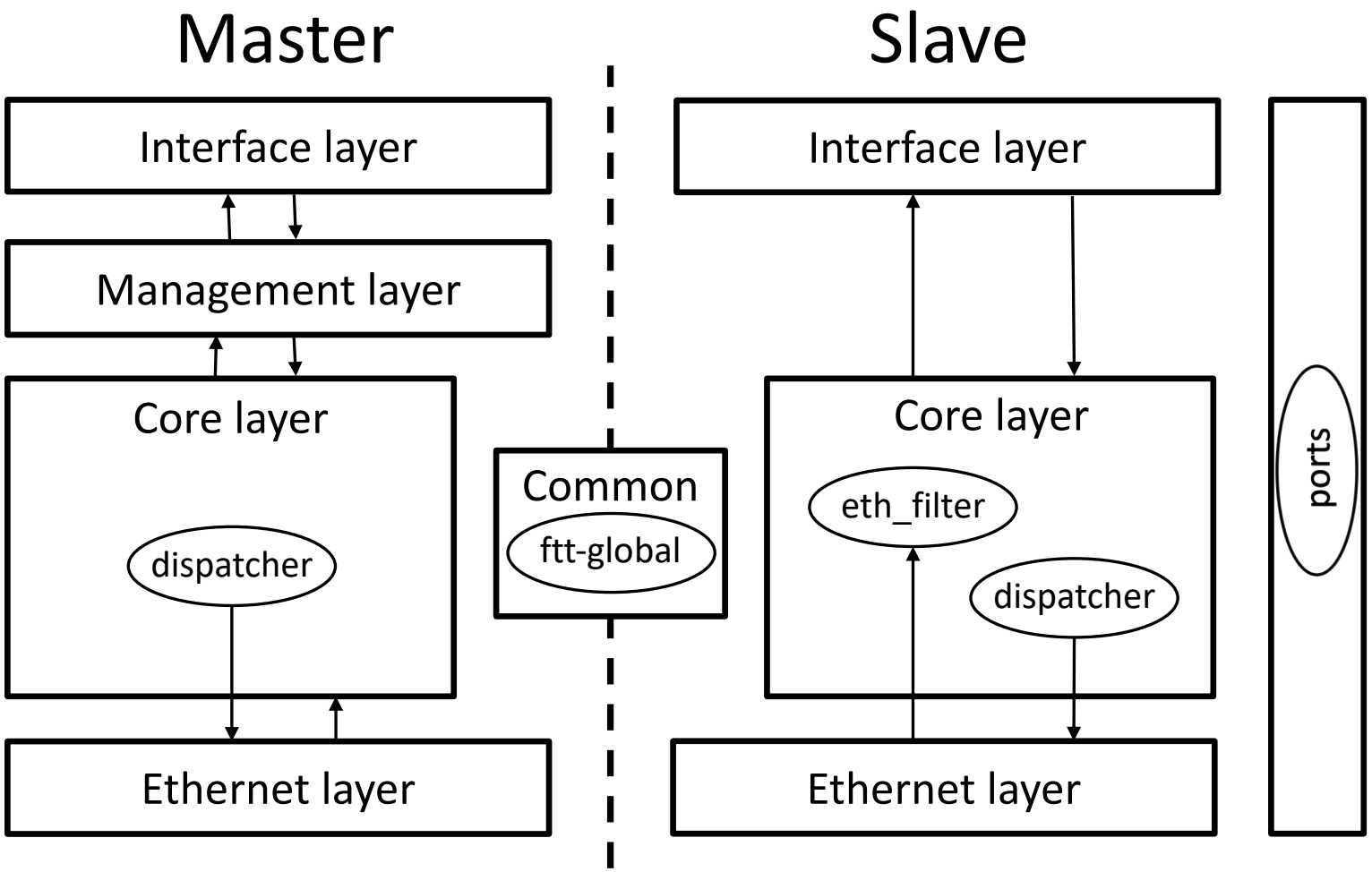

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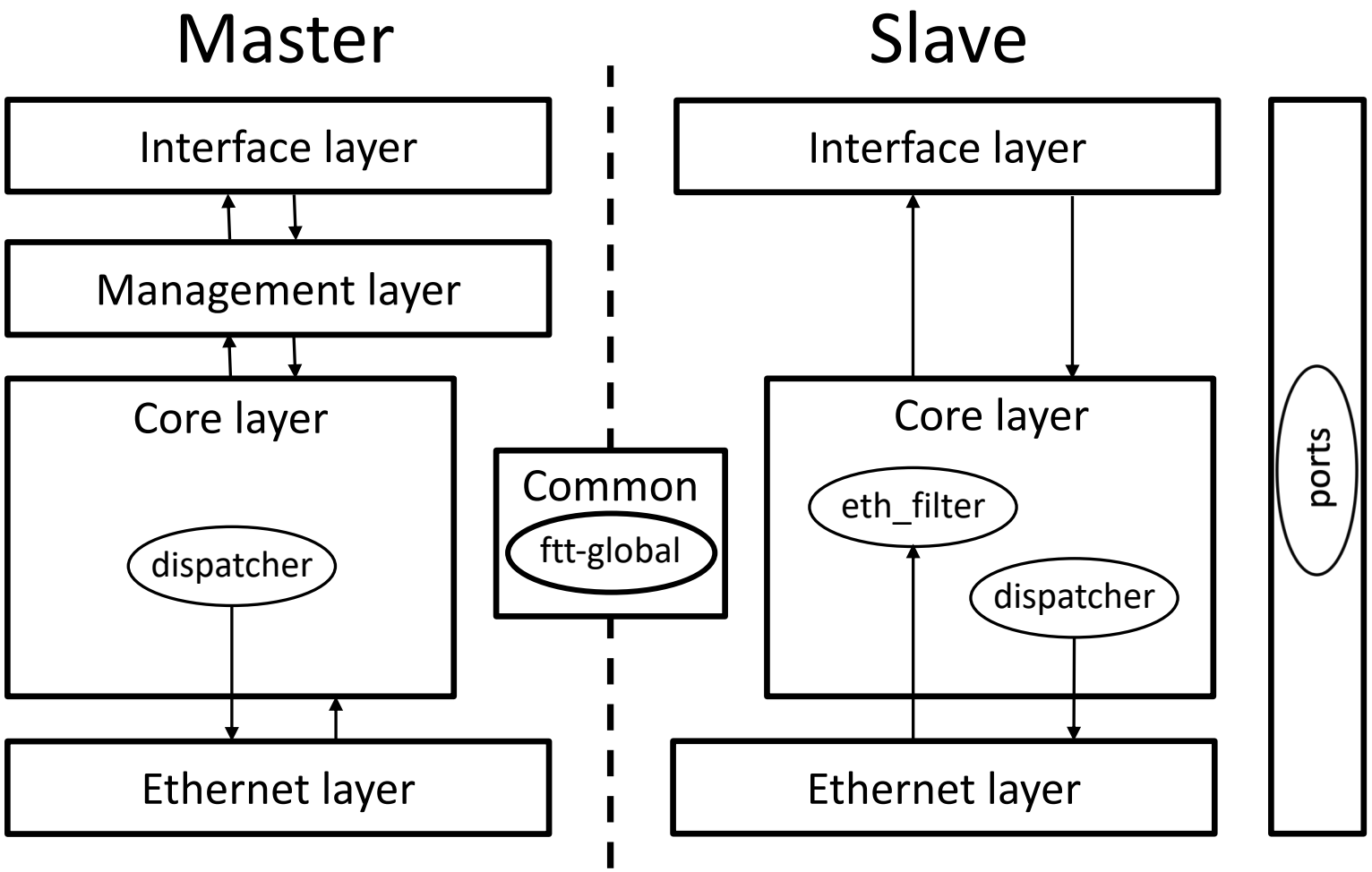

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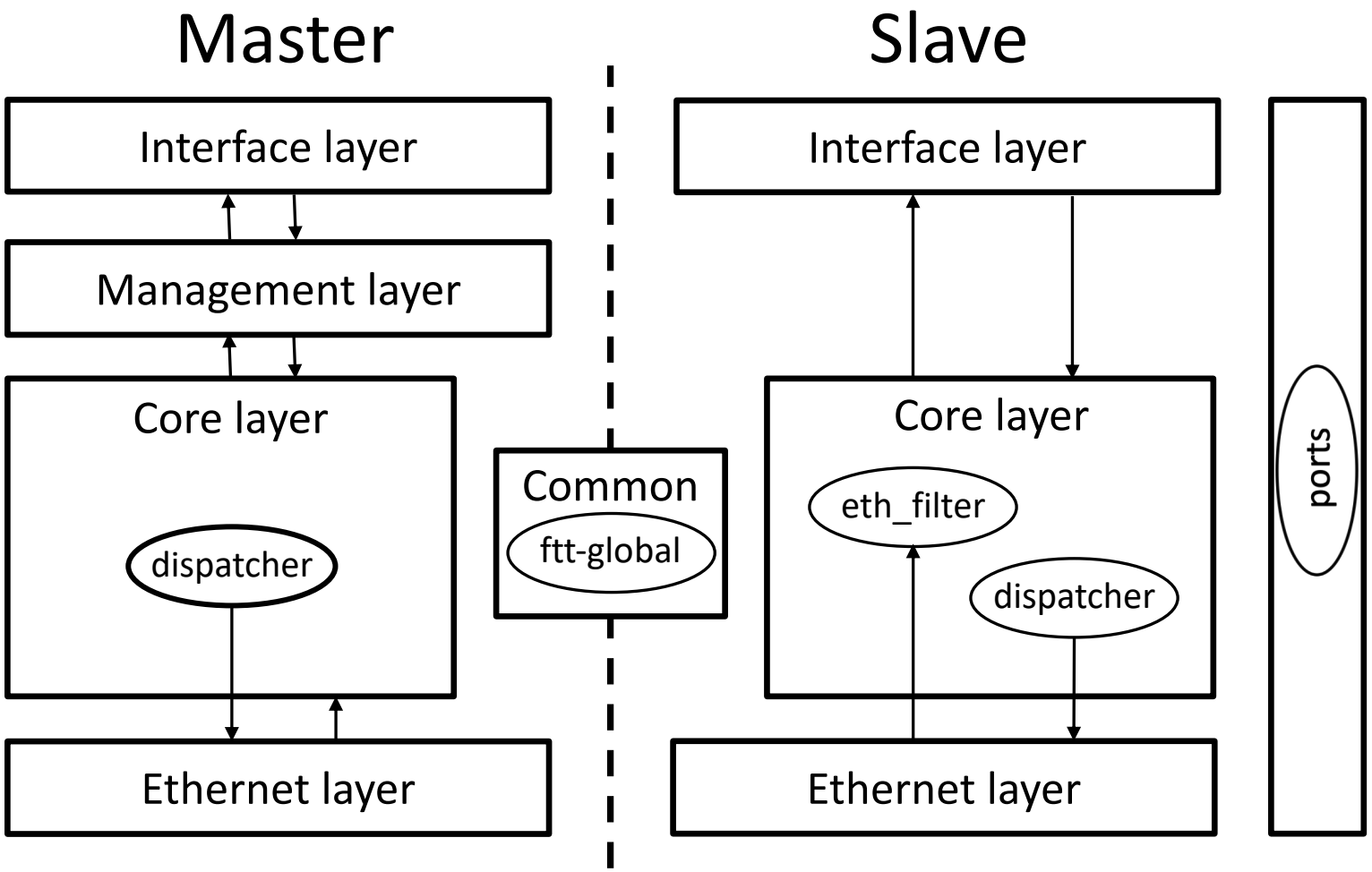

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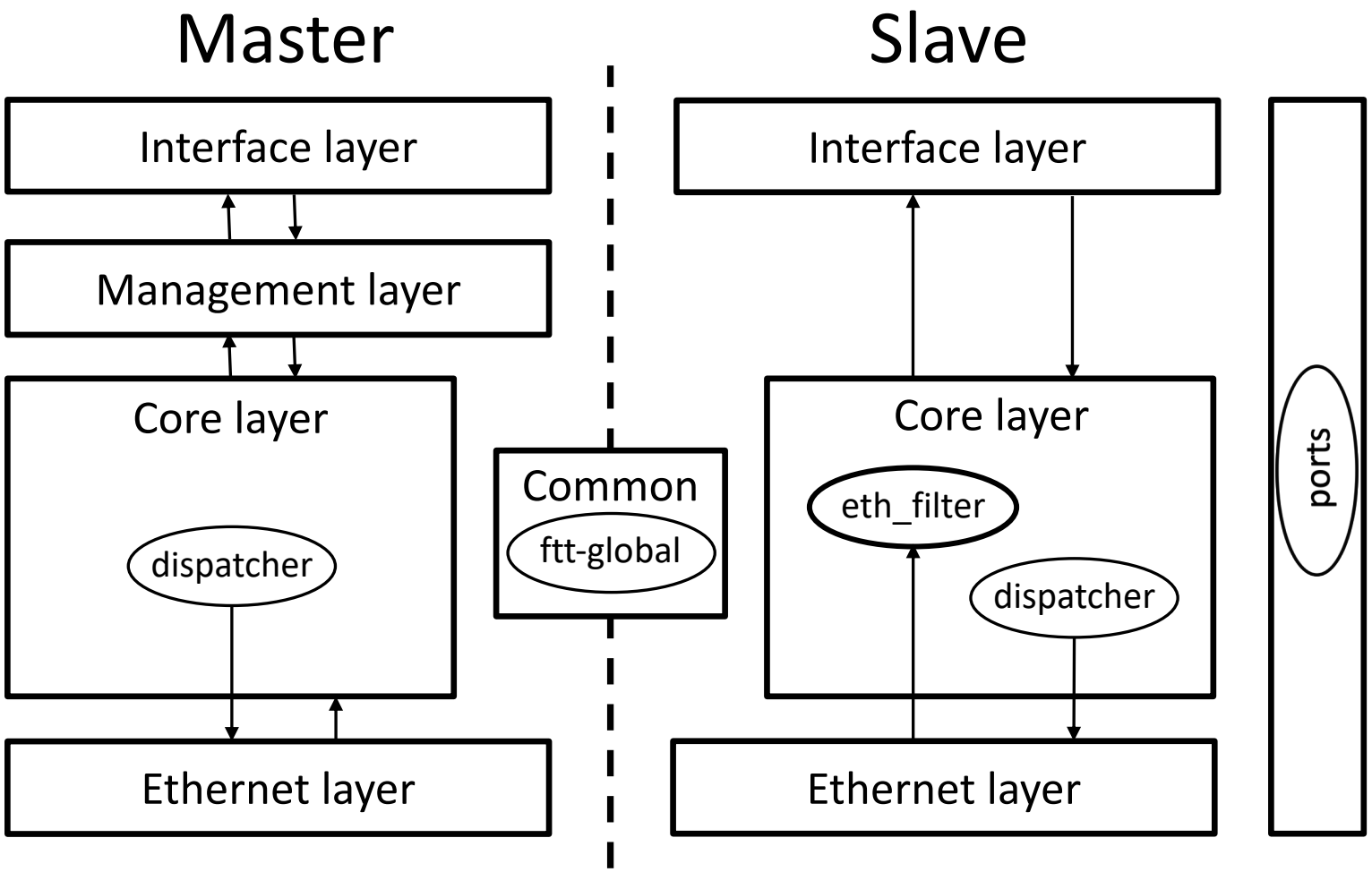

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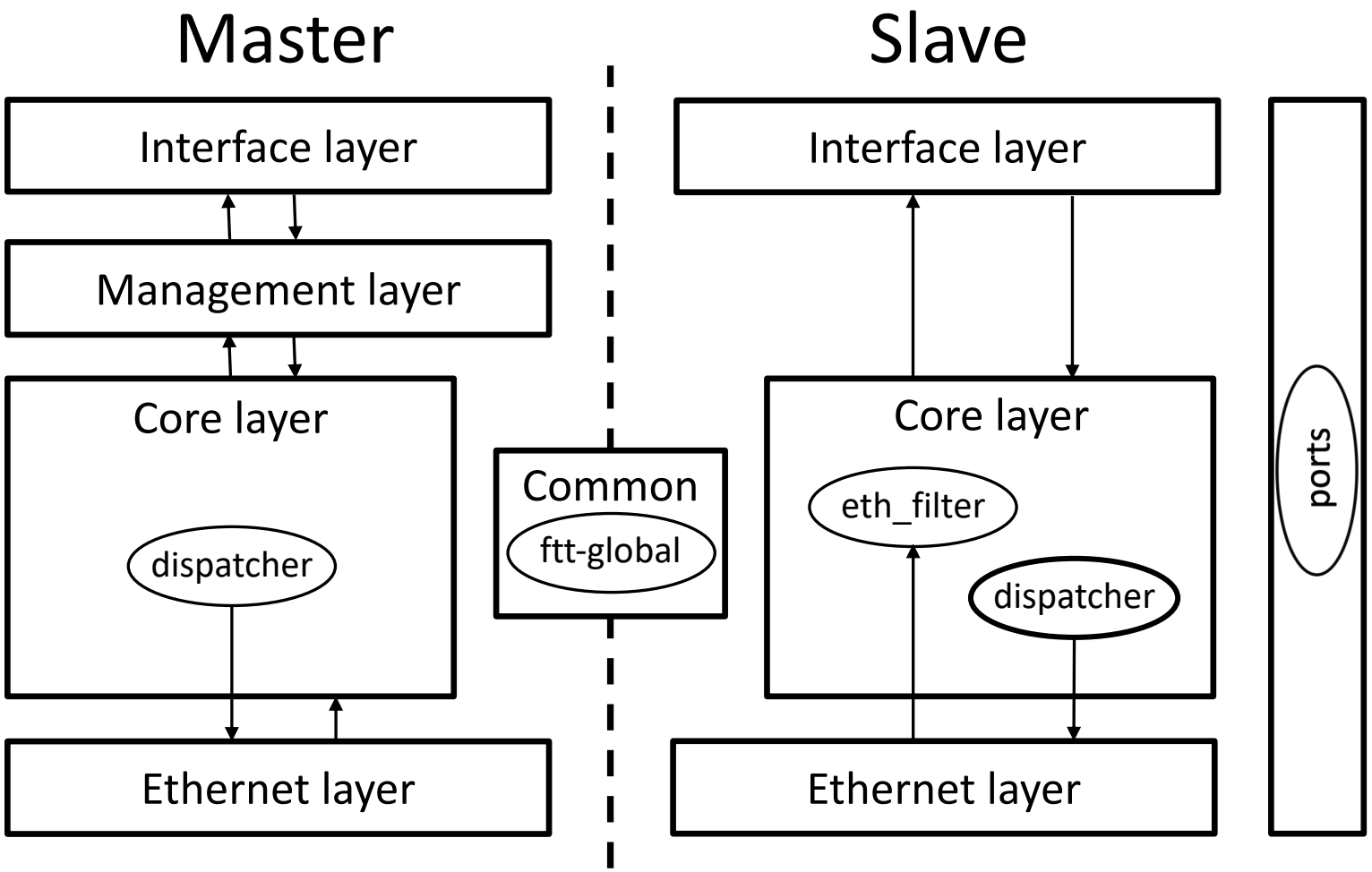

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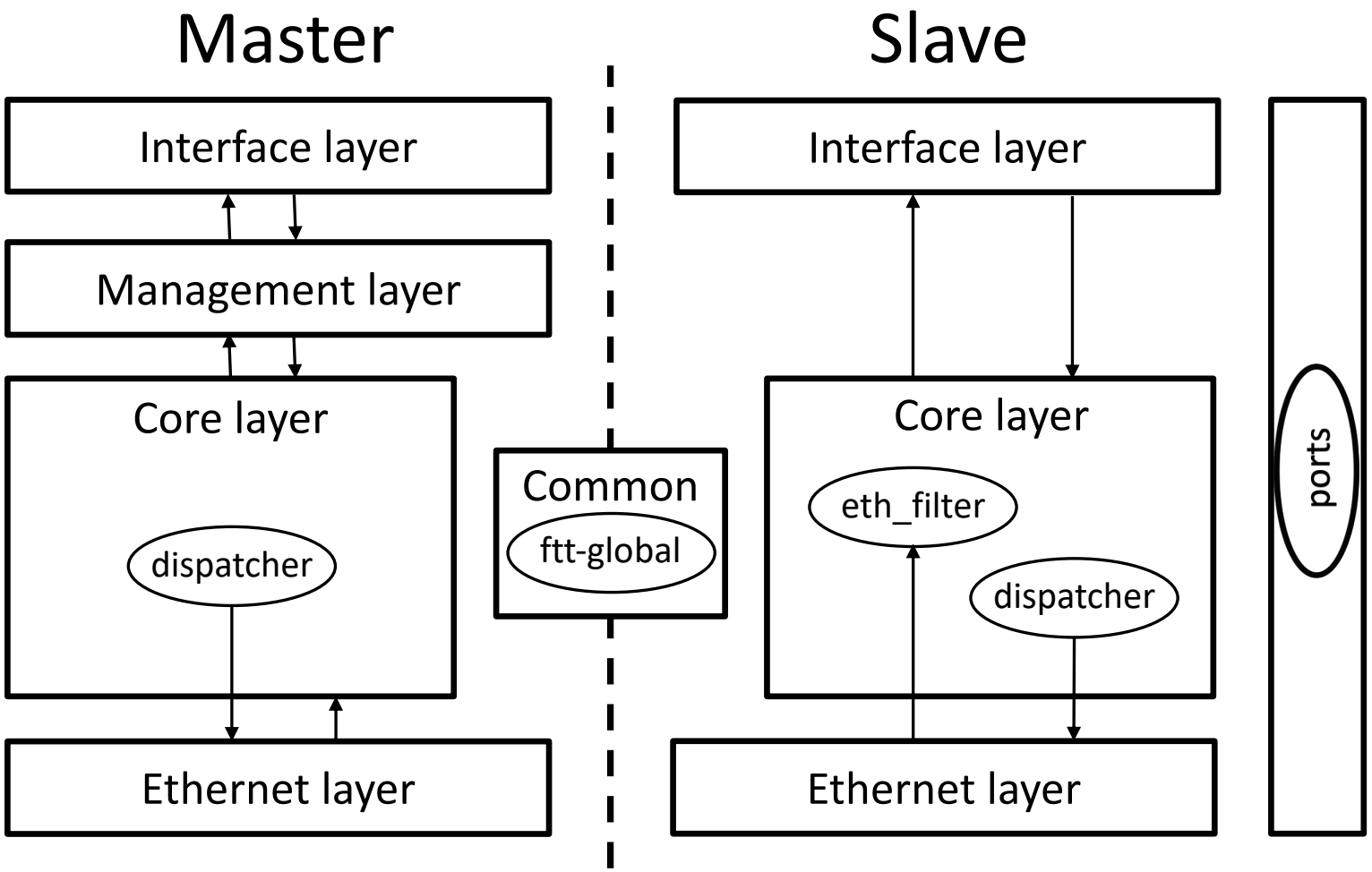

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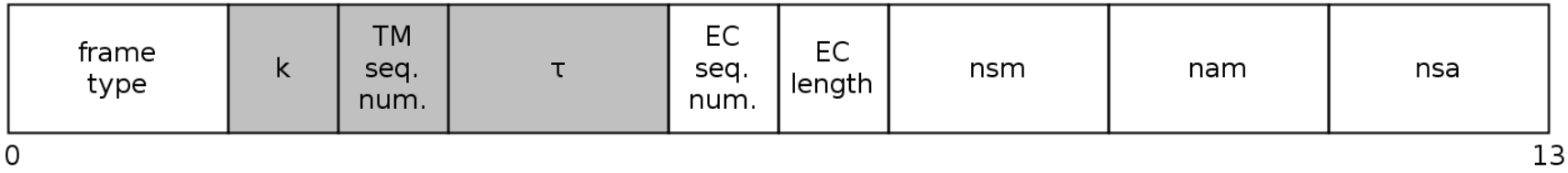
Implementation

Master

– Modify the ftt-global file to add to the TM the information related to the SECSM.



Implementation

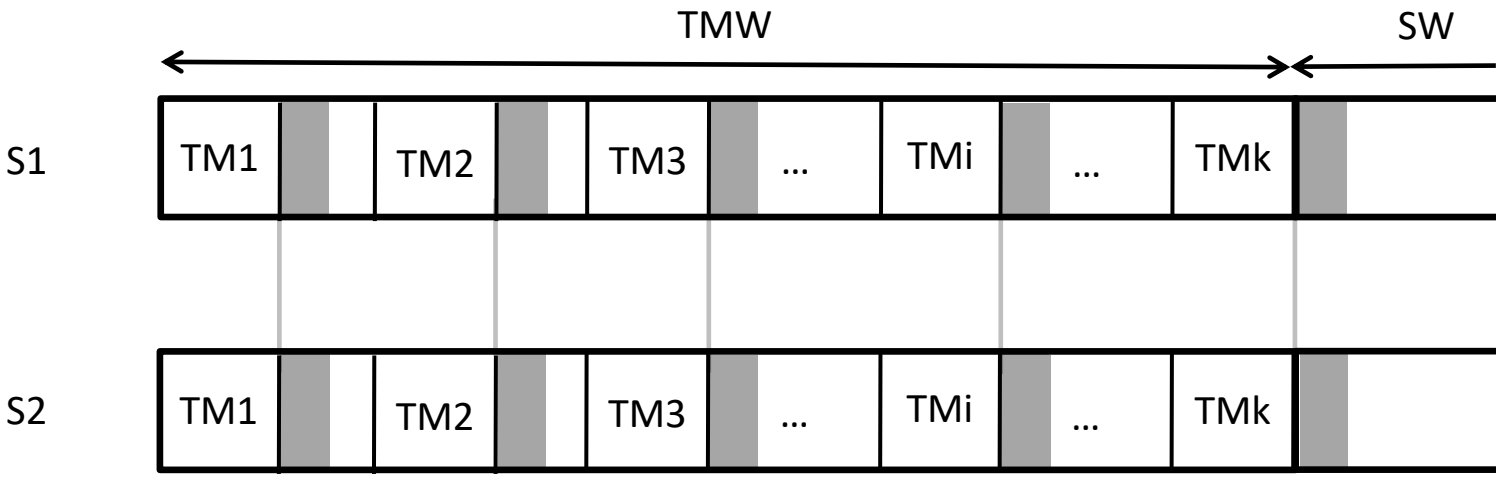
Master

- Modify the master dispatcher file to implement the multiple transmission of the TM:
  - Create and transmit the TM replicas in a loop.
  - Use a busy wait to implement the inter-transmission time.

Implementation

Slave

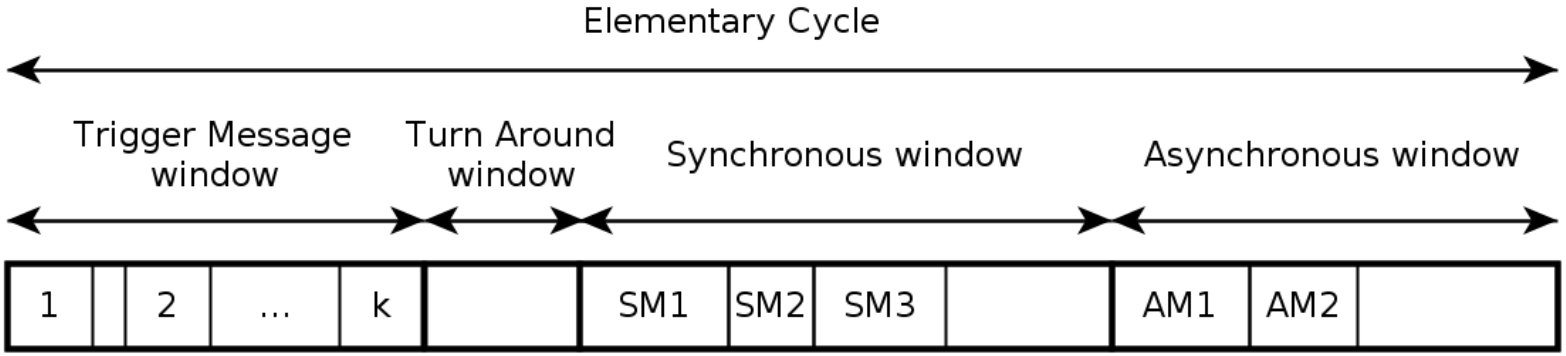
– Slaves need time to process the TM replicas.



Implementation

Slave

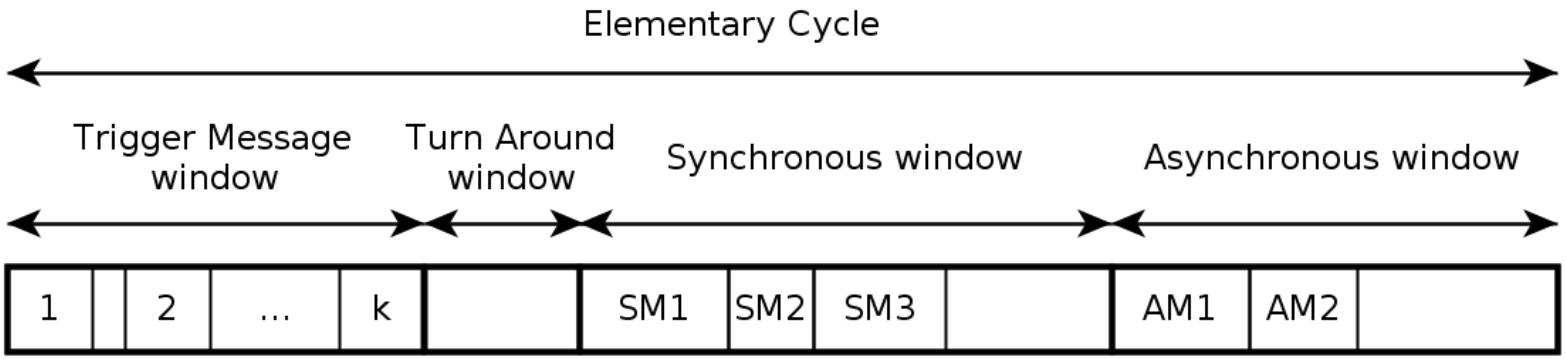
– Propose the modification of the SECSM specification to add the Turn Around Window (TAW).



Implementation

Slave

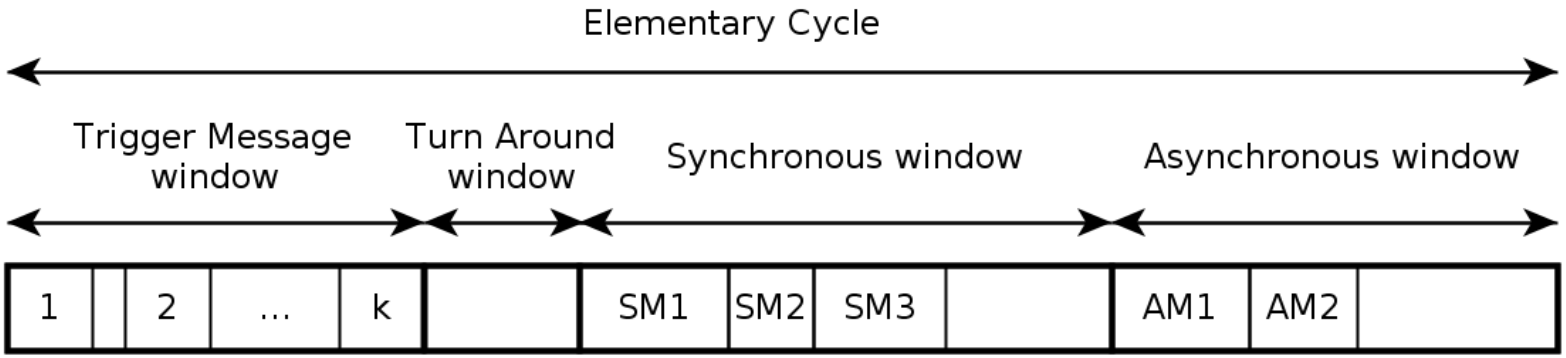
- Modify the slave eth_filter file to:
  - Add the TM redundancy management.



Implementation

Slave

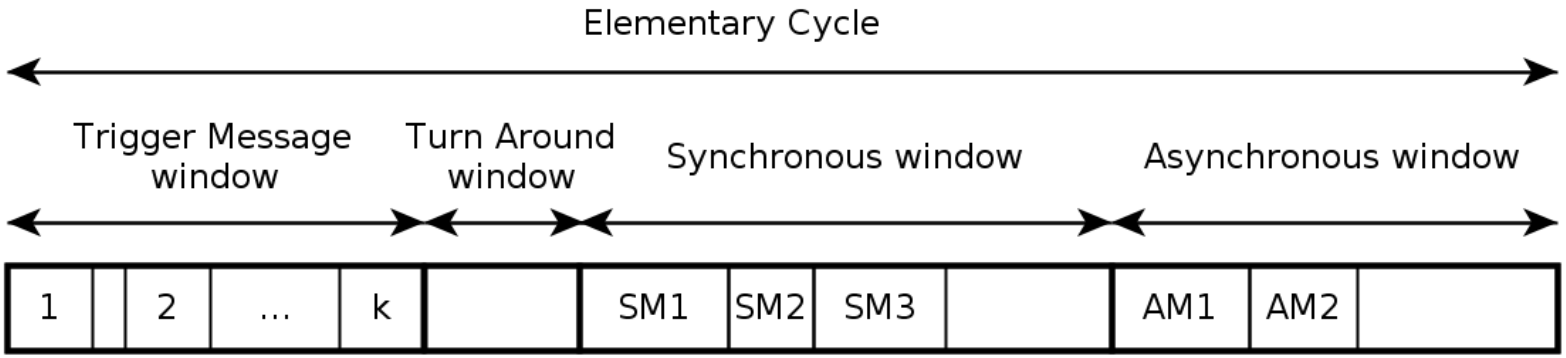
- Modify the slave eth_filter file to:
  - Calculate the end of the TMW from the subset of replicas received.



Implementation

Slave

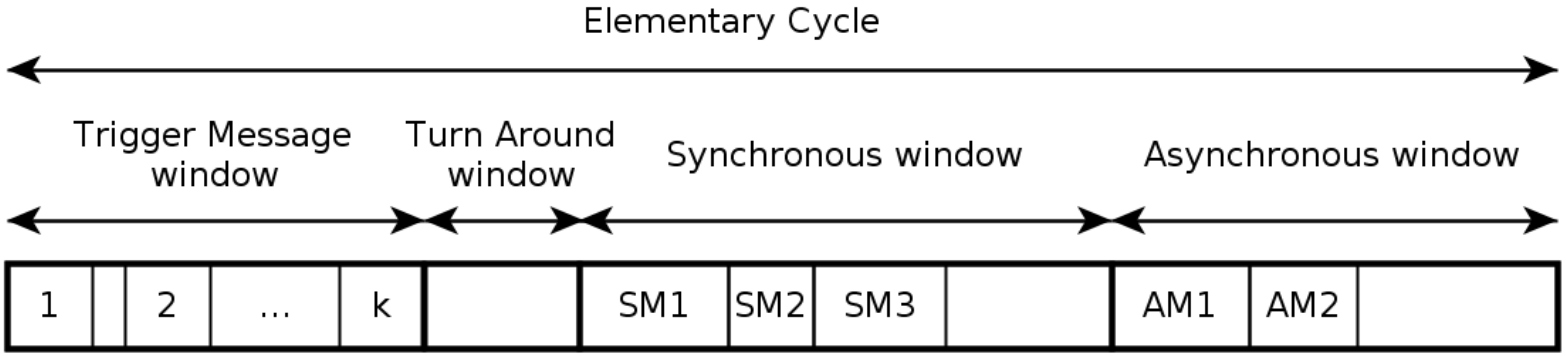
- Modify the slave eth_filter file to:
  - Calculate the end of the EC from the subset of replicas received.



Implementation

Slave

– Modify the slave dispatcher file to add the TAW.



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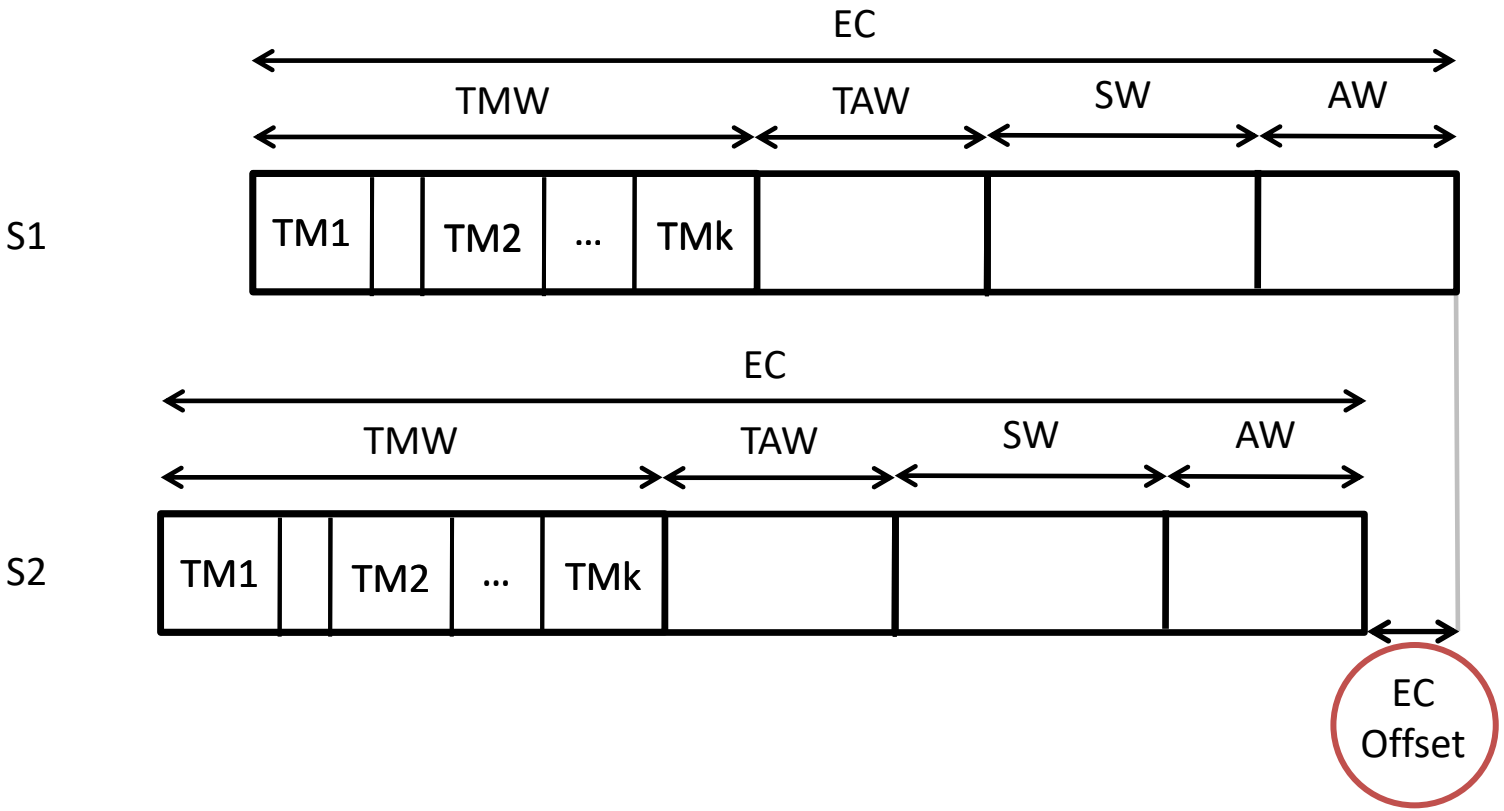
Verification

Measure



Verification

Test

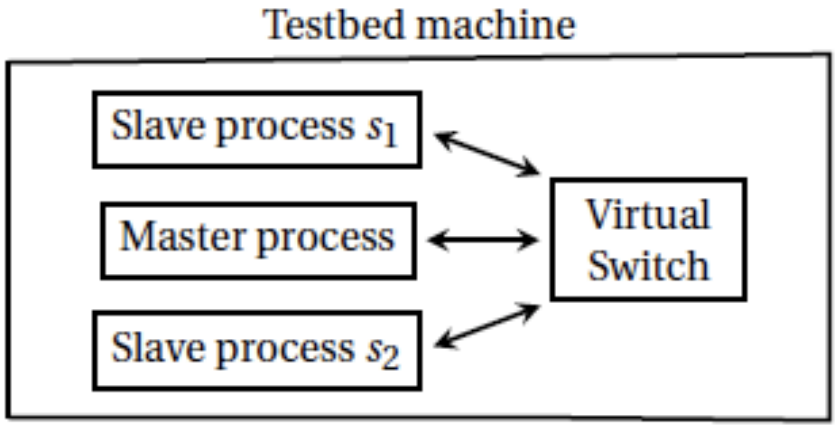
- Test the mechanism in the presence of transient faults.
- Make an exhaustive verification.
  - Test all the possible combinations of TM losses for two slaves and a k = 4.

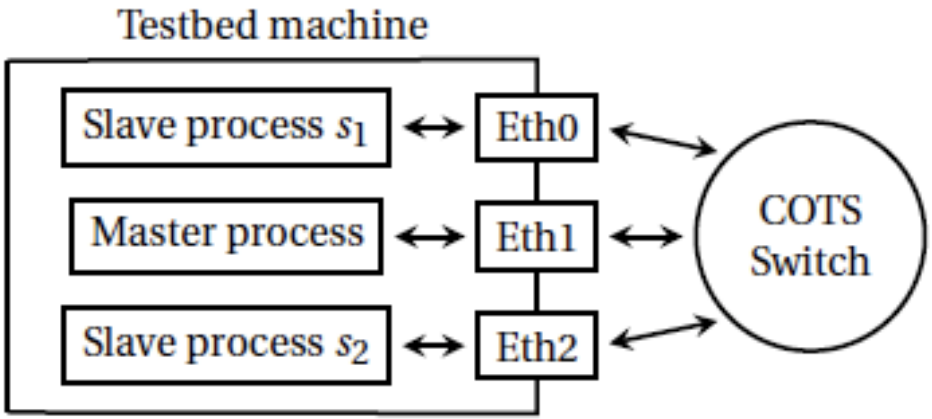
$$\left(\sum_{e=0}^{3}\binom{4}{e}\right)^{2}$$

- Software implemented fault injection (SWIFI).

Verification

Prototypes





Verification

Results

Configuration	Measured EC Offset		
	max (µs)	mean (µs)	std. dev.(µs)
Virtual Switch	47.62	1.94	0.84
COTS Switch	91.37	0.69	1.36

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Conclusions

Summary

- This work is part of the FT4FTT research Project.
- Implementation and validation of the SECSM in the master and the slaves.
- Proposal of modification of the SECSM specification.
- Verification of the integration.
- Writting of a short paper.

Conclusions

Published and presented conference paper

Gessner, D., Álvarez, I., Ballesteros, A., Barranco, M., Proenza, J., *Towards an Experimental Assessment of the Slave Elementary Cycle Synchronization Mechanism in the Flexible Time-Triggered Replicated Star for Ethernet*. In Proc. 19th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), September 16-19, 2014, Barcelona, Spain.

Conclusions

Future work

- Implement each slave in a different machine.
- Integrate the SECSM implemented with the rest of the FTTRS architecture.
- Adapt the available FTT-SE code to work with the Xenomai Linux kernel.

Implementation and Verification of the Slave Elementary Cycle Synchronization Mechanism of the Flexible Time-Triggered Replicated Star for Ethernet

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