OSPERT'15

A New Configurable and Parallel Embedded Real-time Micro-Kernel for Multi-core platforms

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ULB HIPPEROS MangoGem

GOALS

Produce safe and reliable embedded software systems

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MEANS

R&D: experimental platform
→ new kernel architecture

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Produce safe and reliable embedded software systems

MEANS

R&D: experimental platform

→ new kernel architecture

Research: validate good results experimentally

CONSTRAINTS

CONSTRAINTS

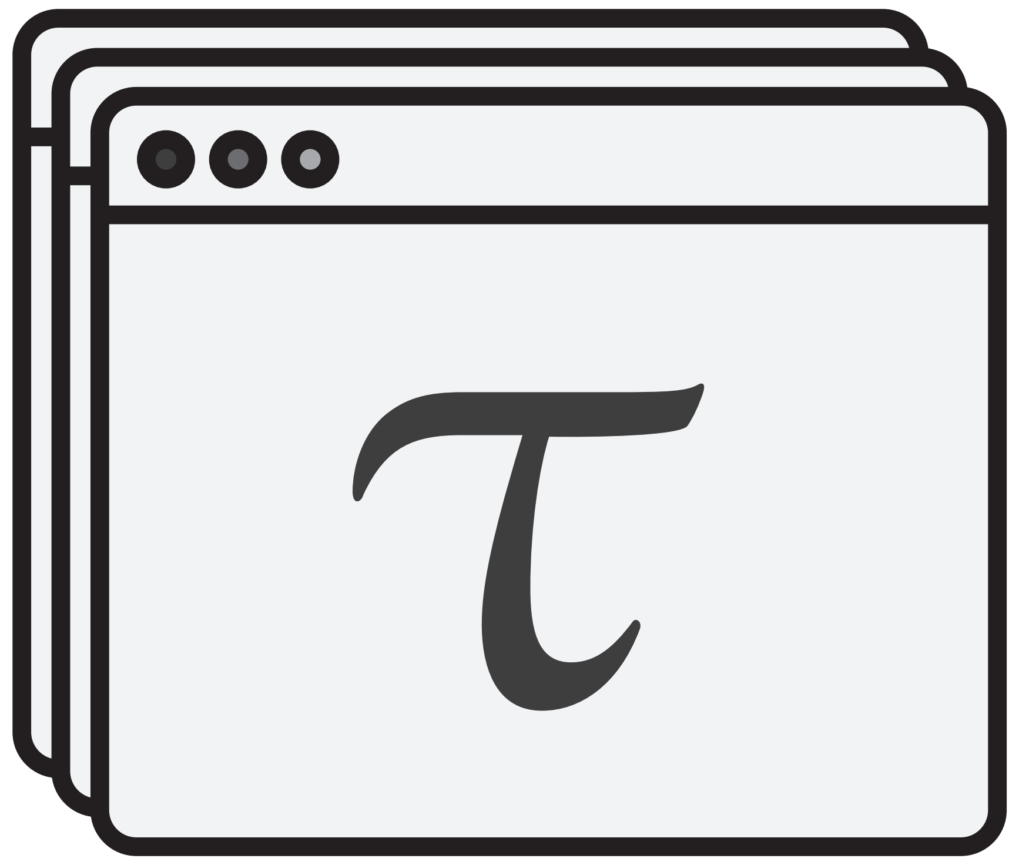
🕒 Real-time

CONSTRAINTS

- Real-time
- Embedded

CONSTRAINTS

- Real-time
- Embedded
- Certifiable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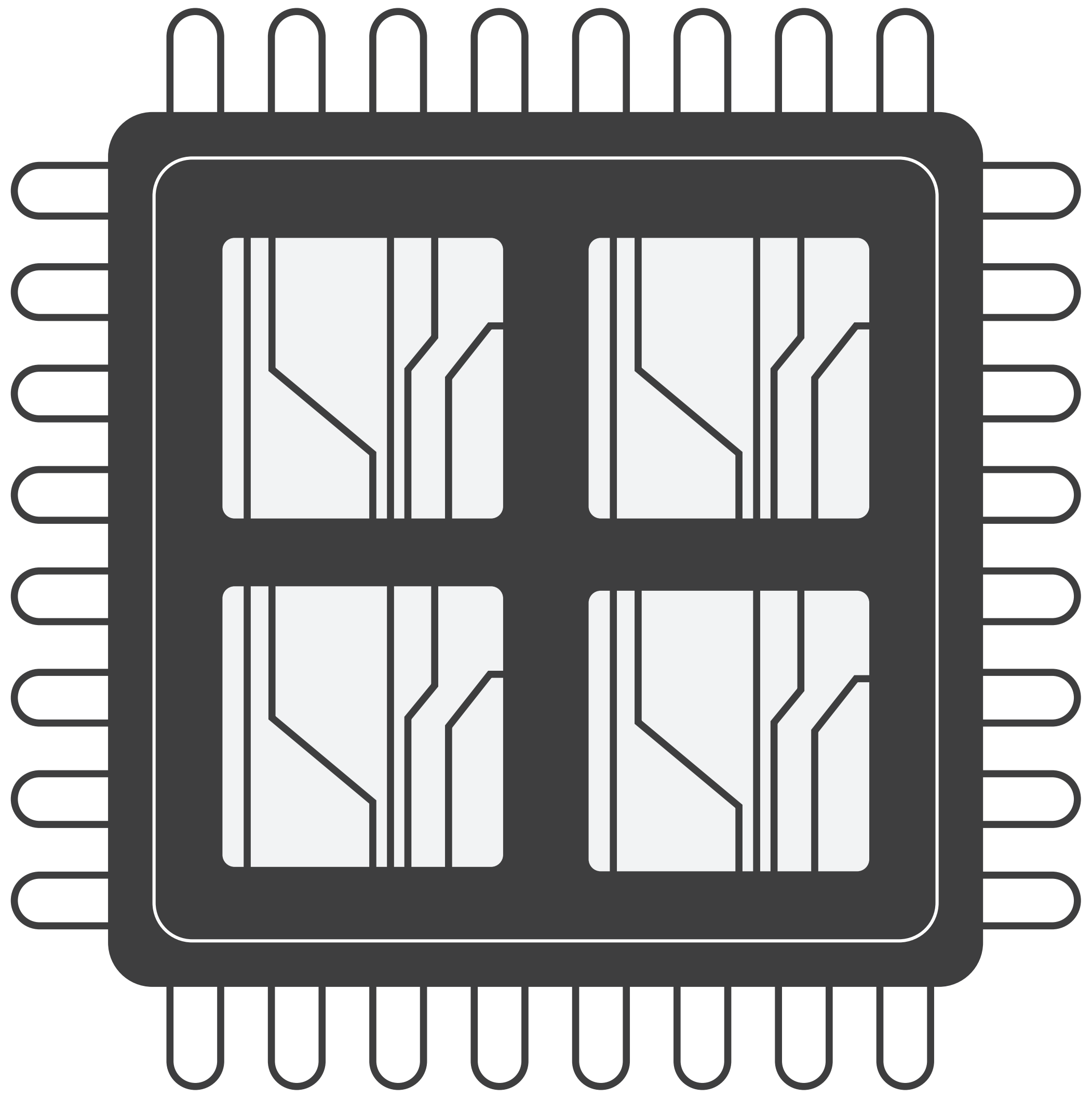
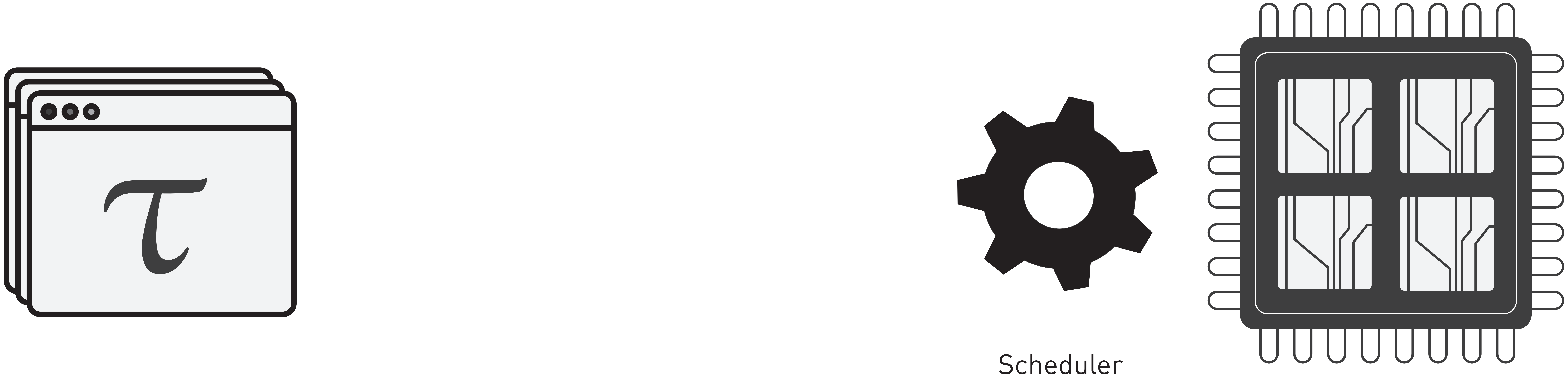




Scheduler

Cores

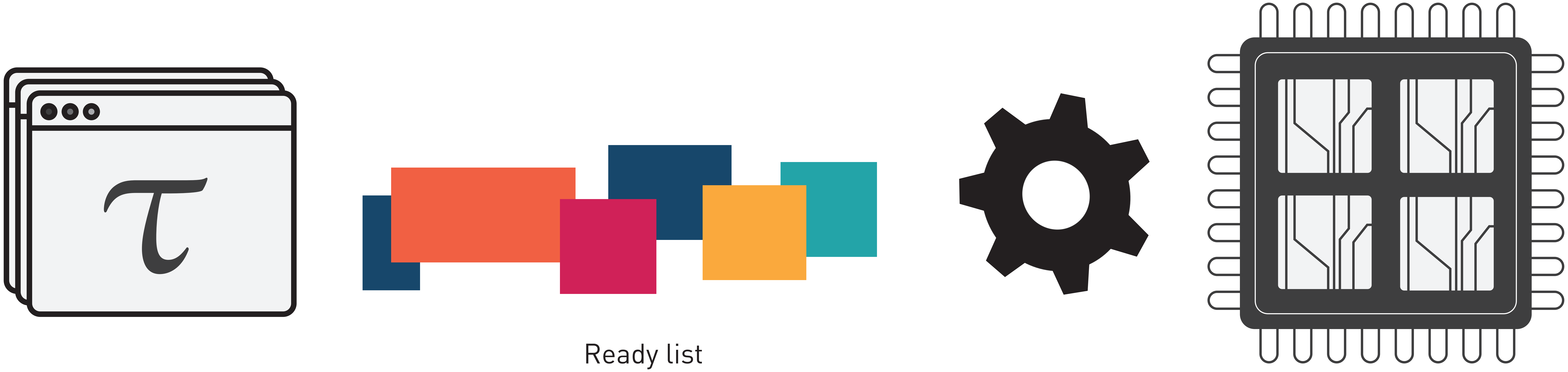
τ

τ

τ

τ

τ


Ready list

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τ

τ

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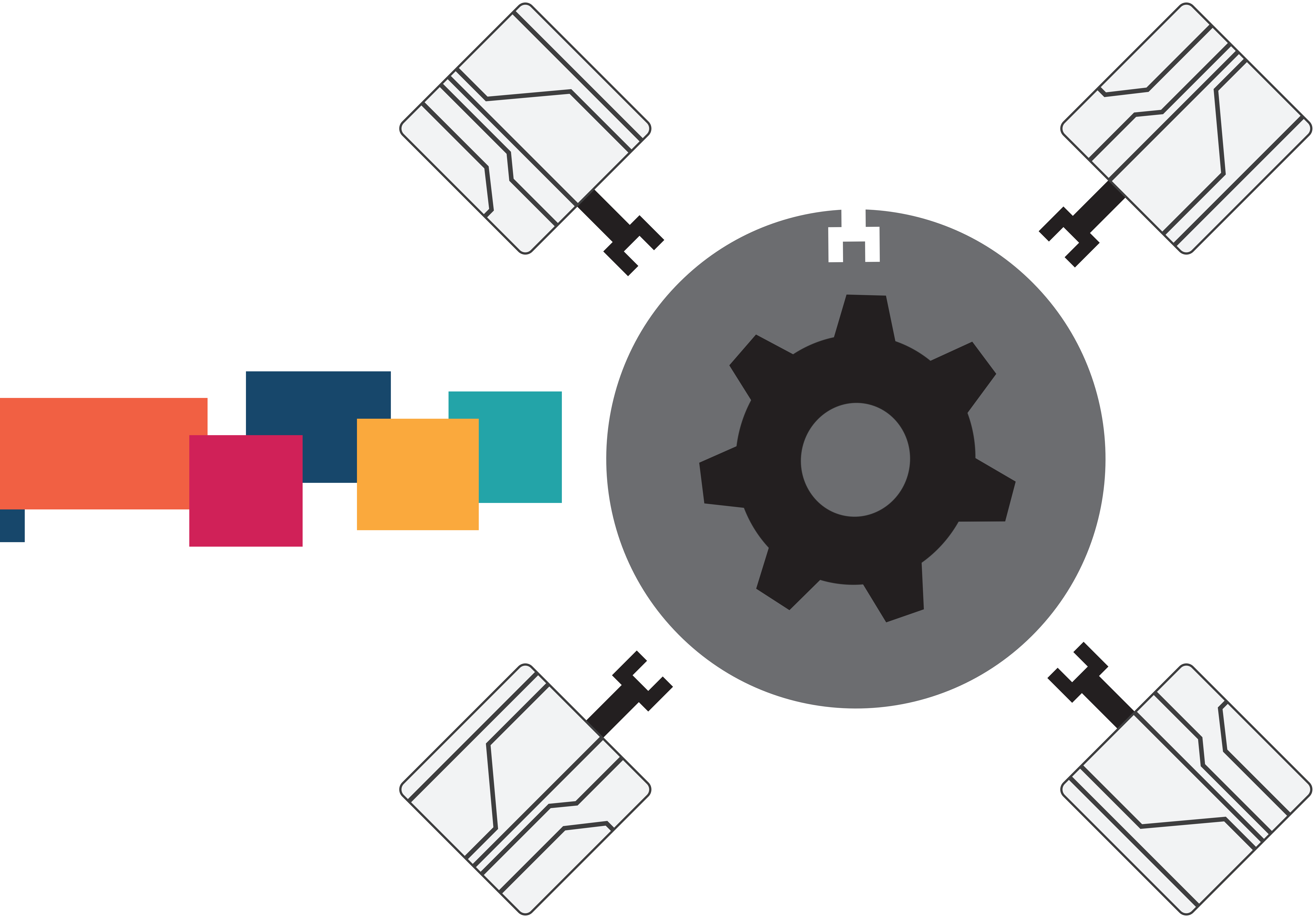
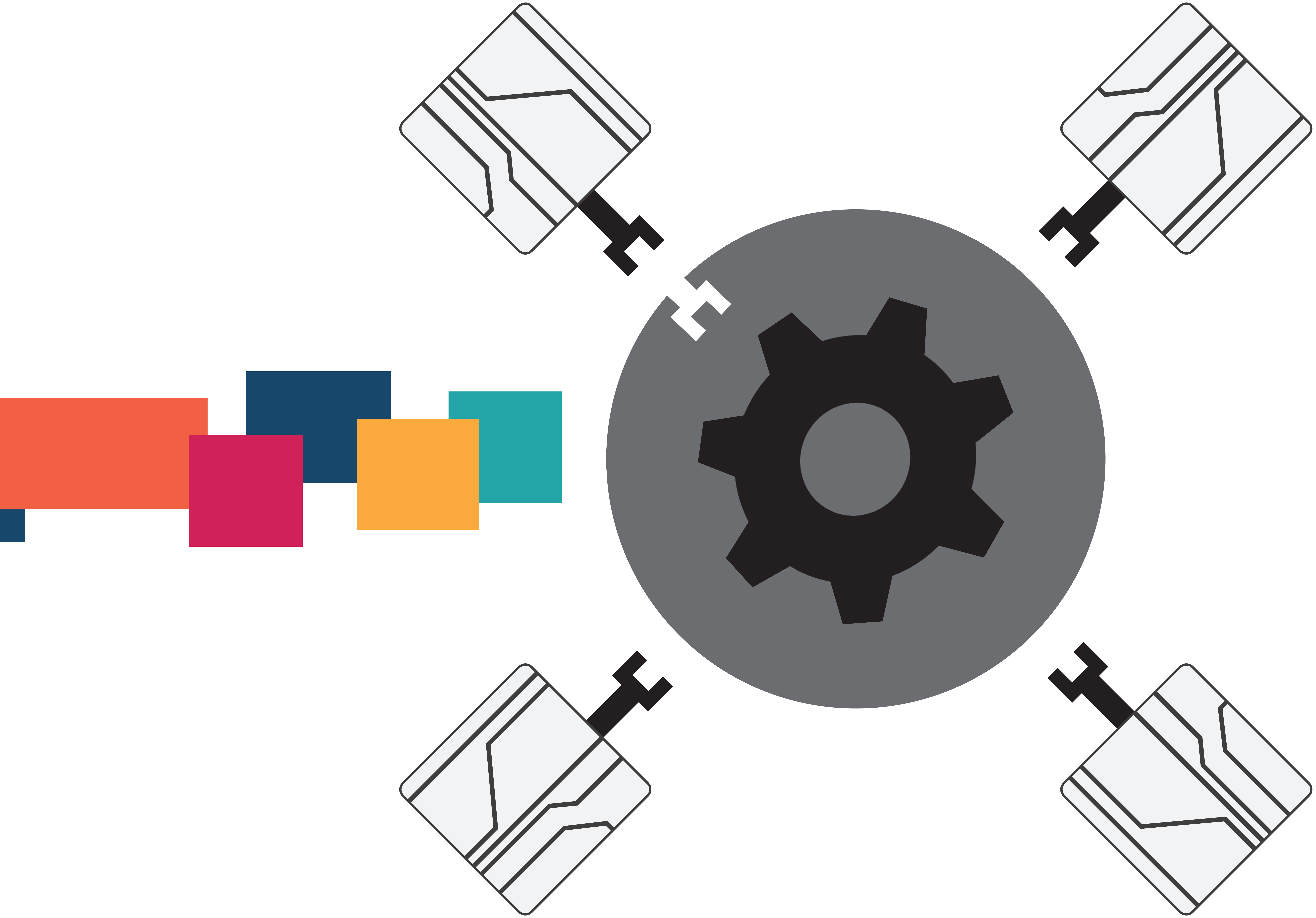
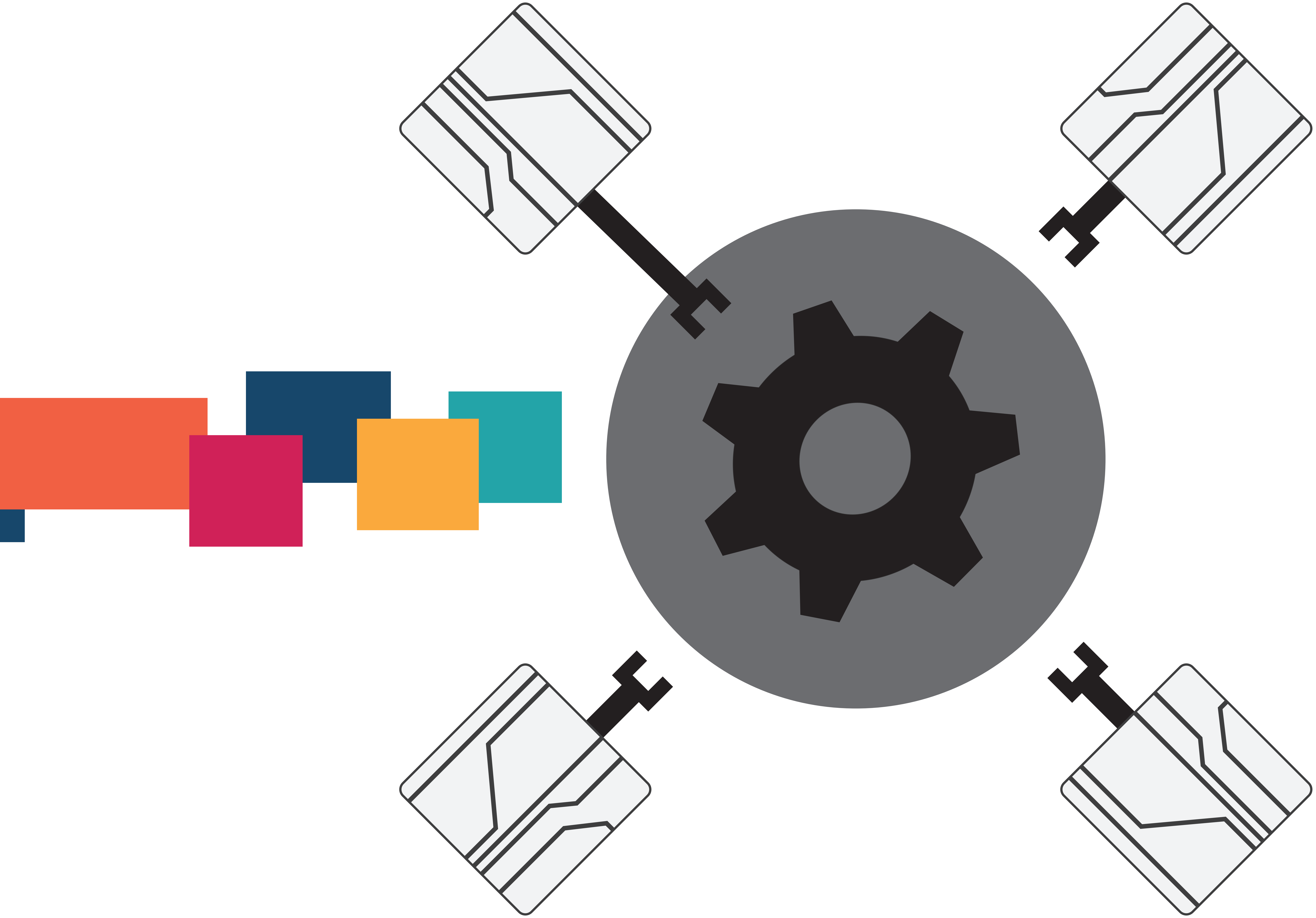
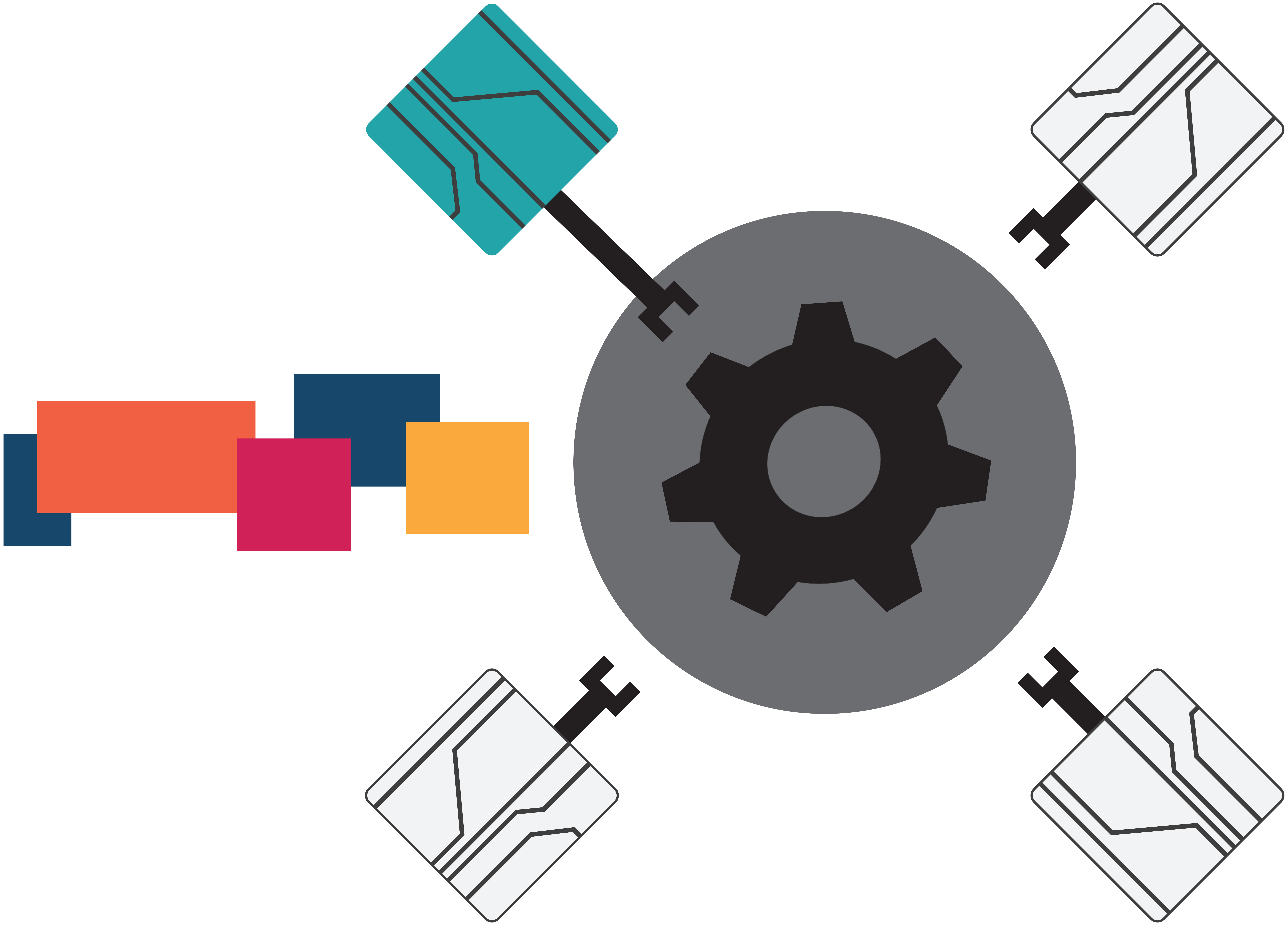
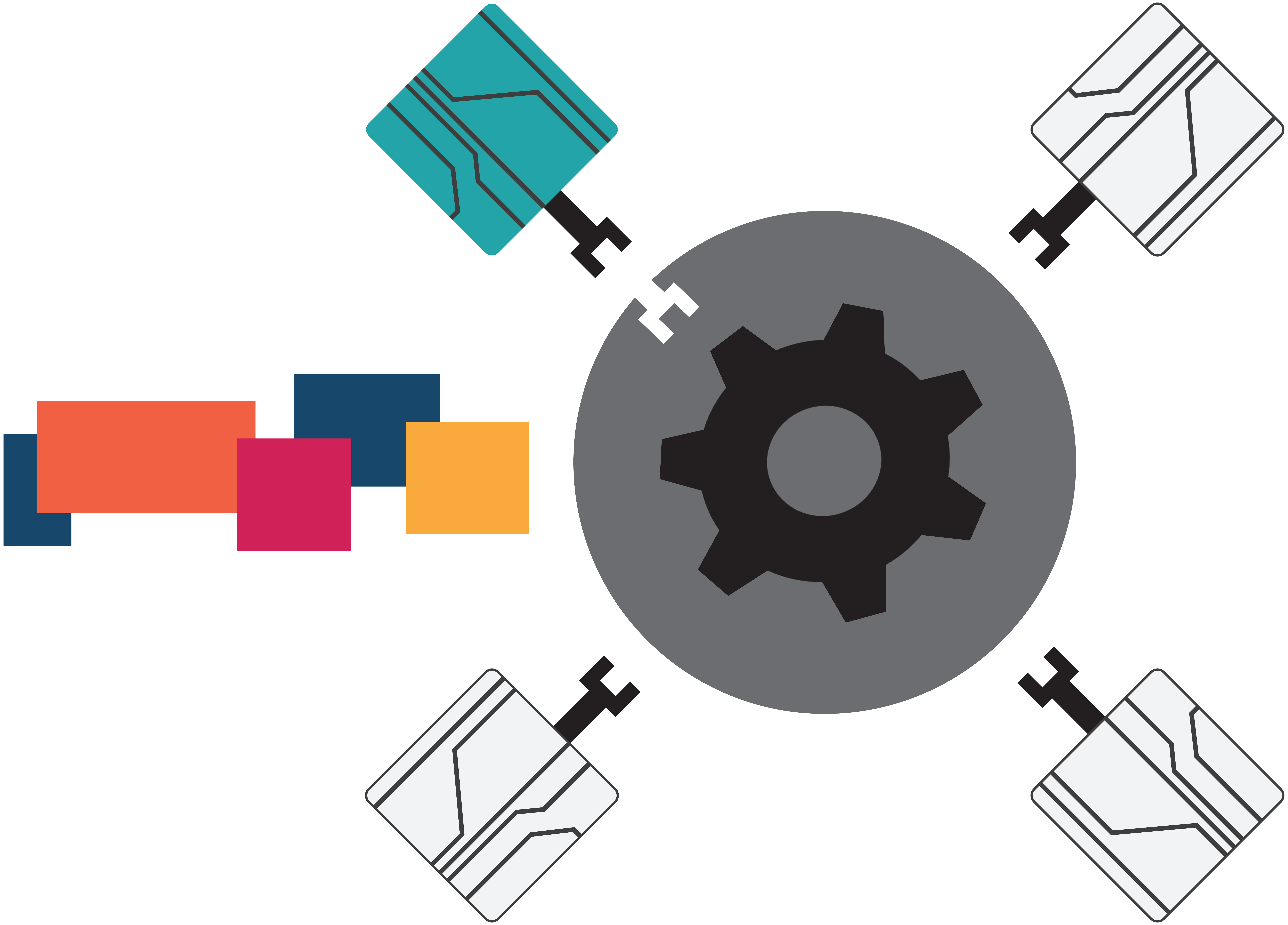
The symmetric approach

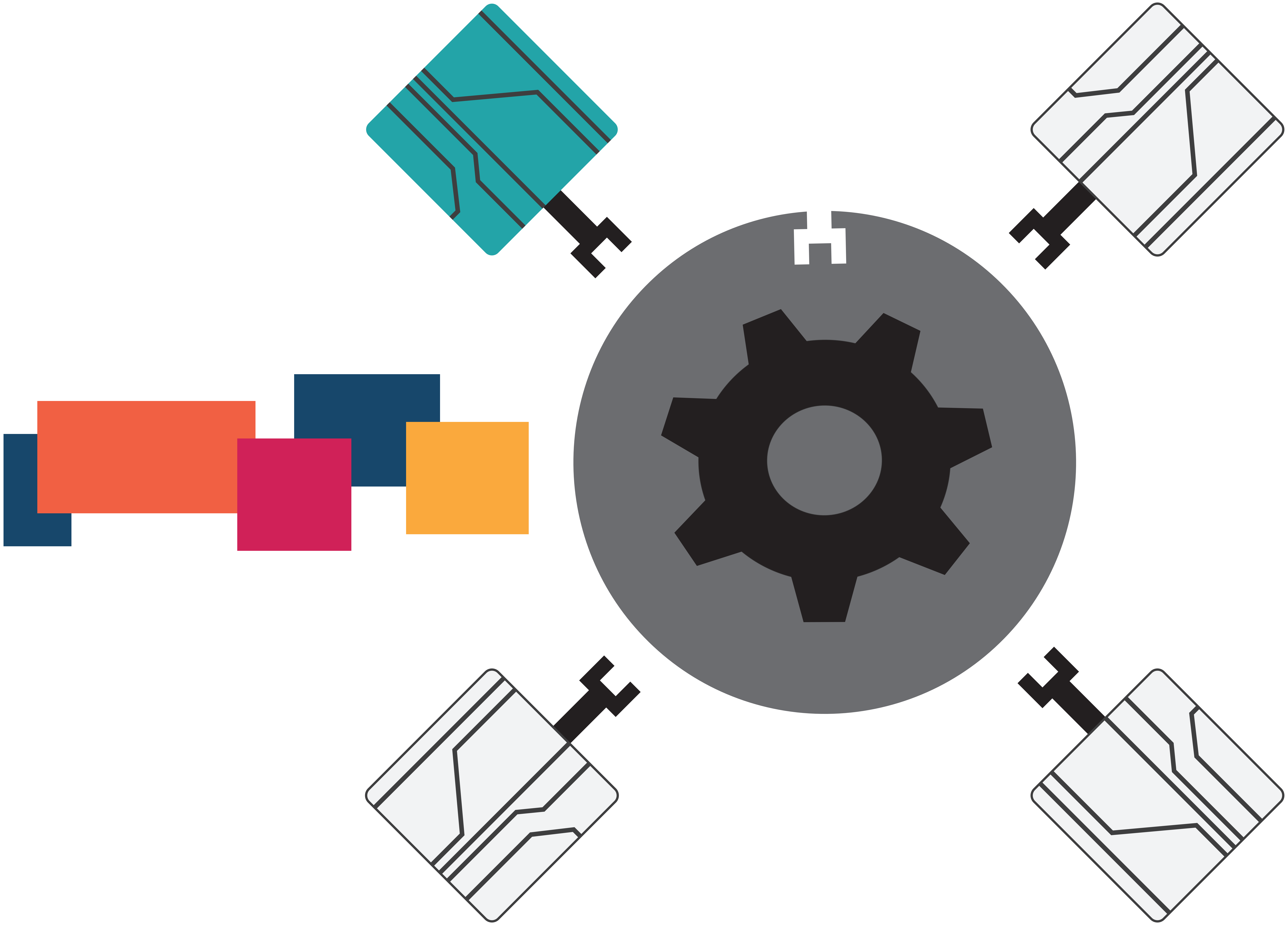


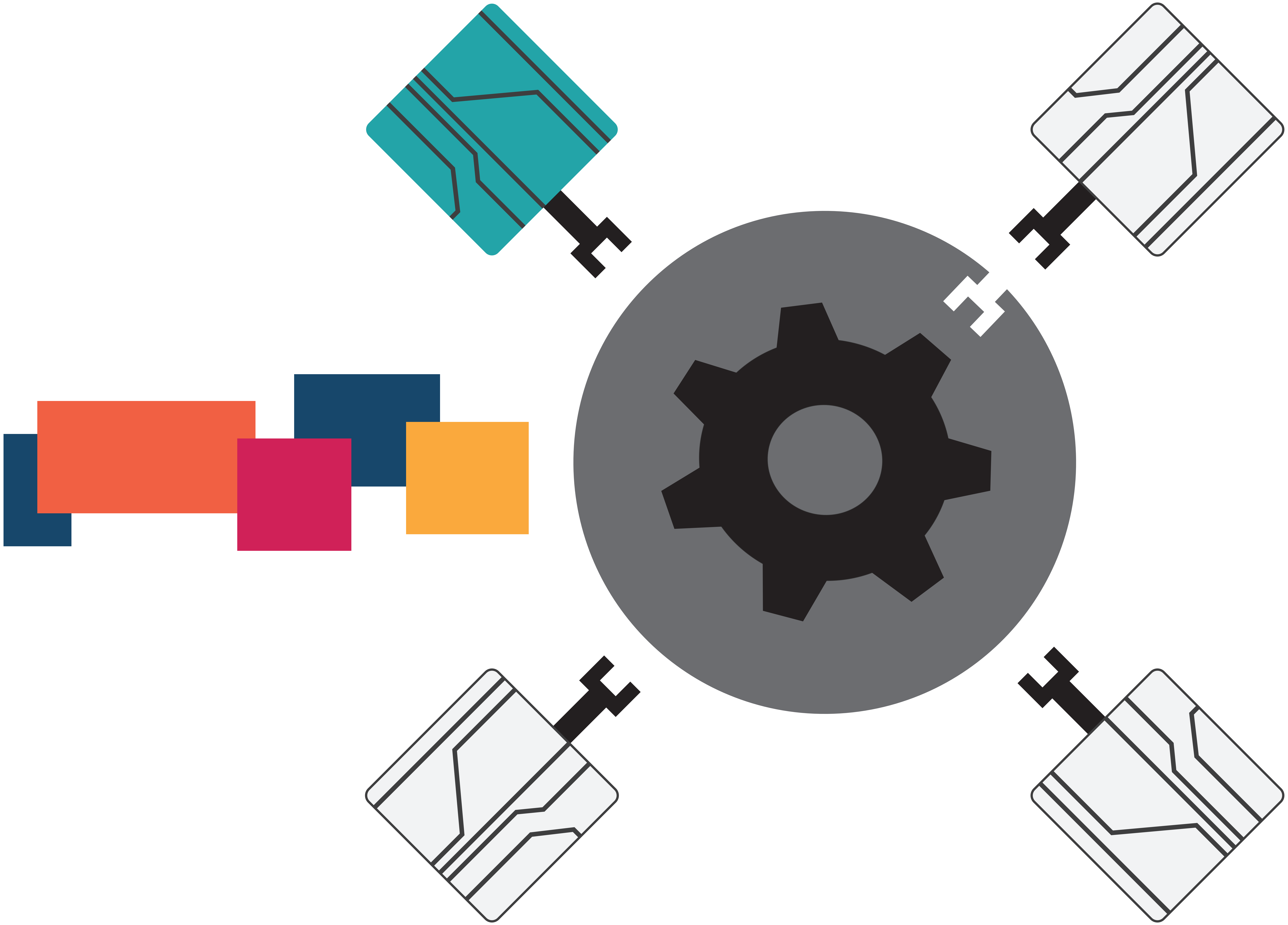


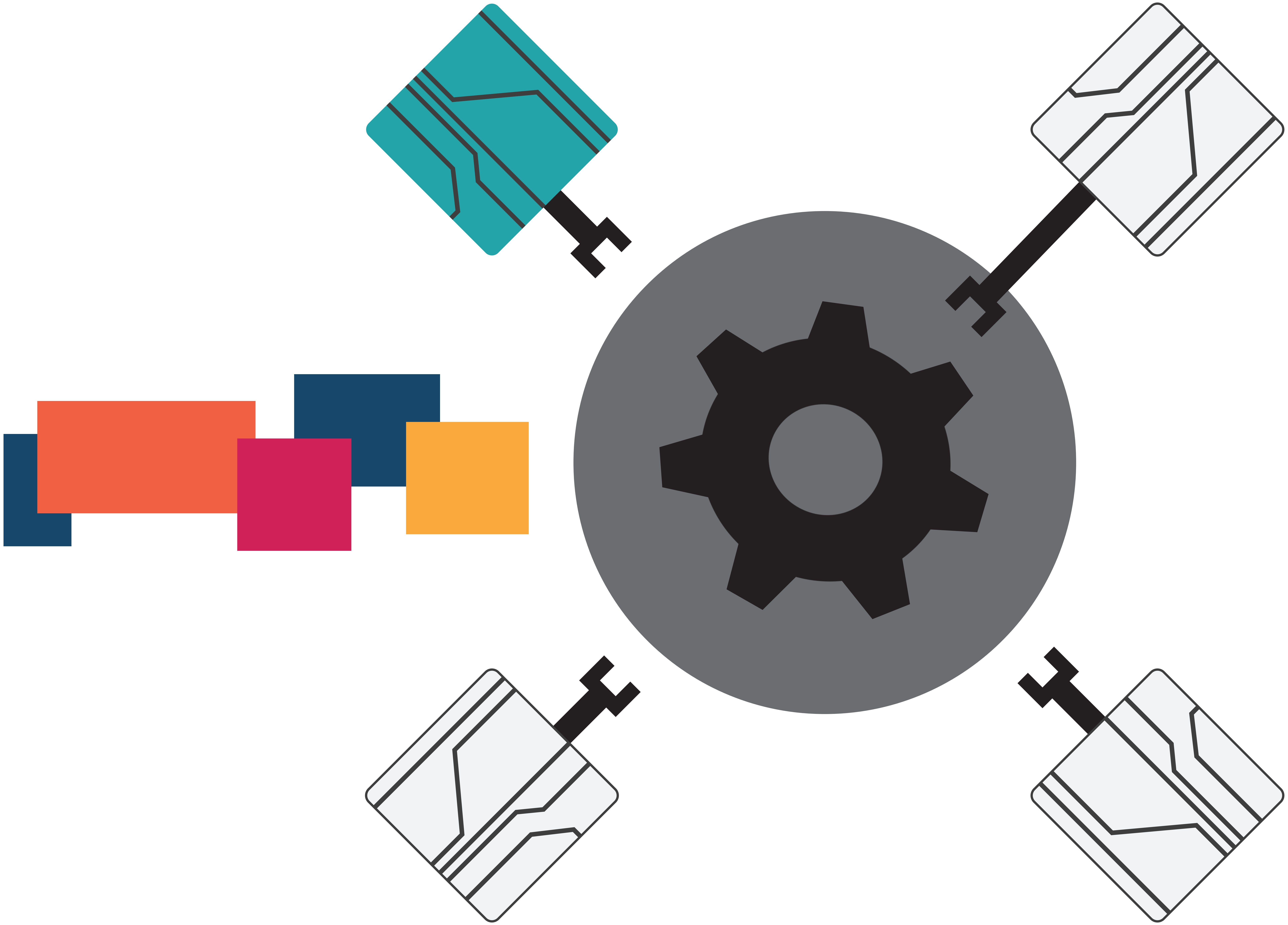


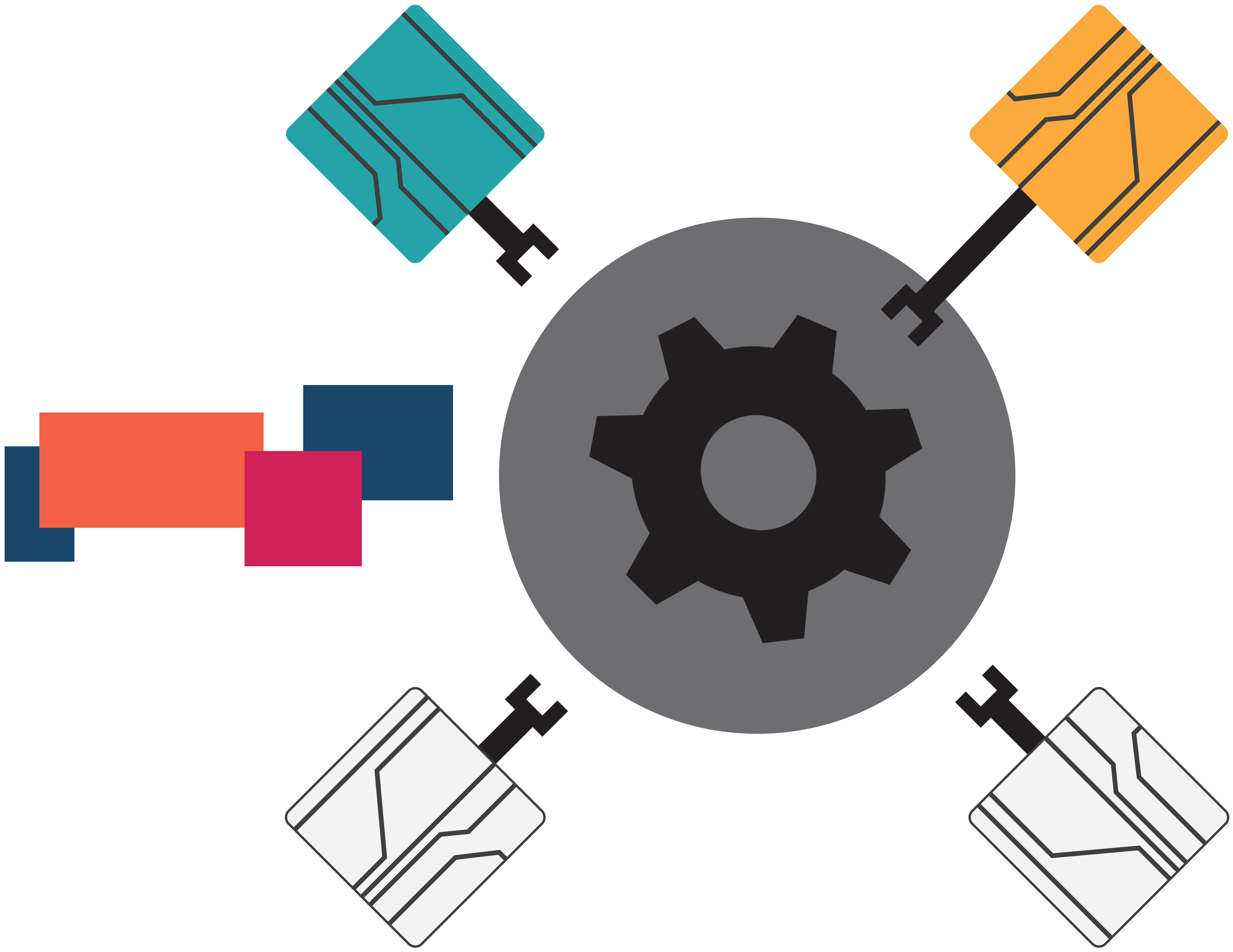


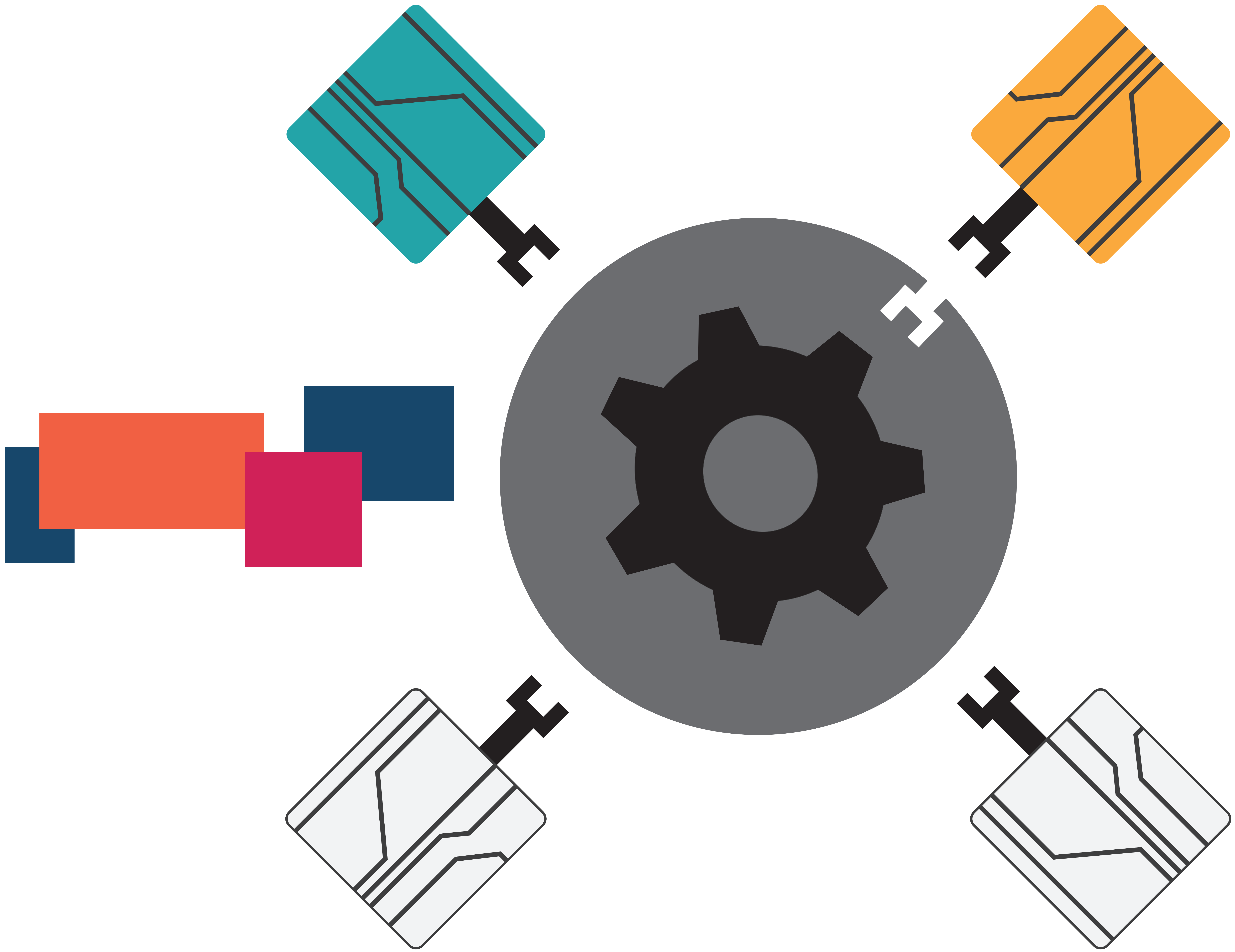


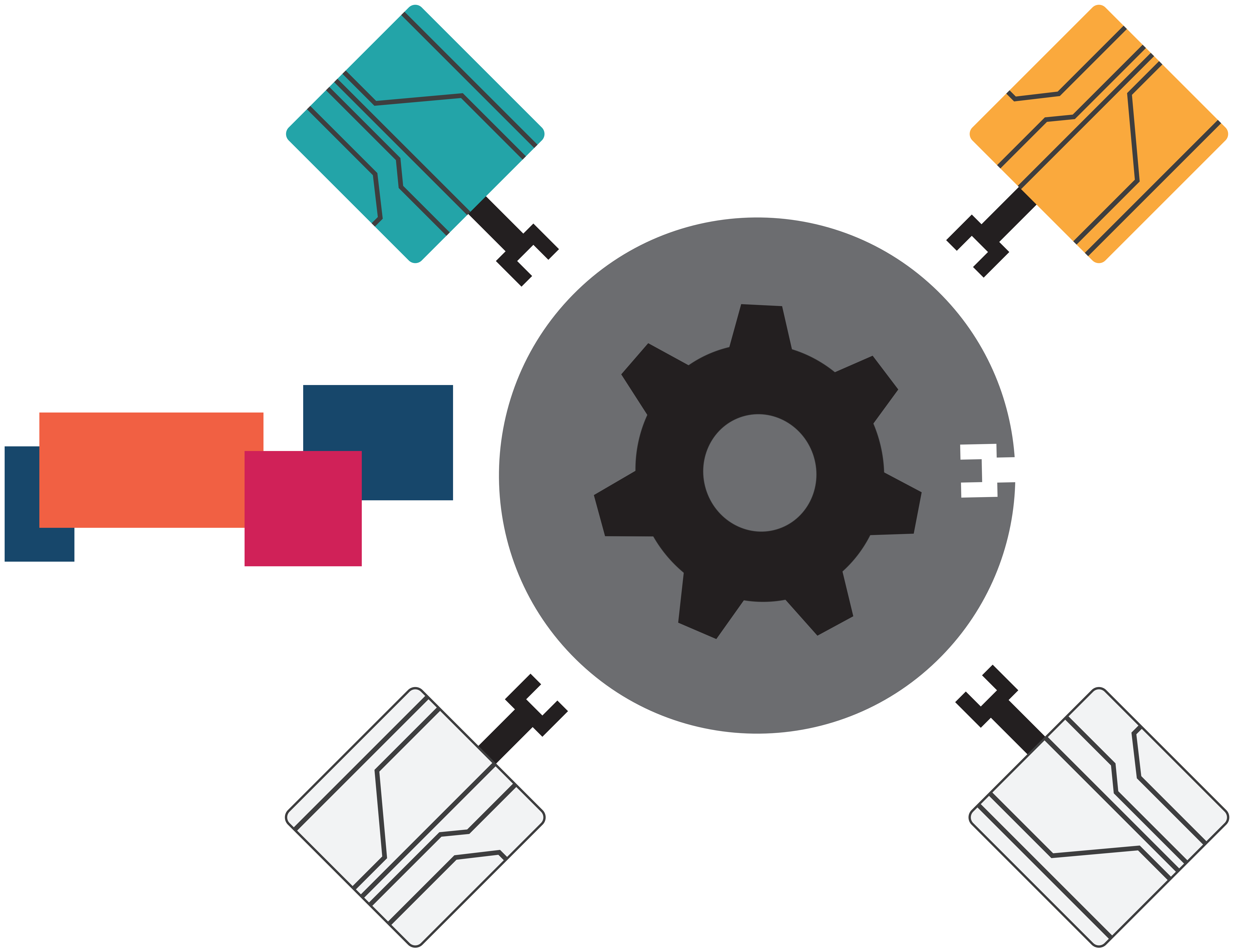


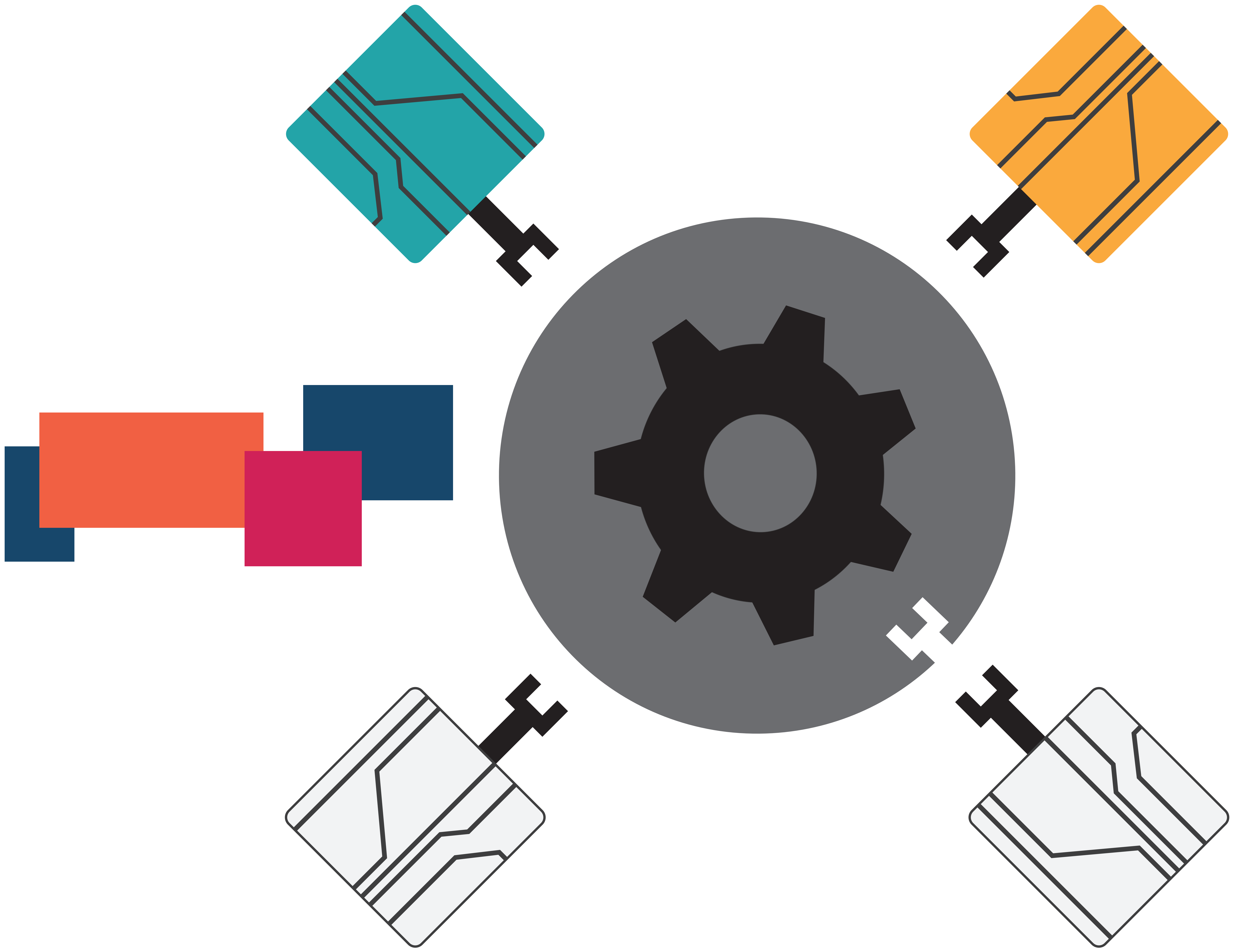


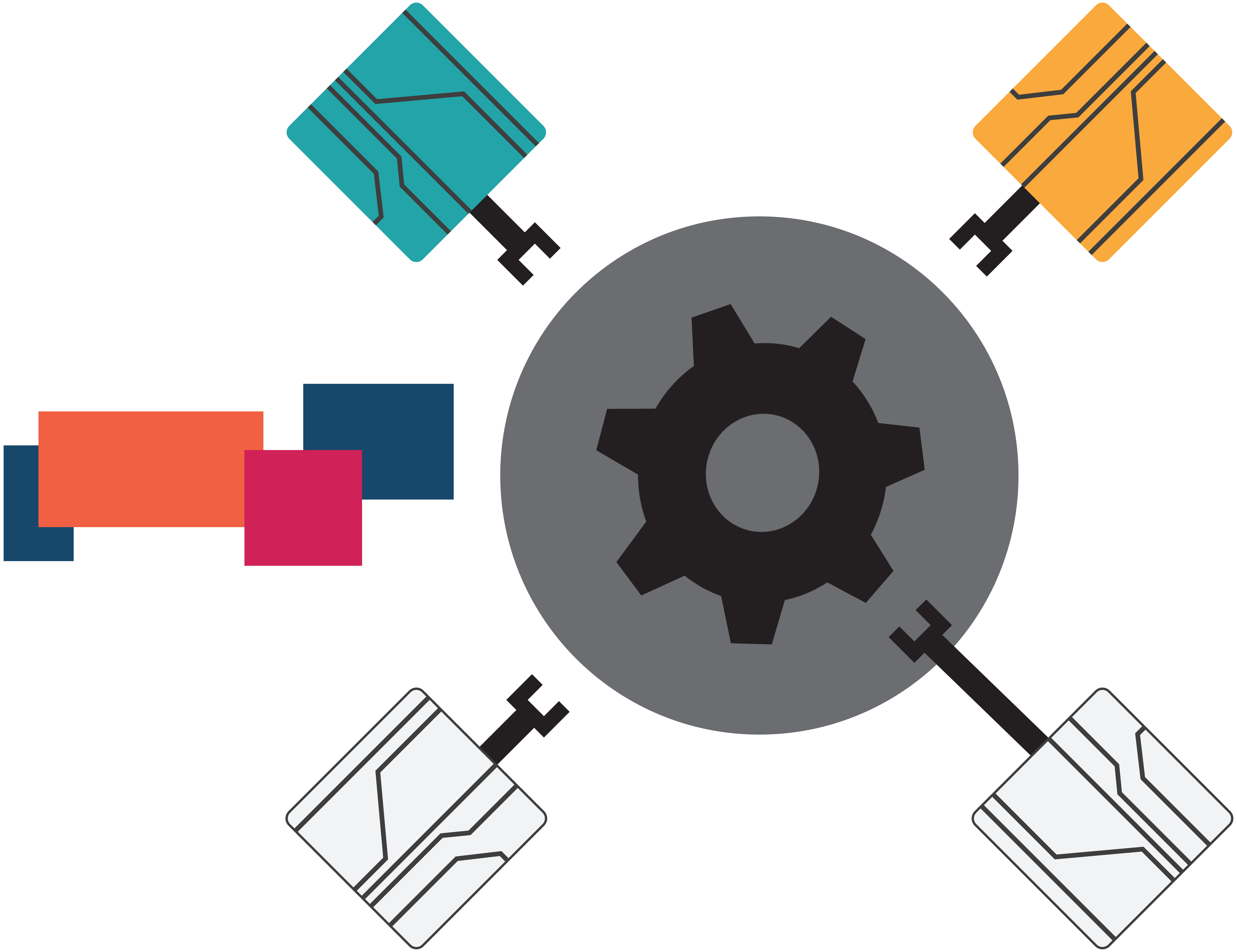


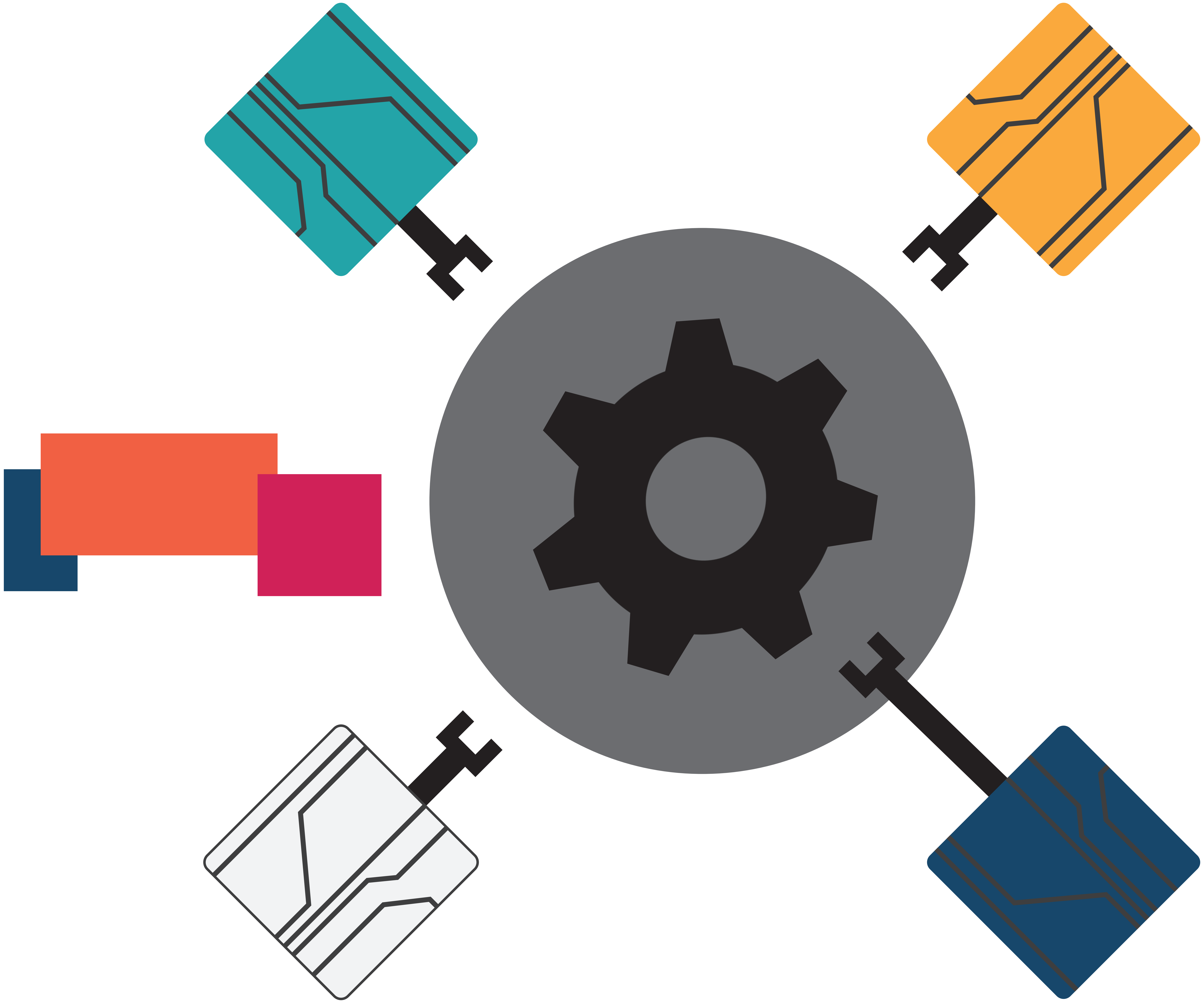


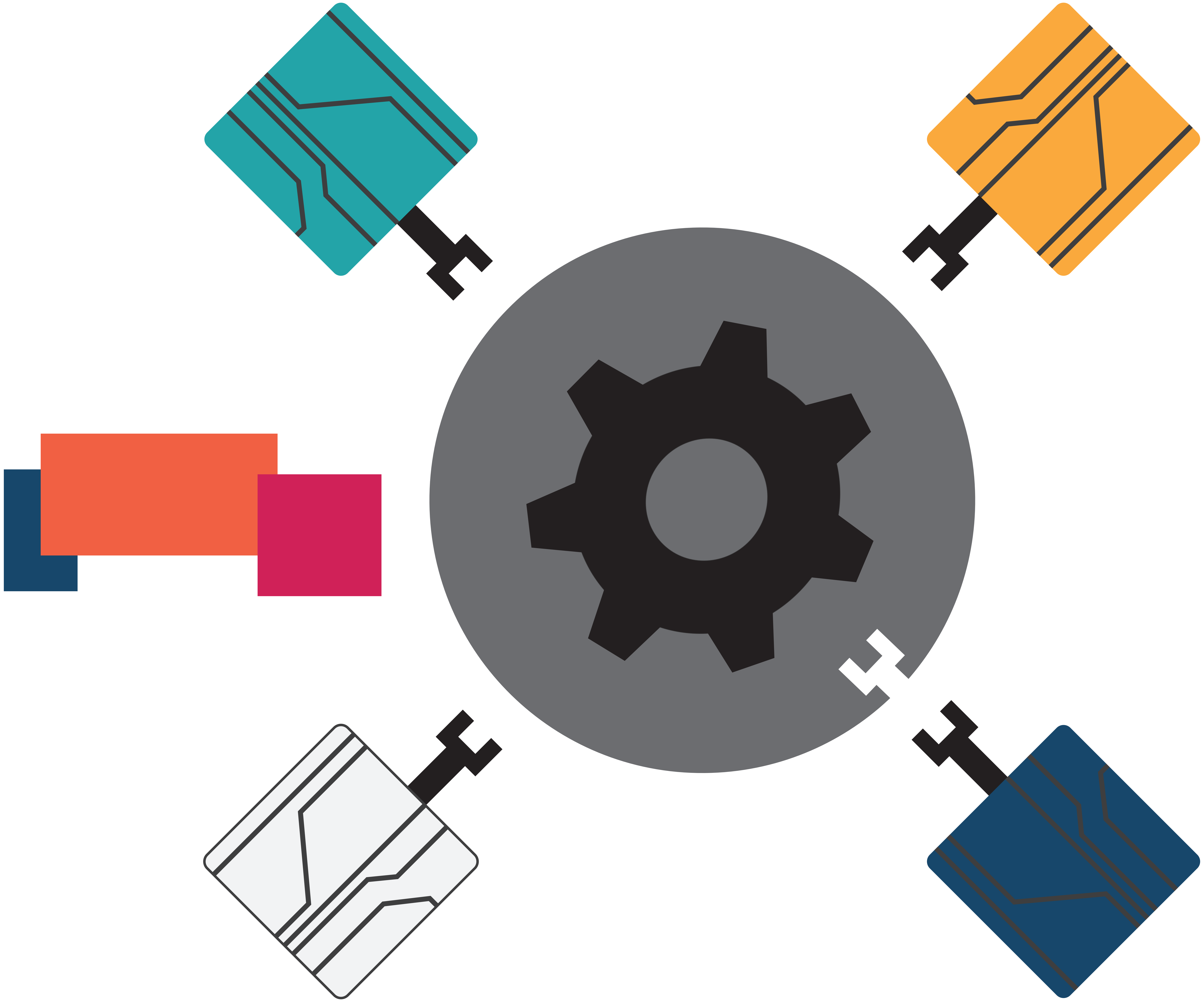


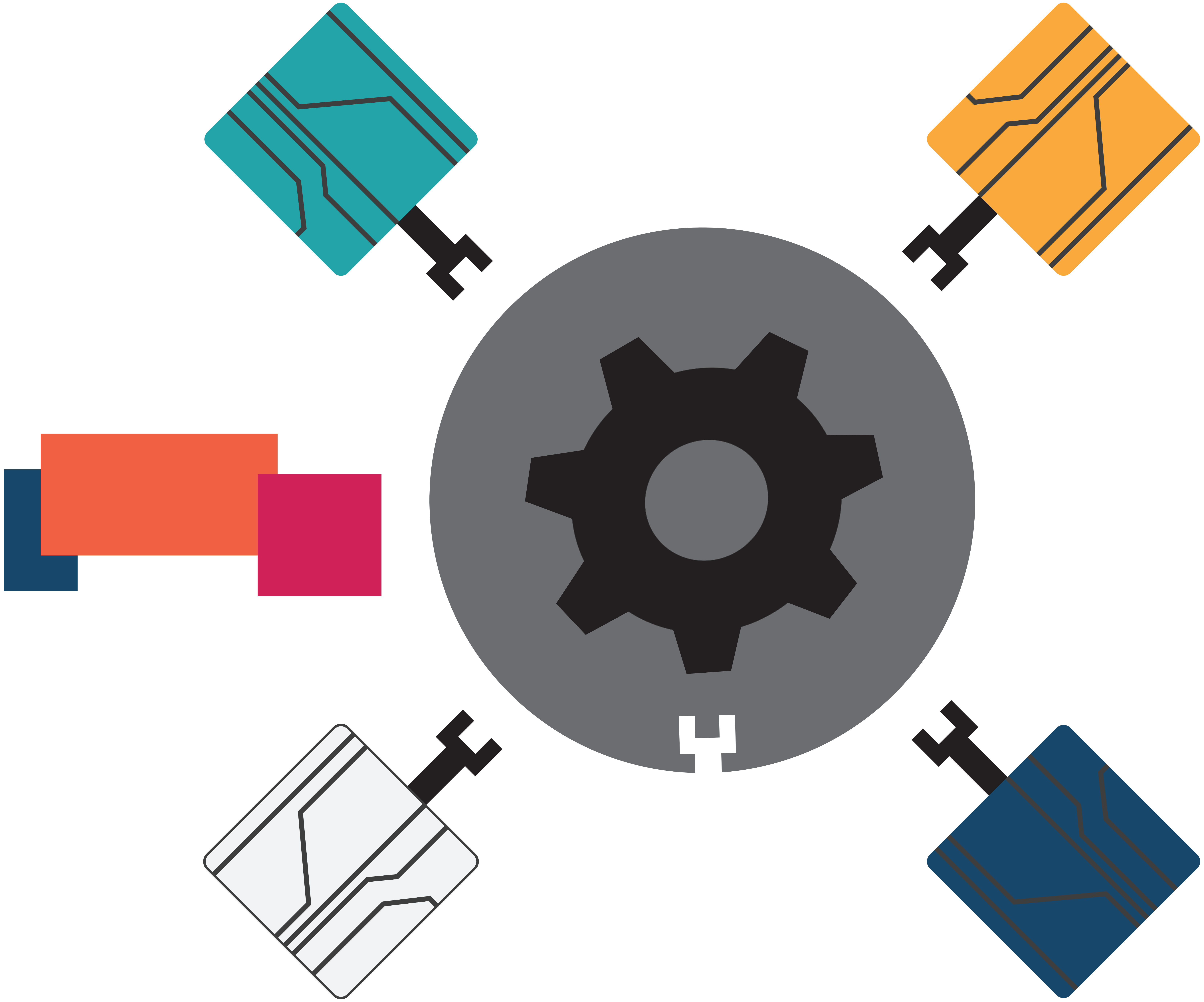


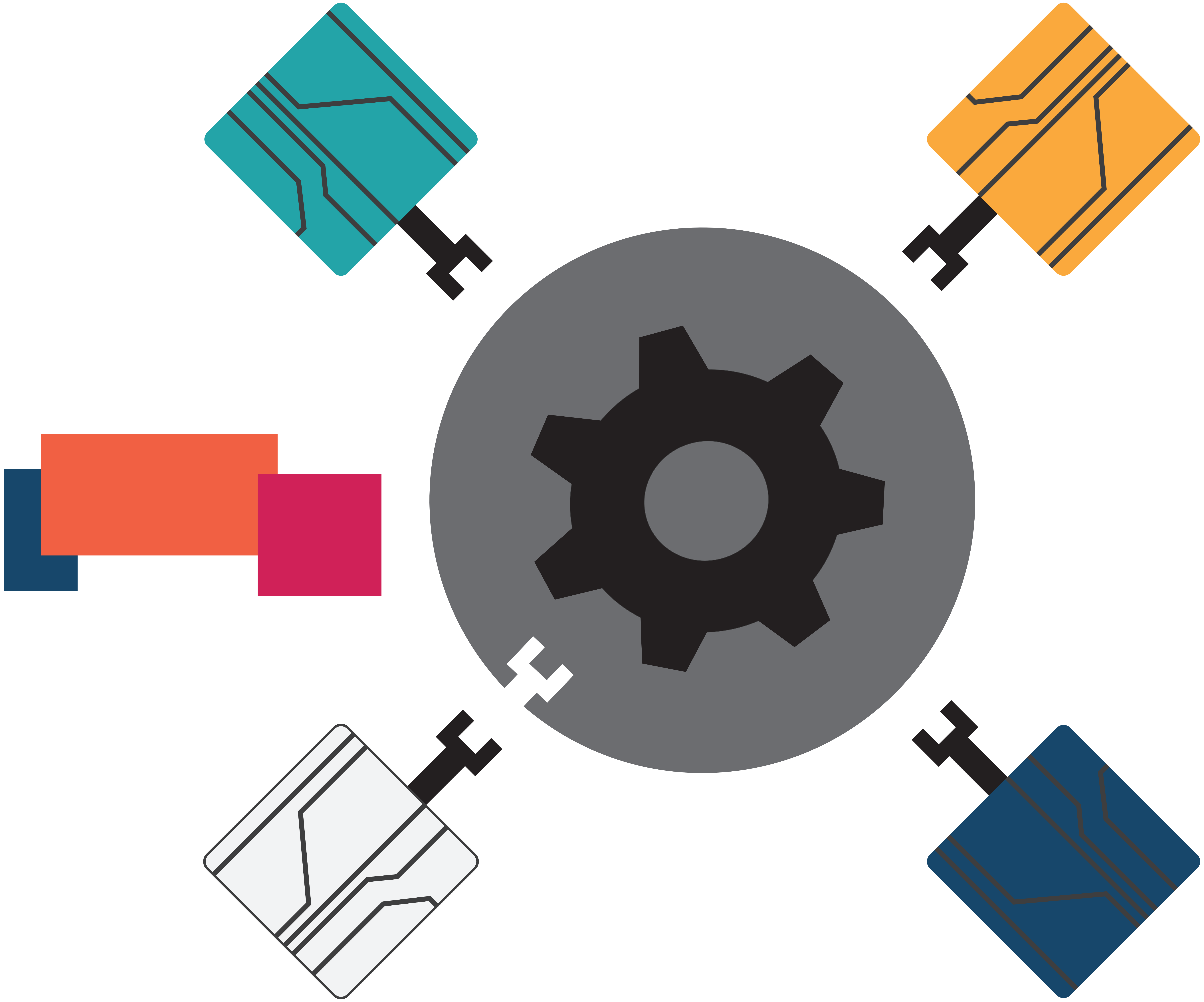


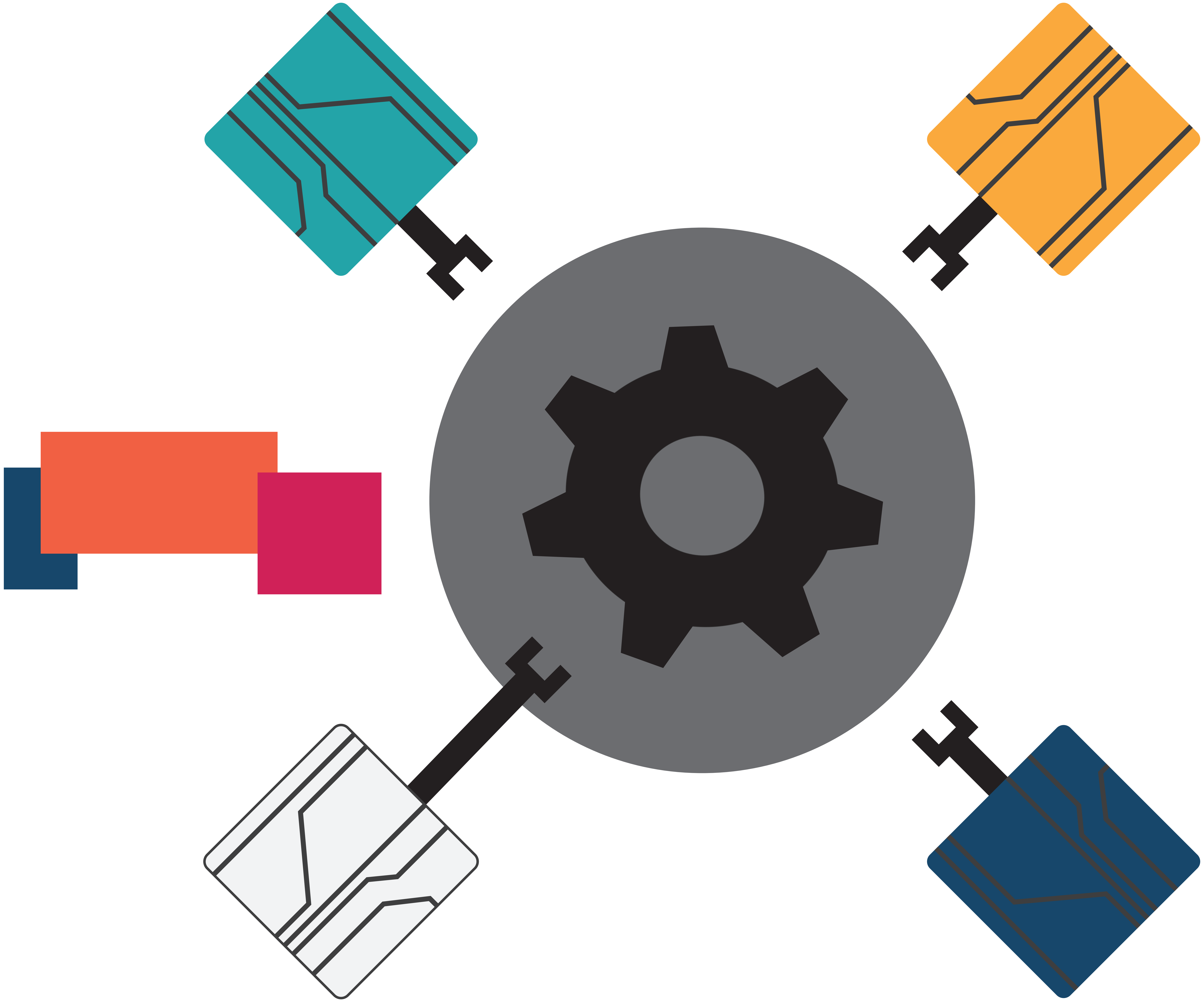


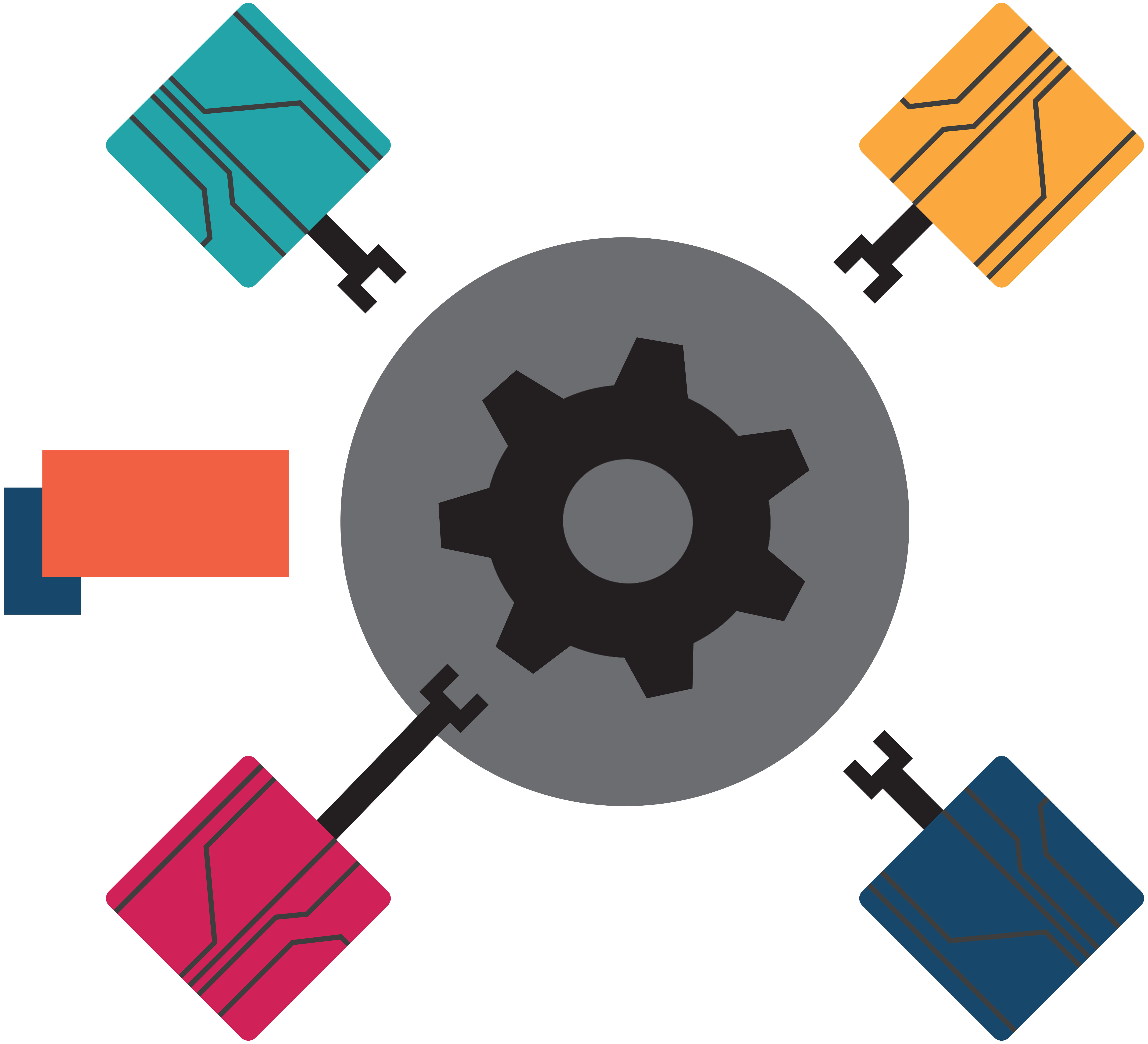


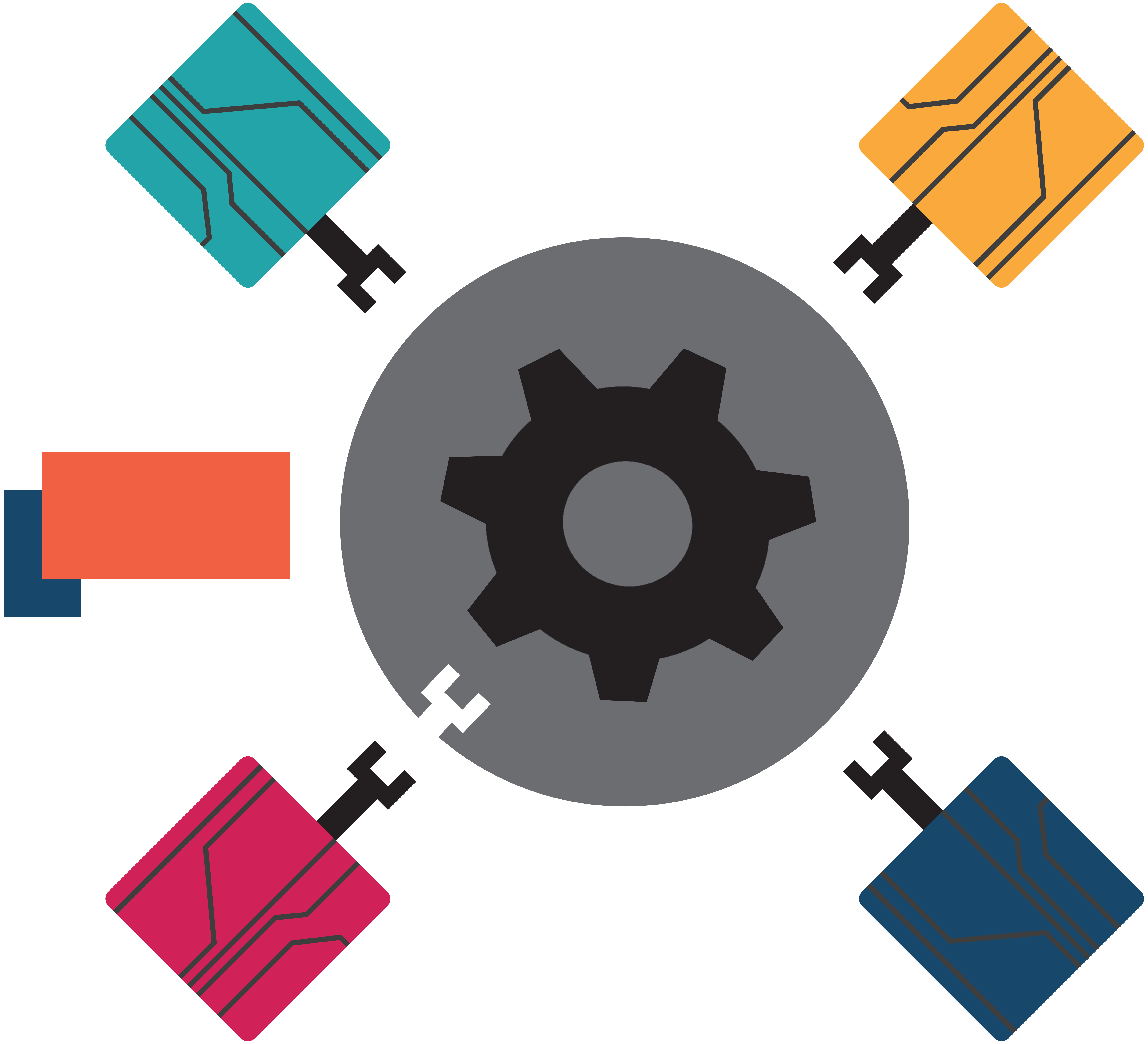


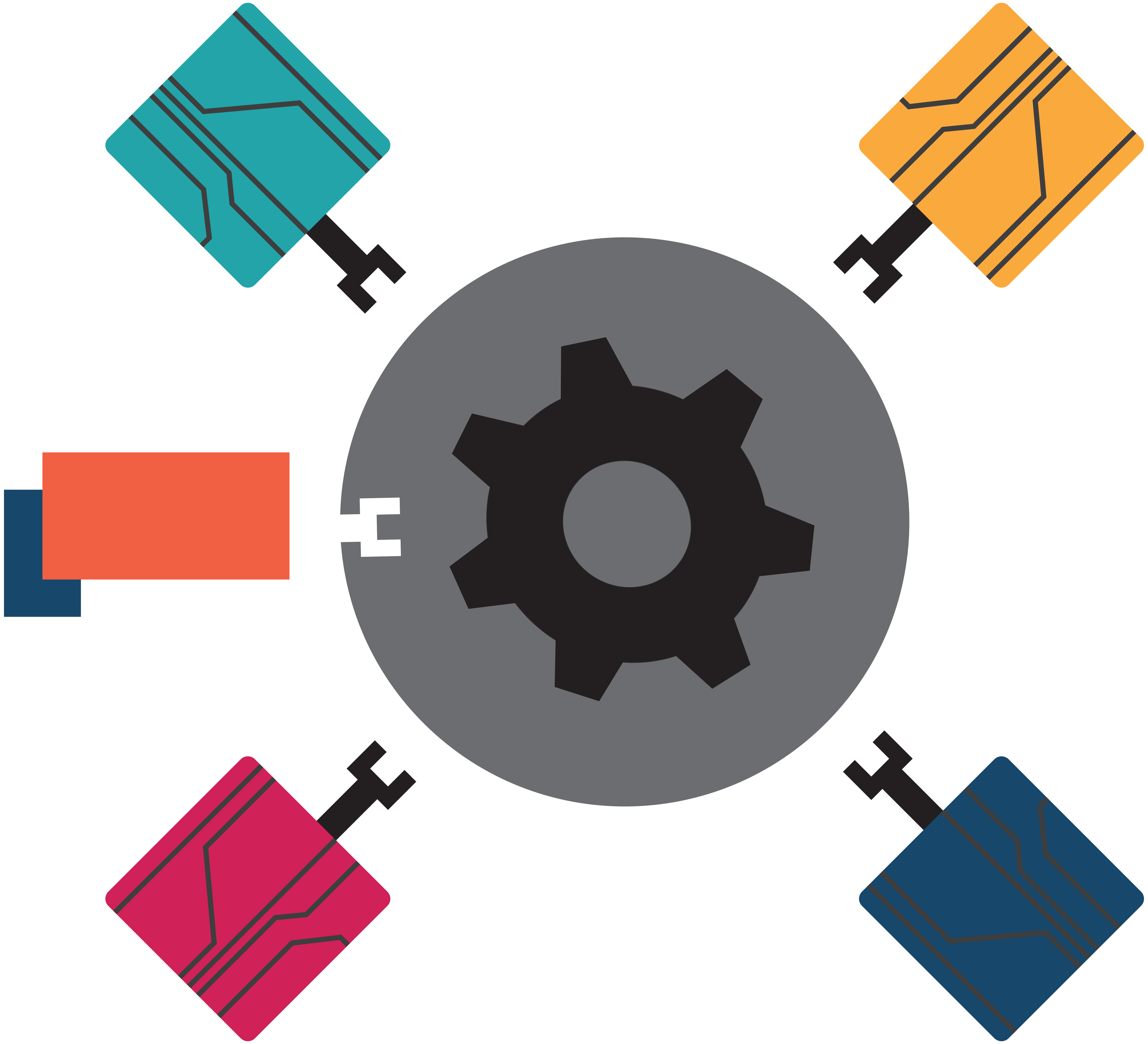


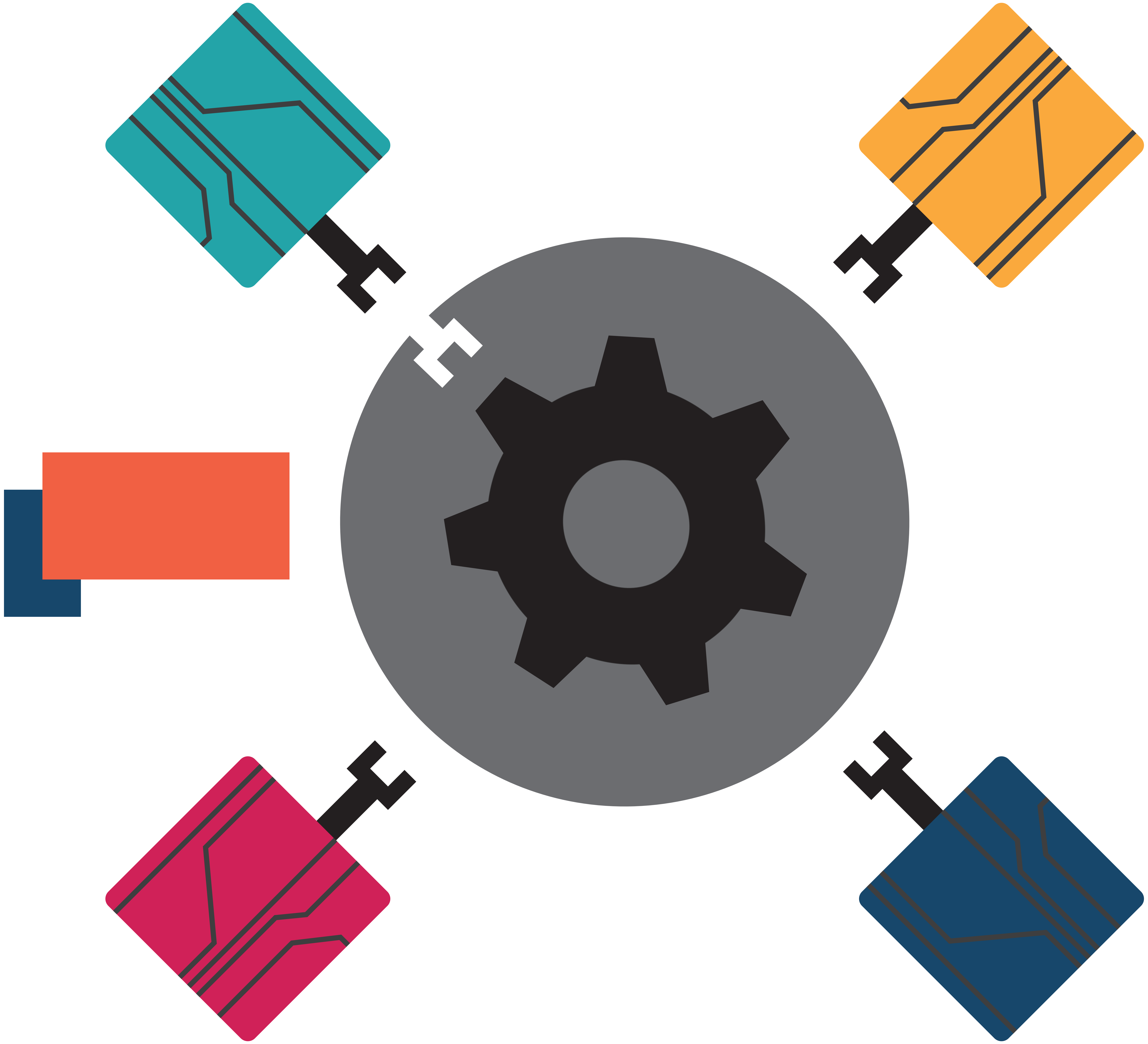


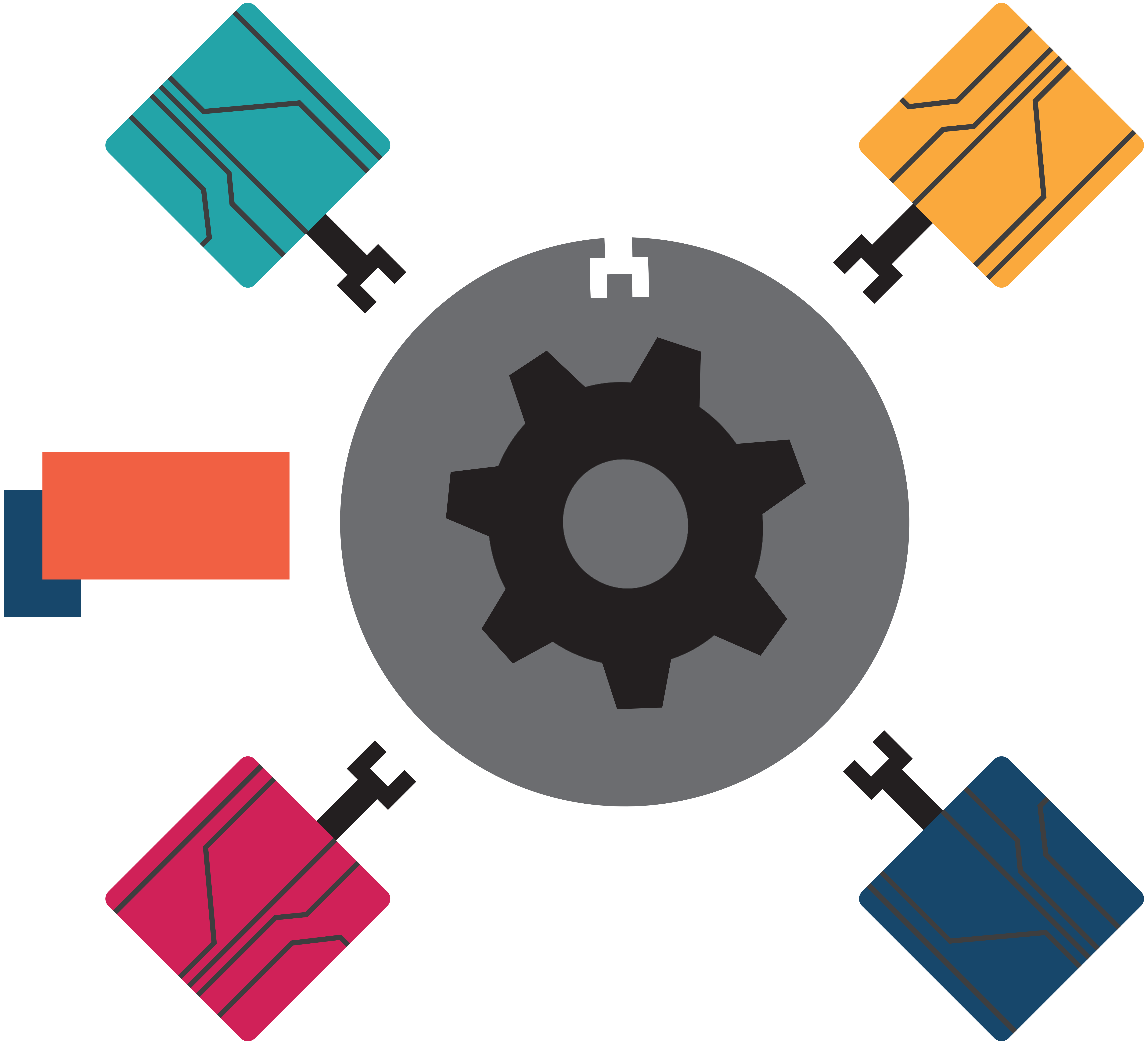




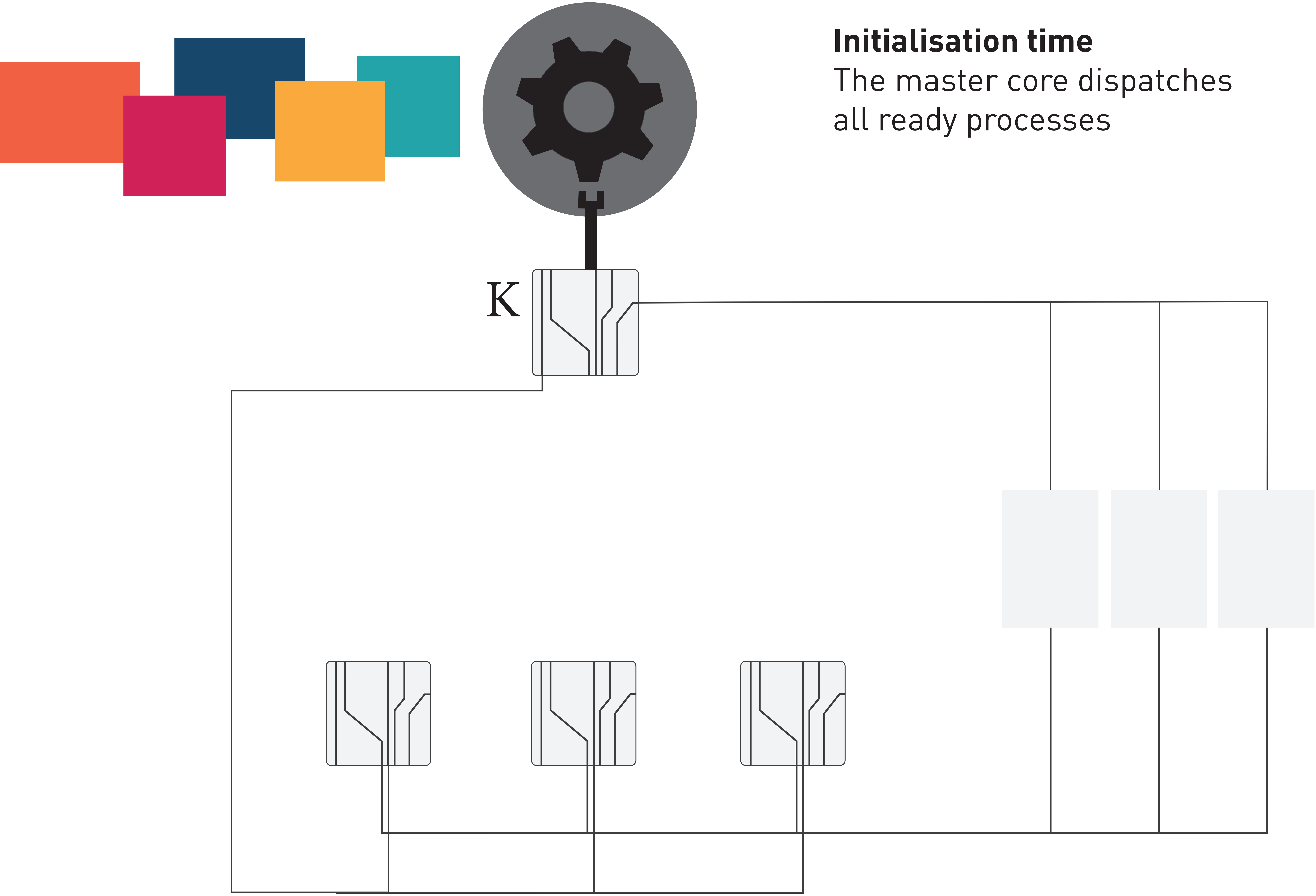








Our approach is asymmetric



Initialisation time

The master core dispatches all ready processes

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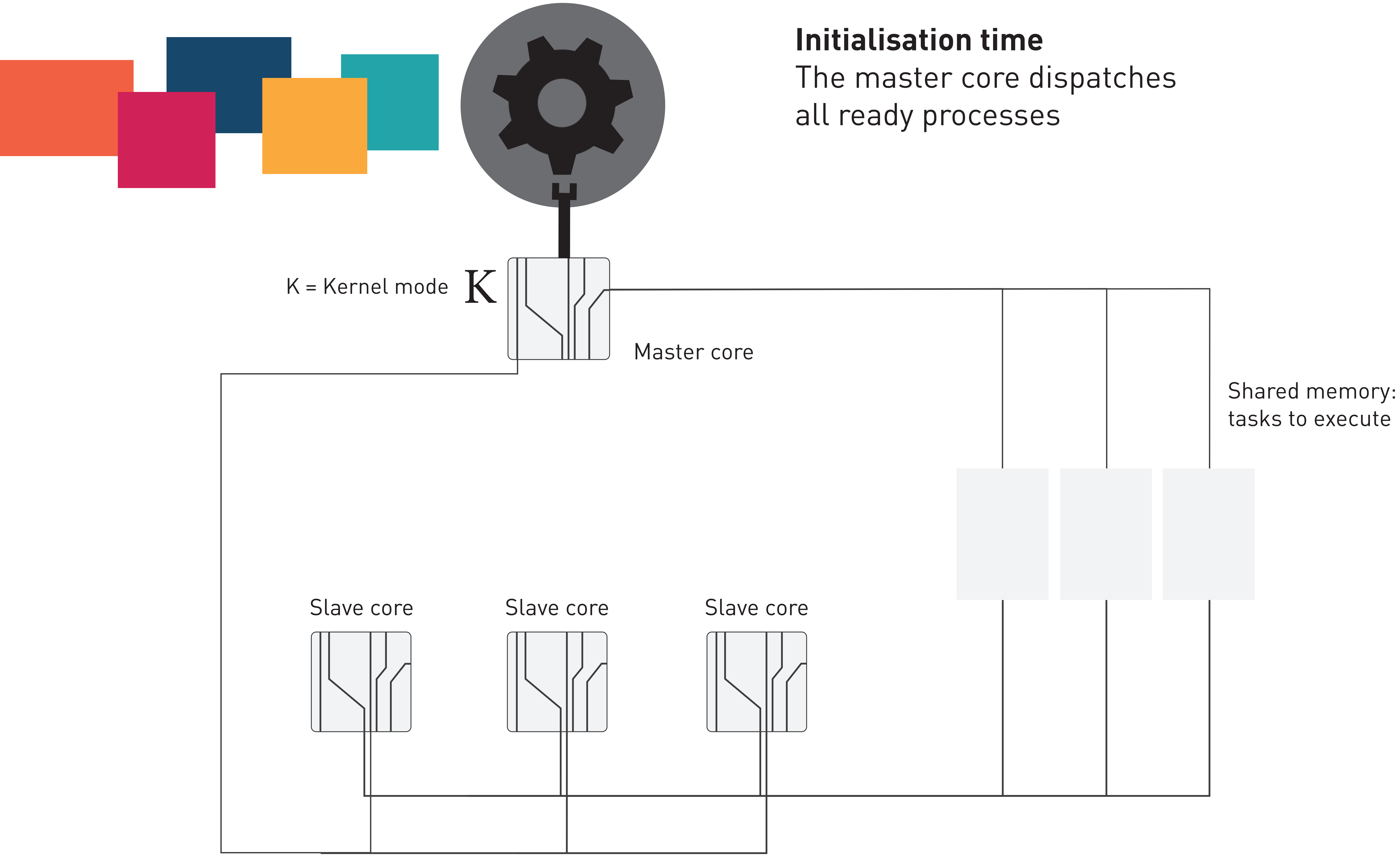


K = Kernel mode

K

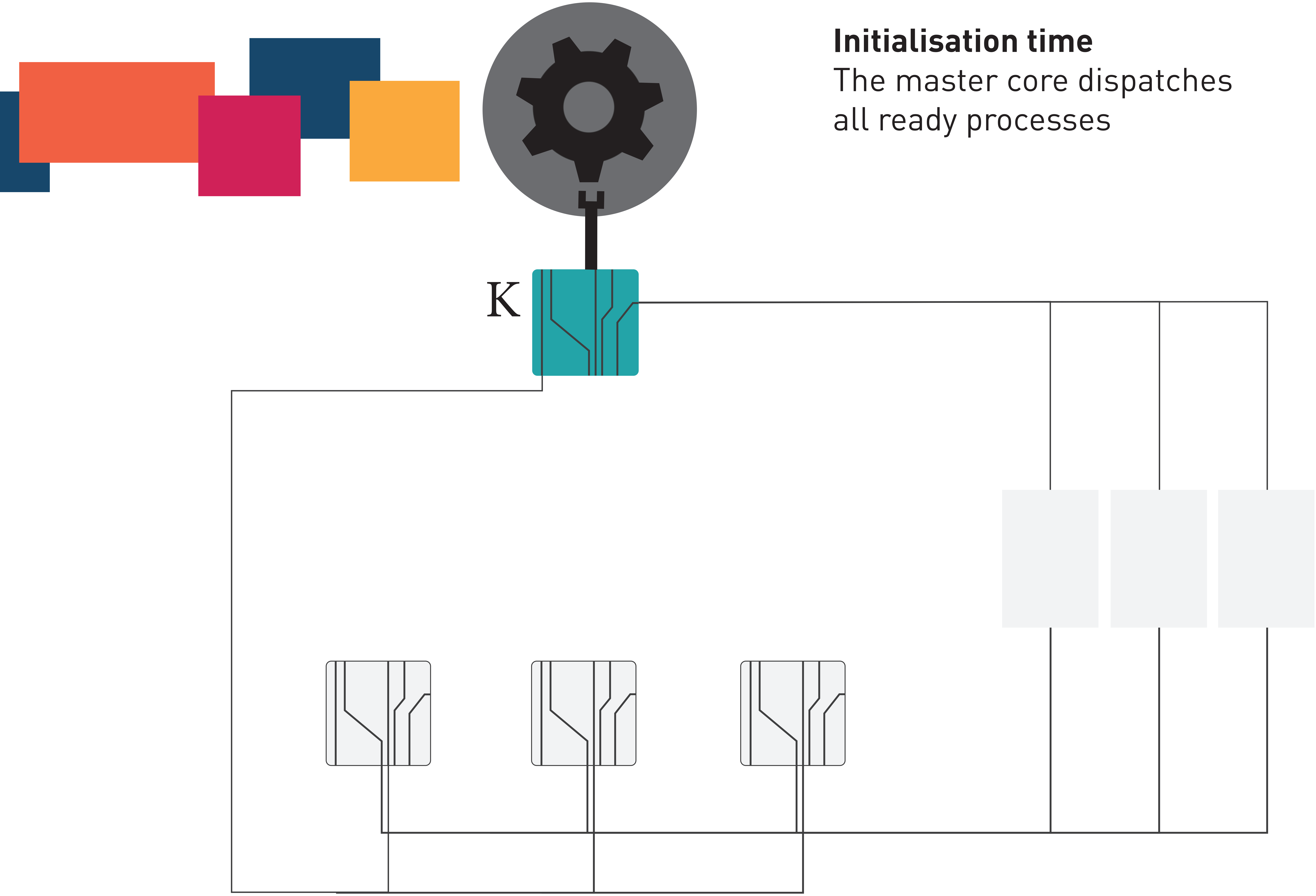
Master core

Shared memory: tasks to execute

Slave core

Slave core

Slave core



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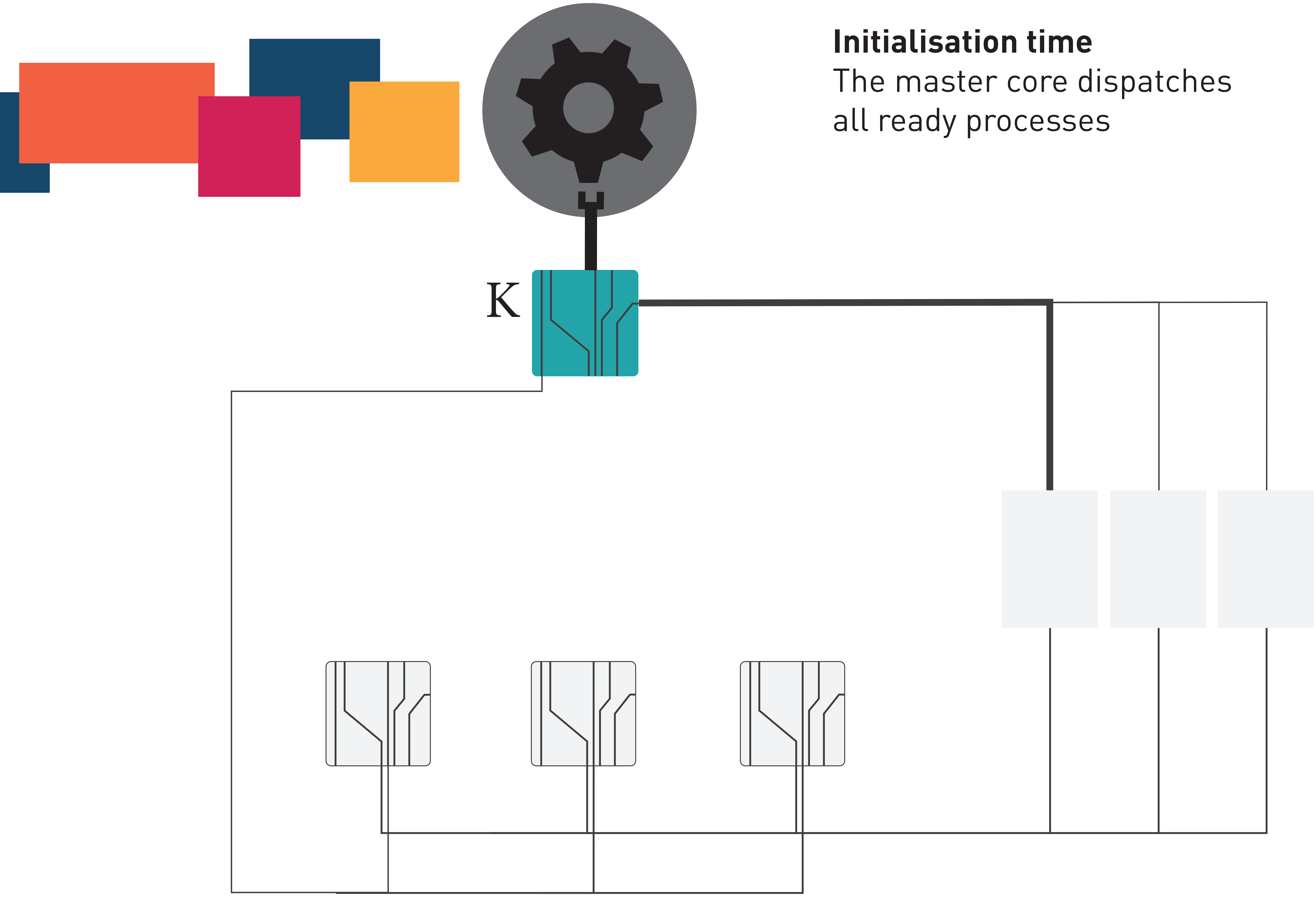

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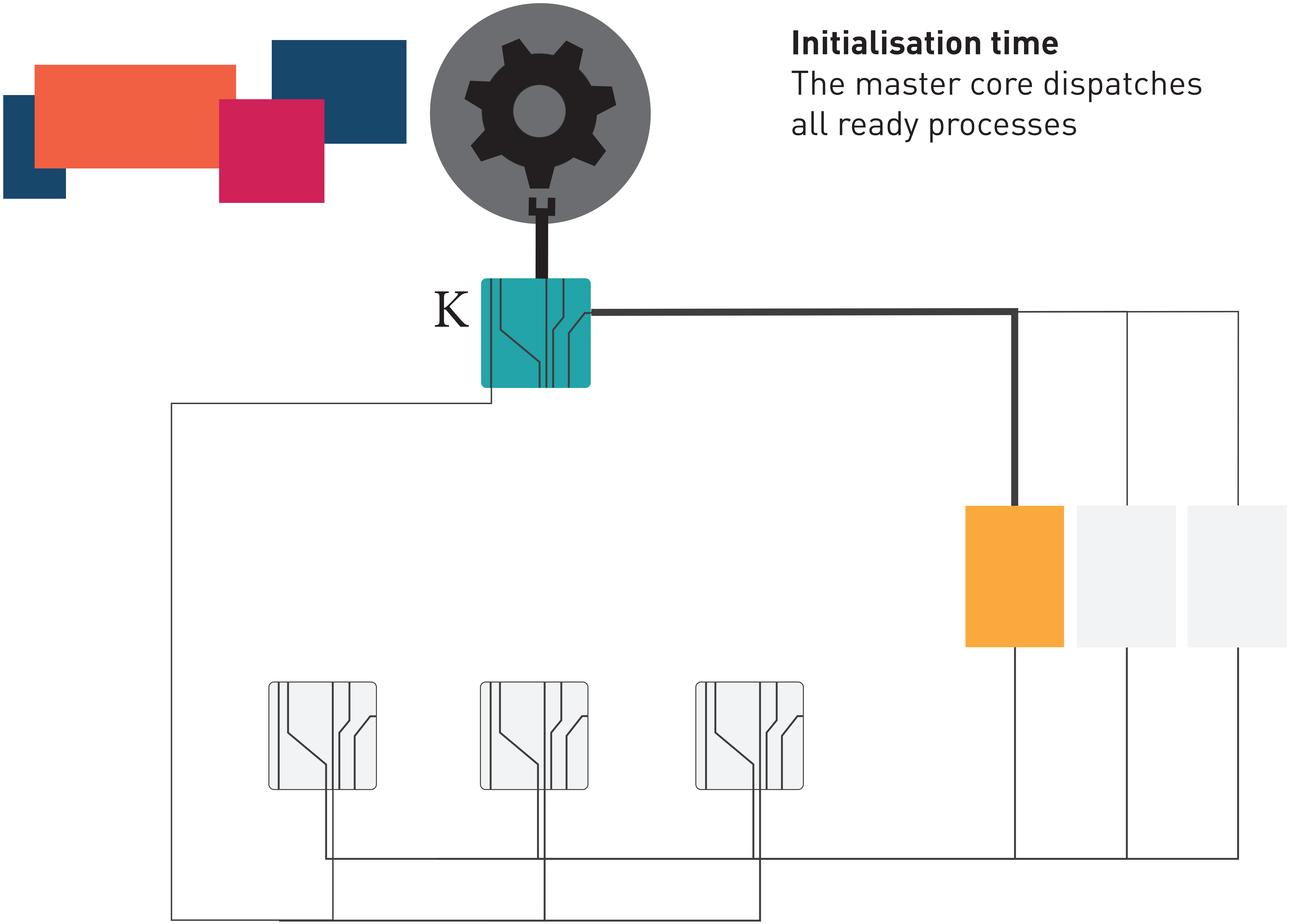

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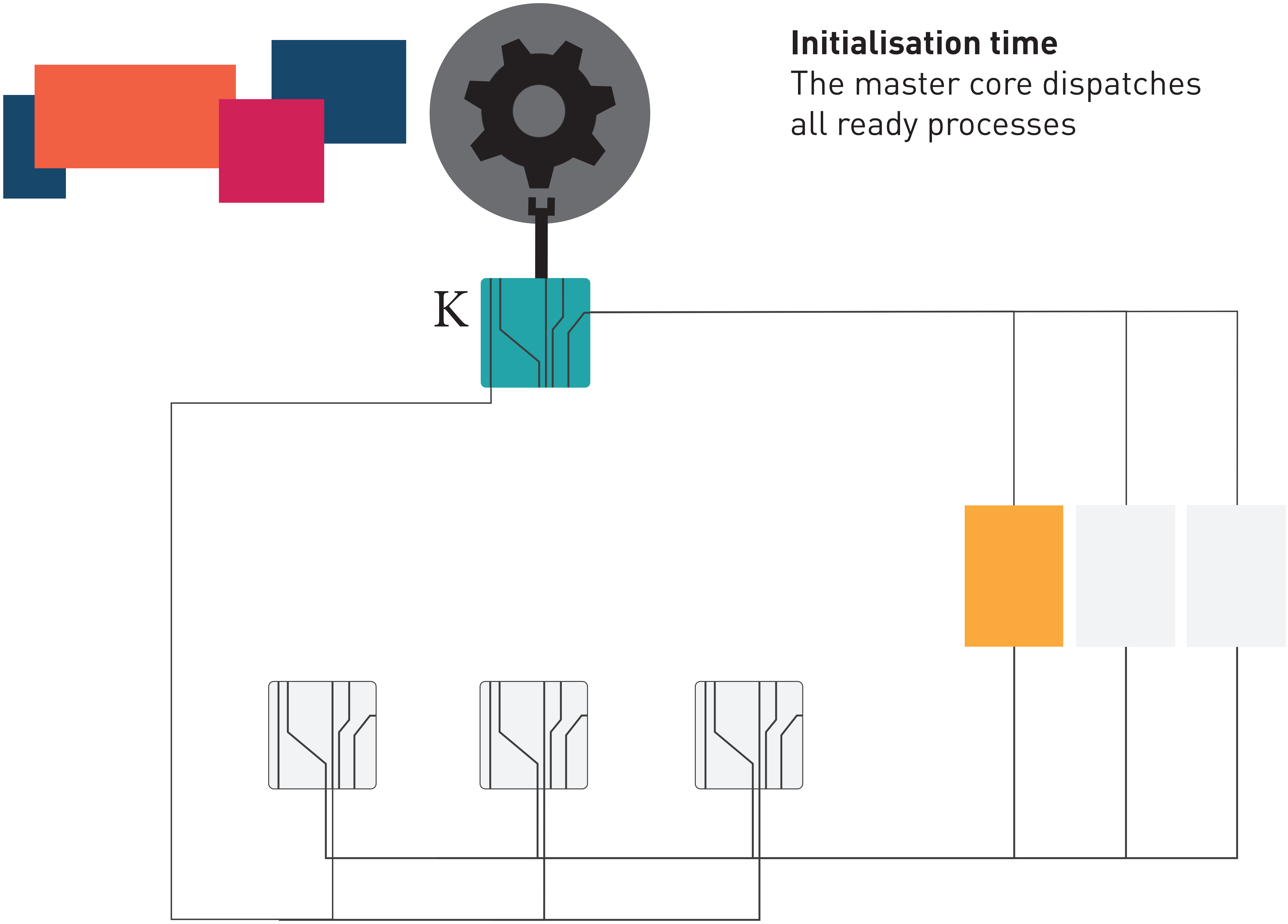

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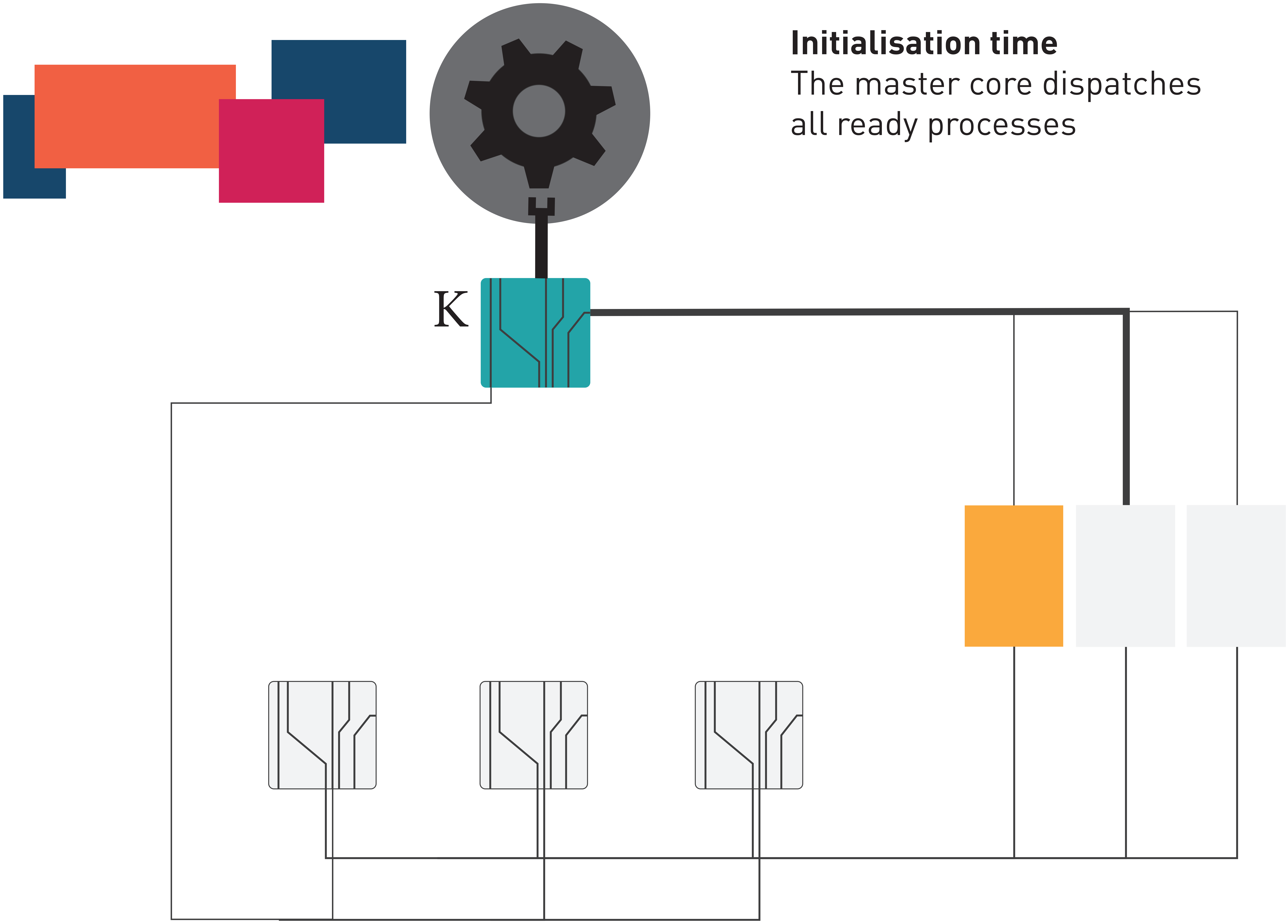

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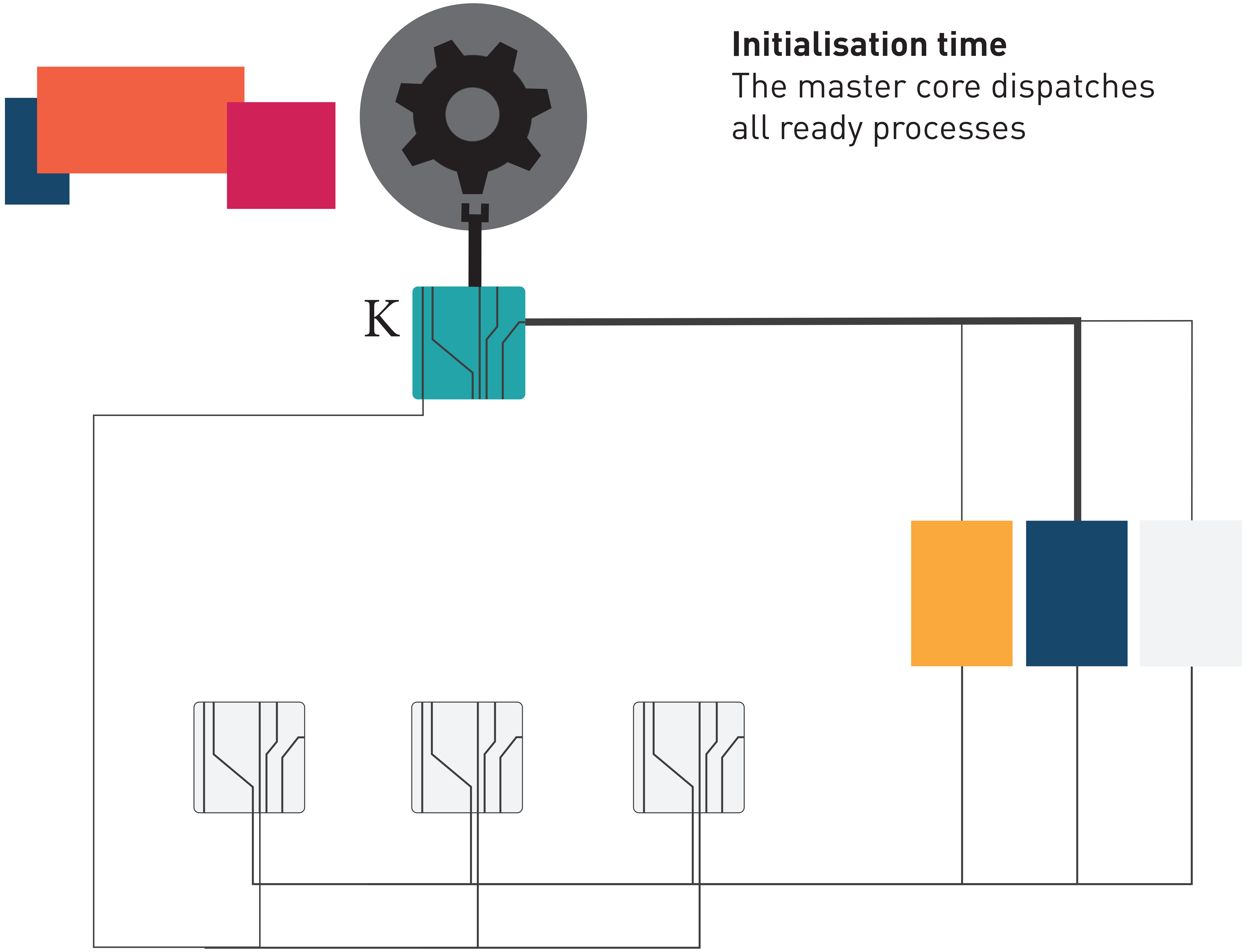

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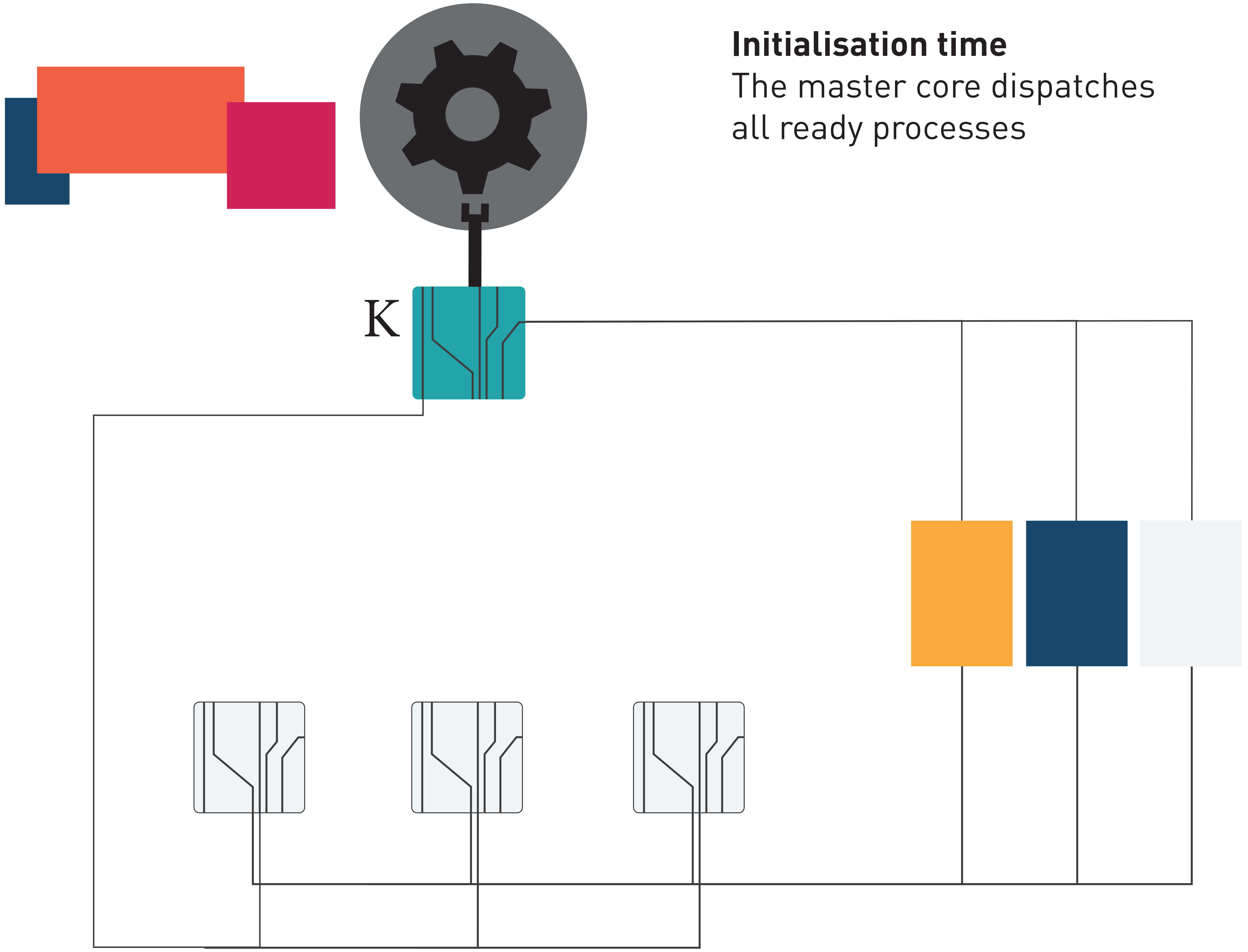

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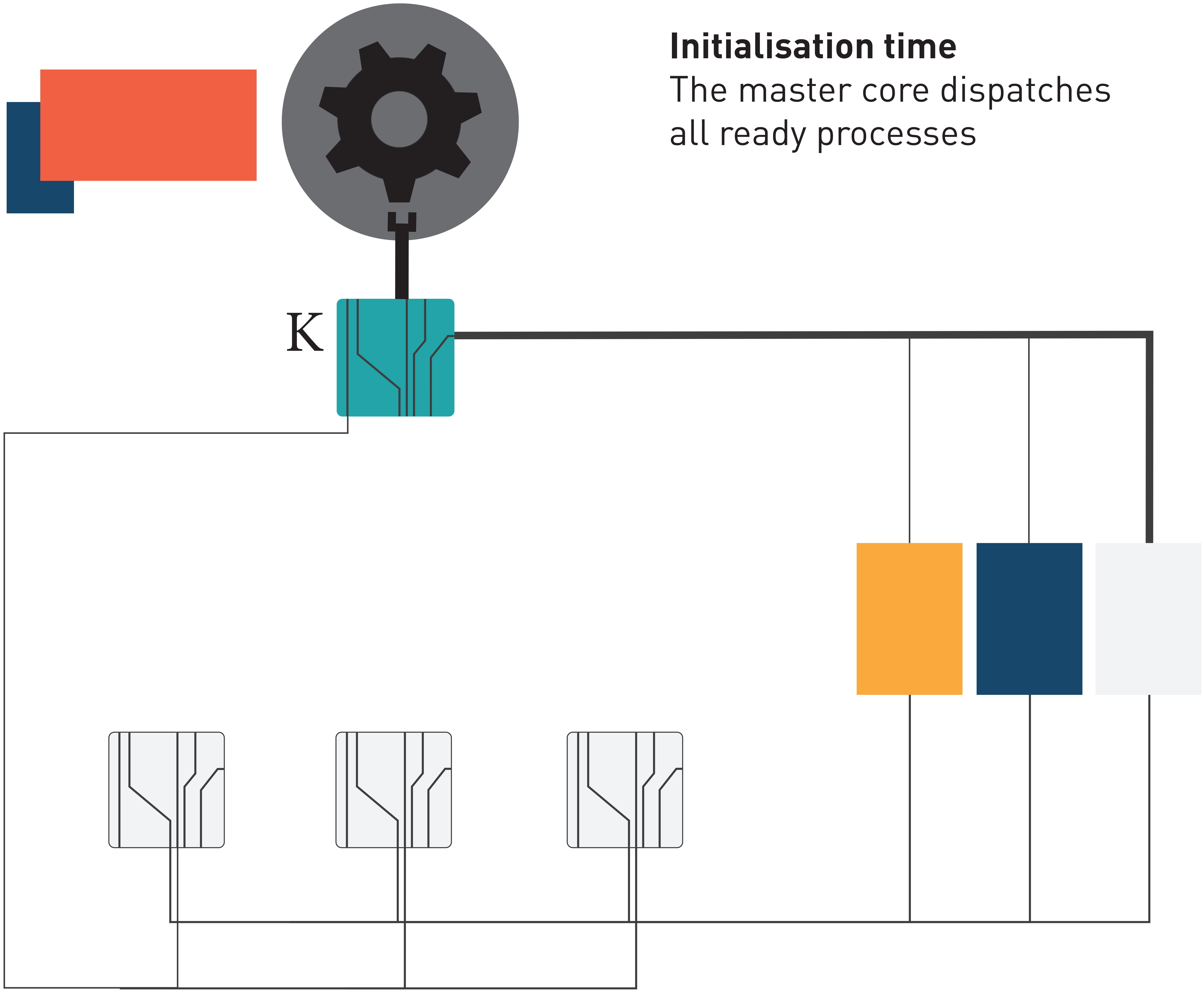

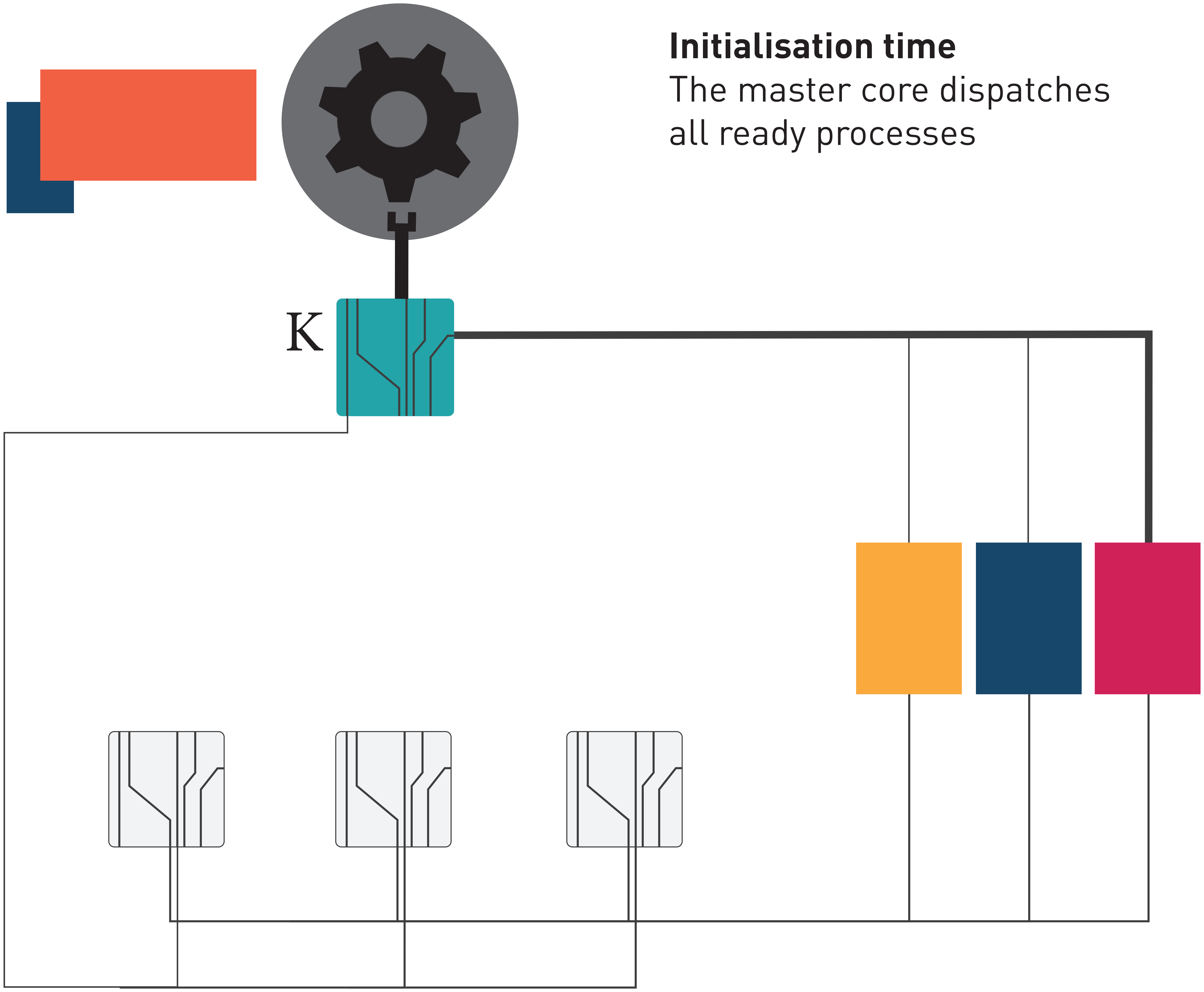

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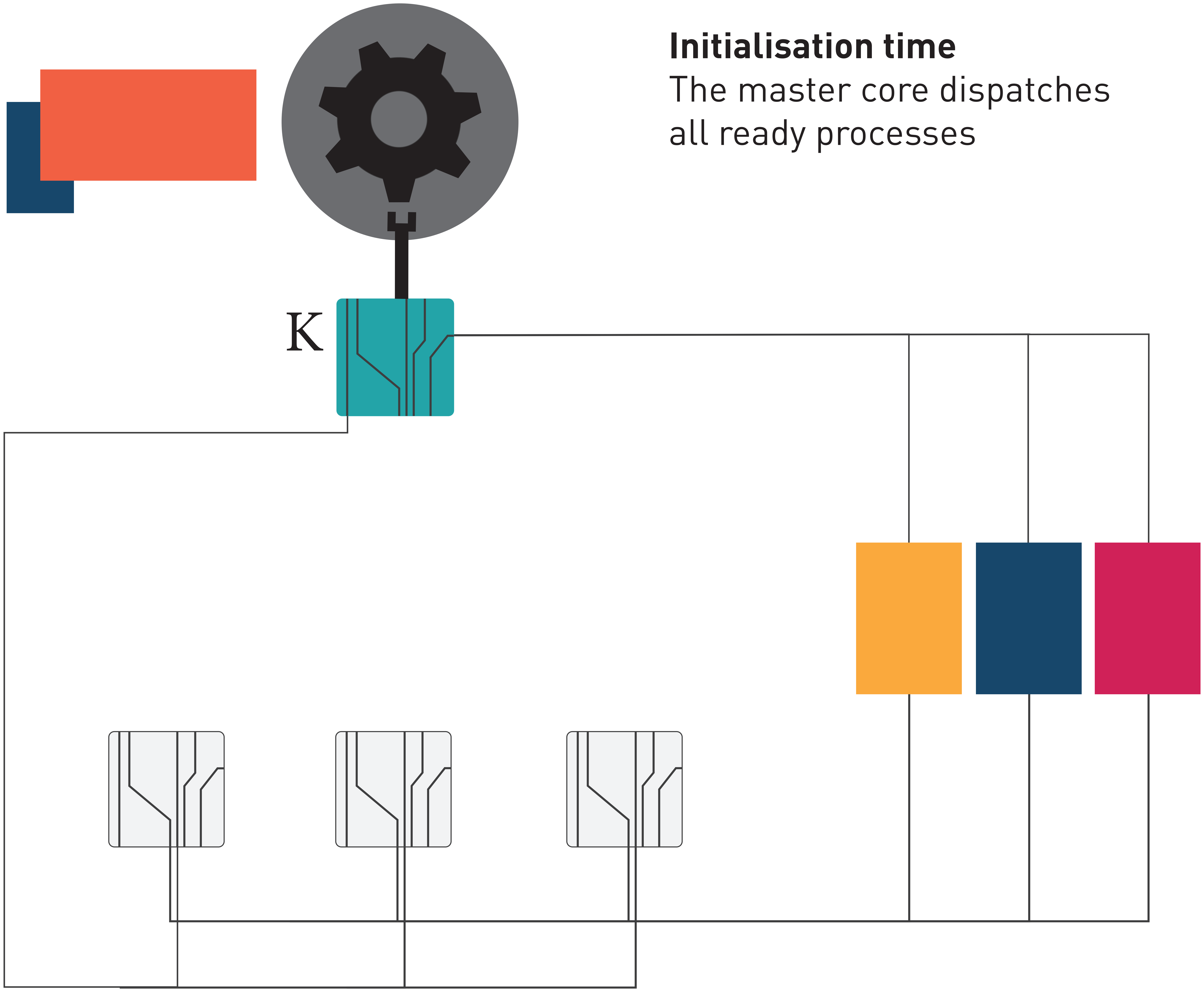

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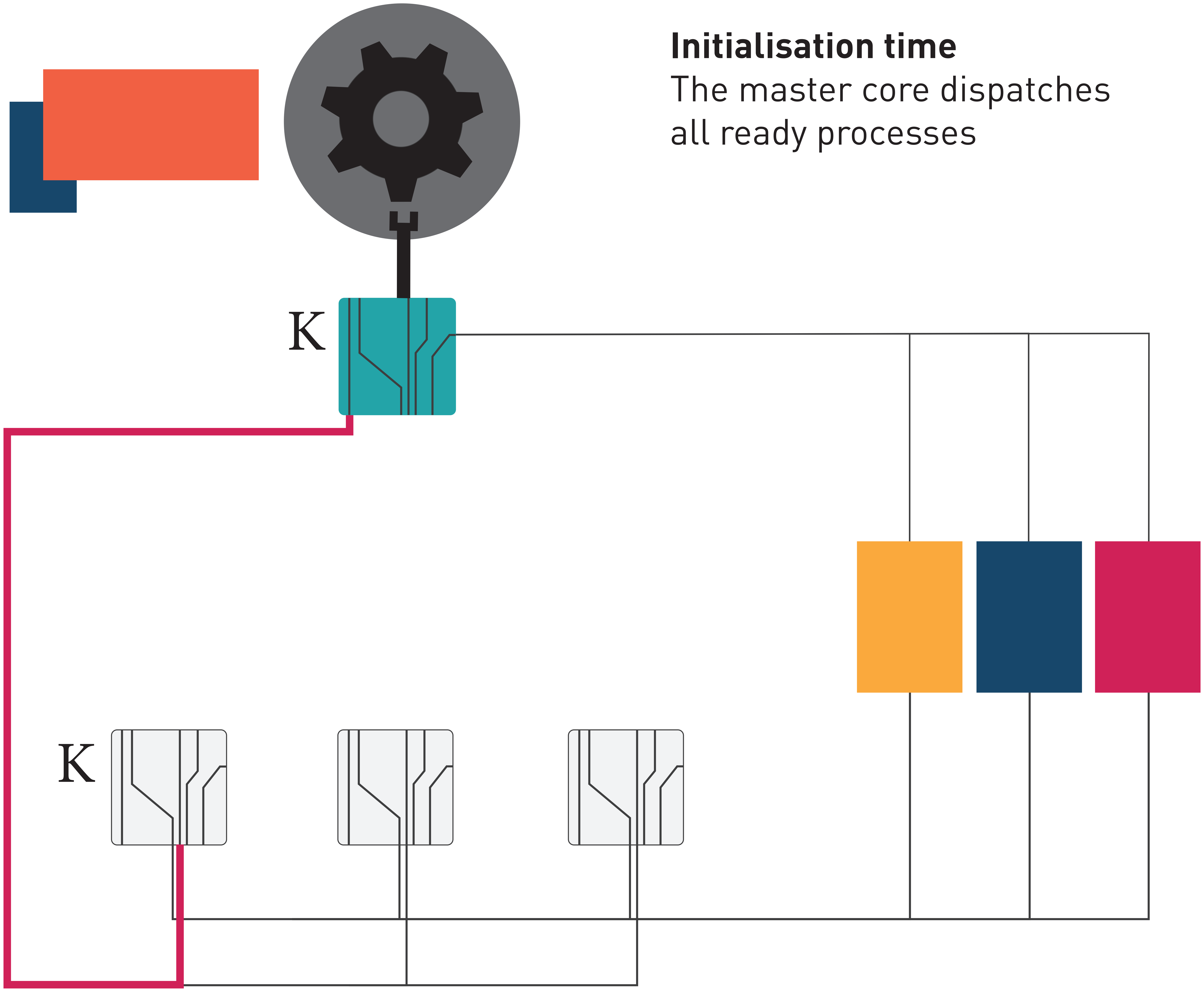

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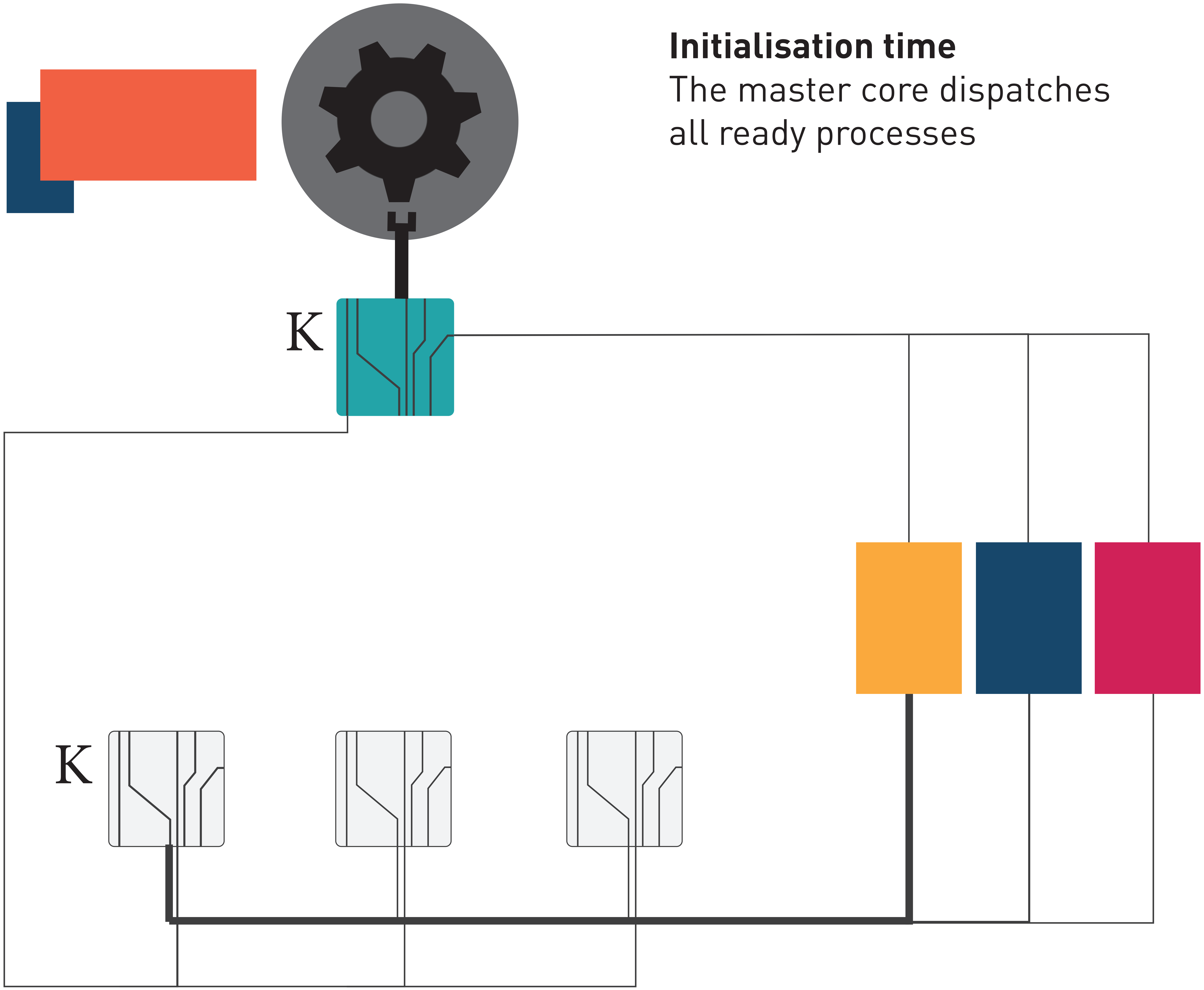

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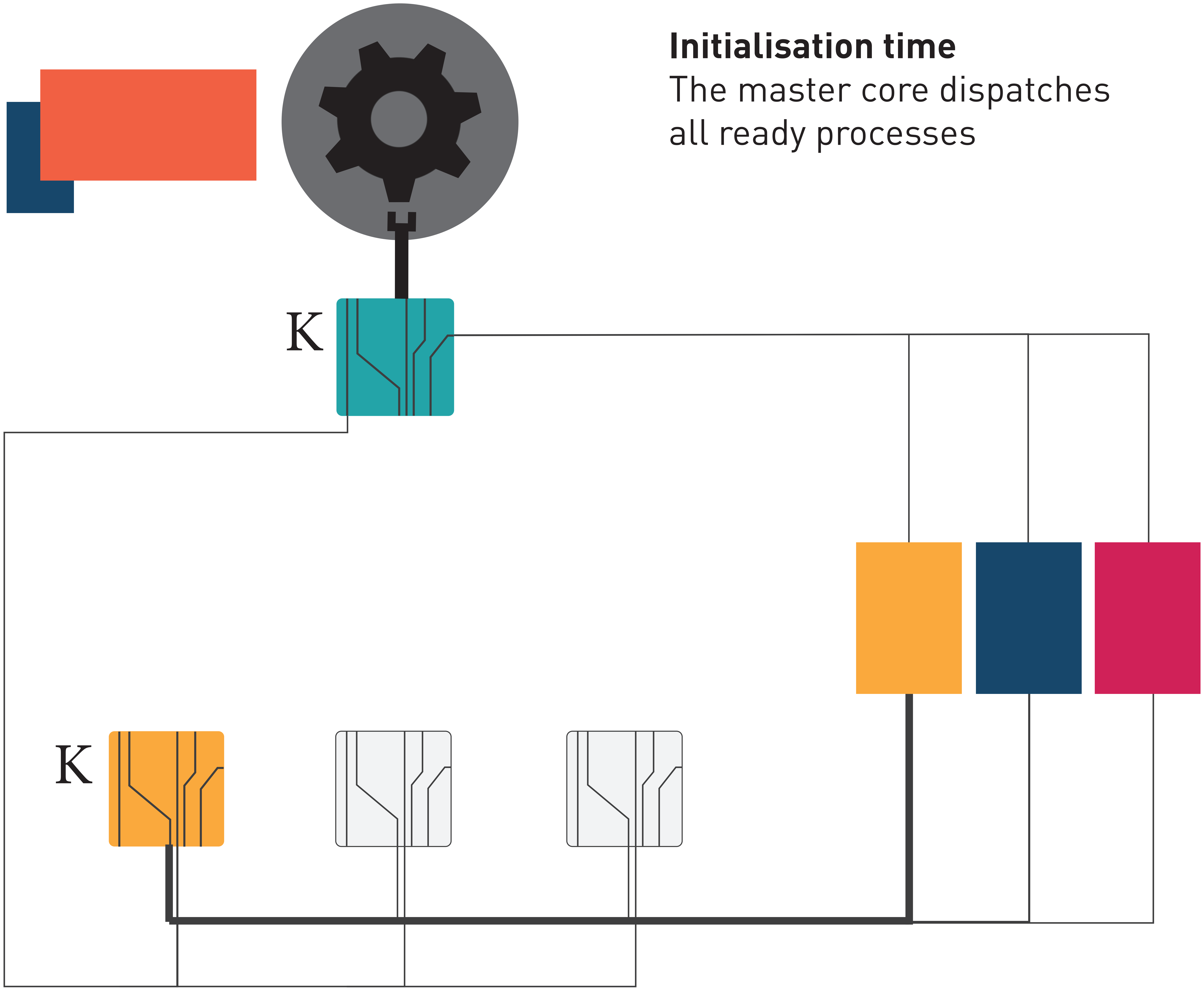

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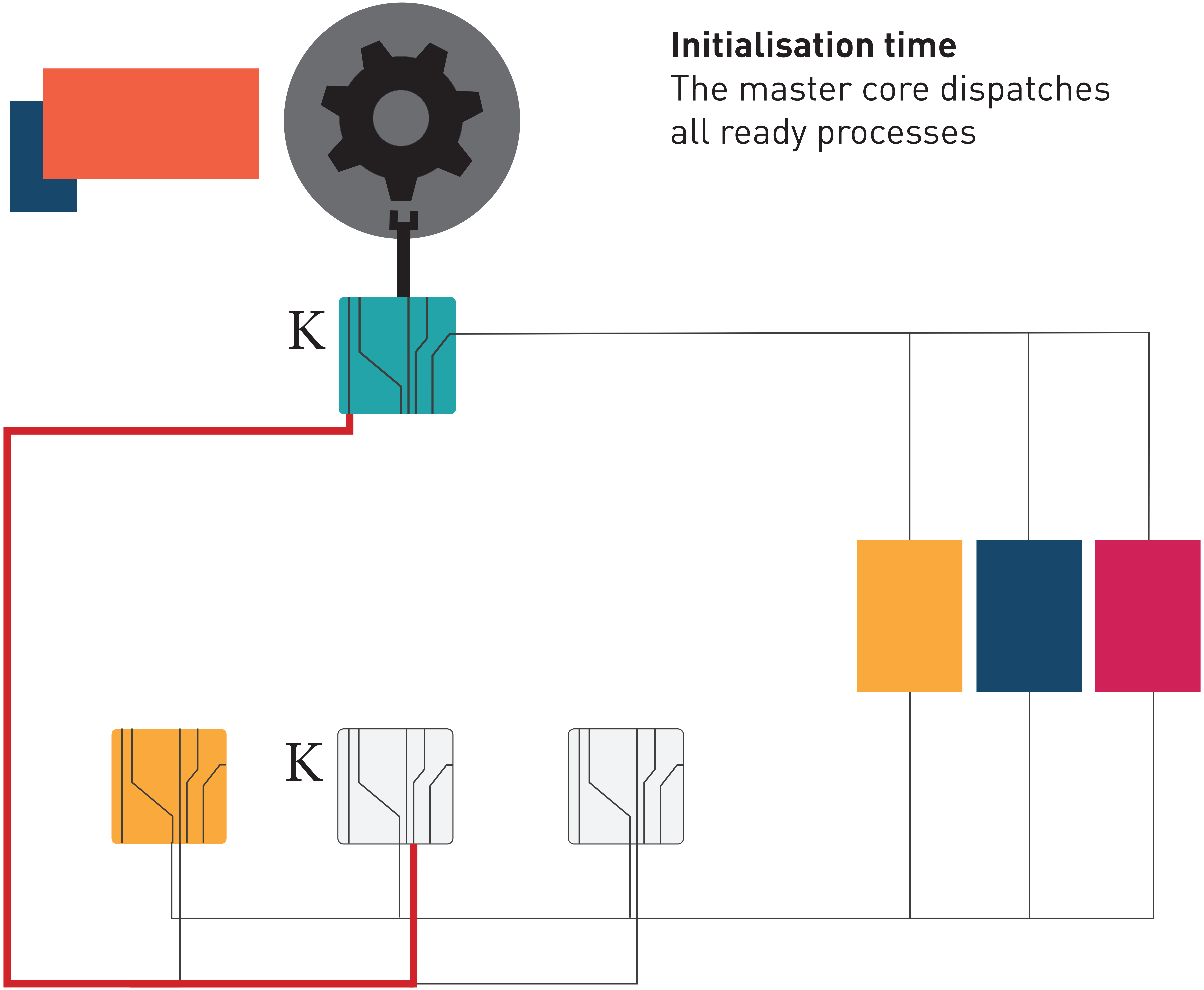

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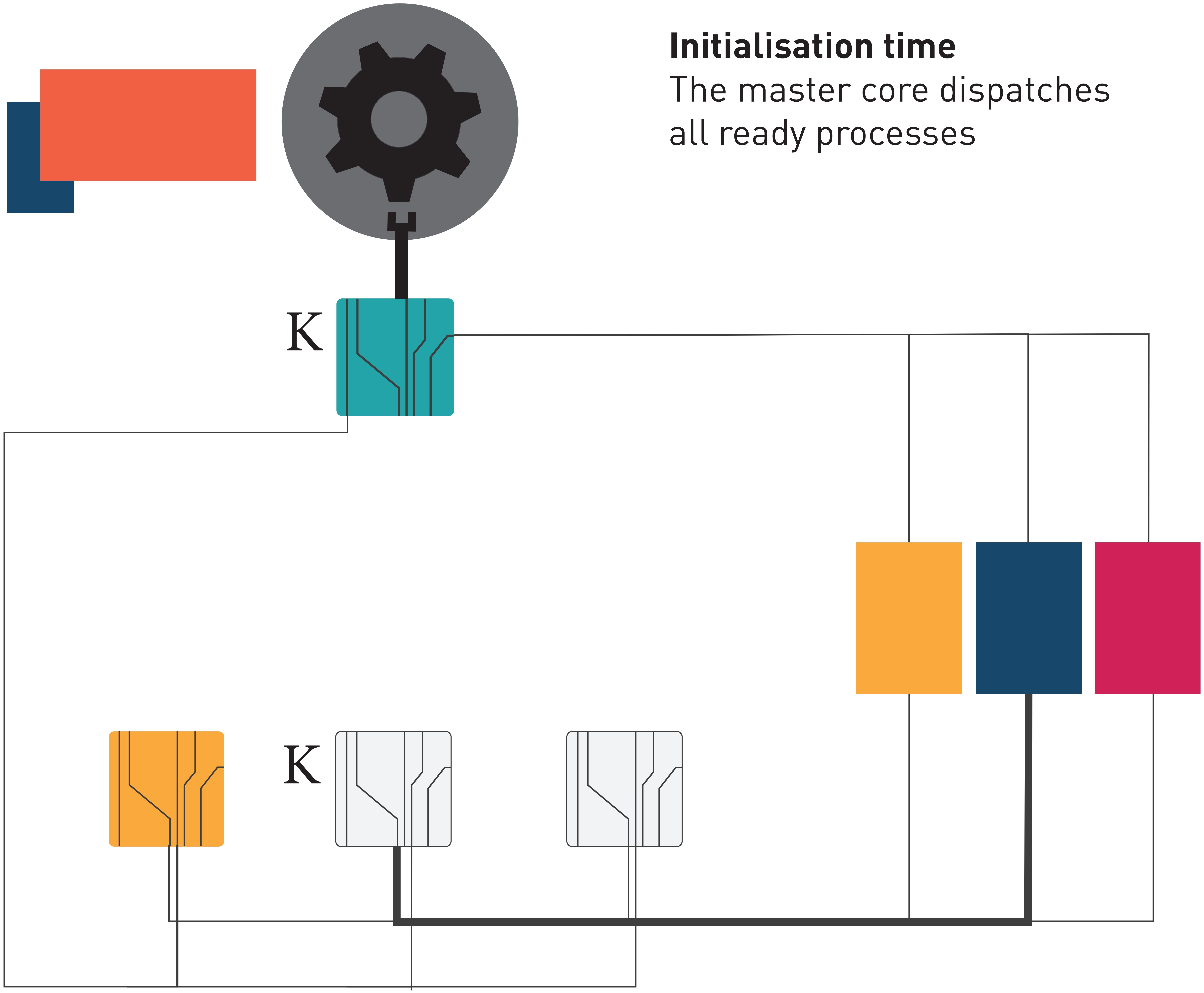

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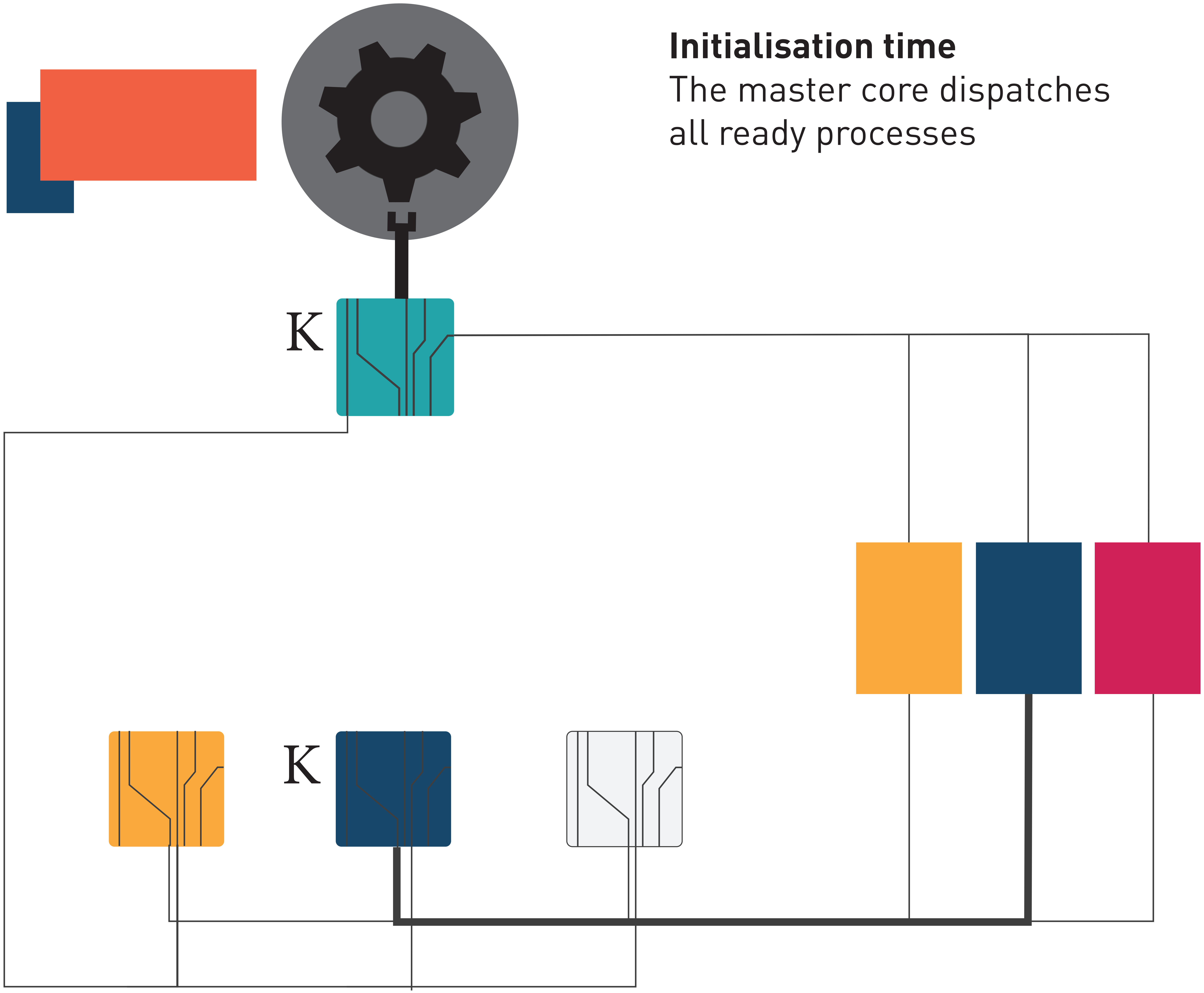

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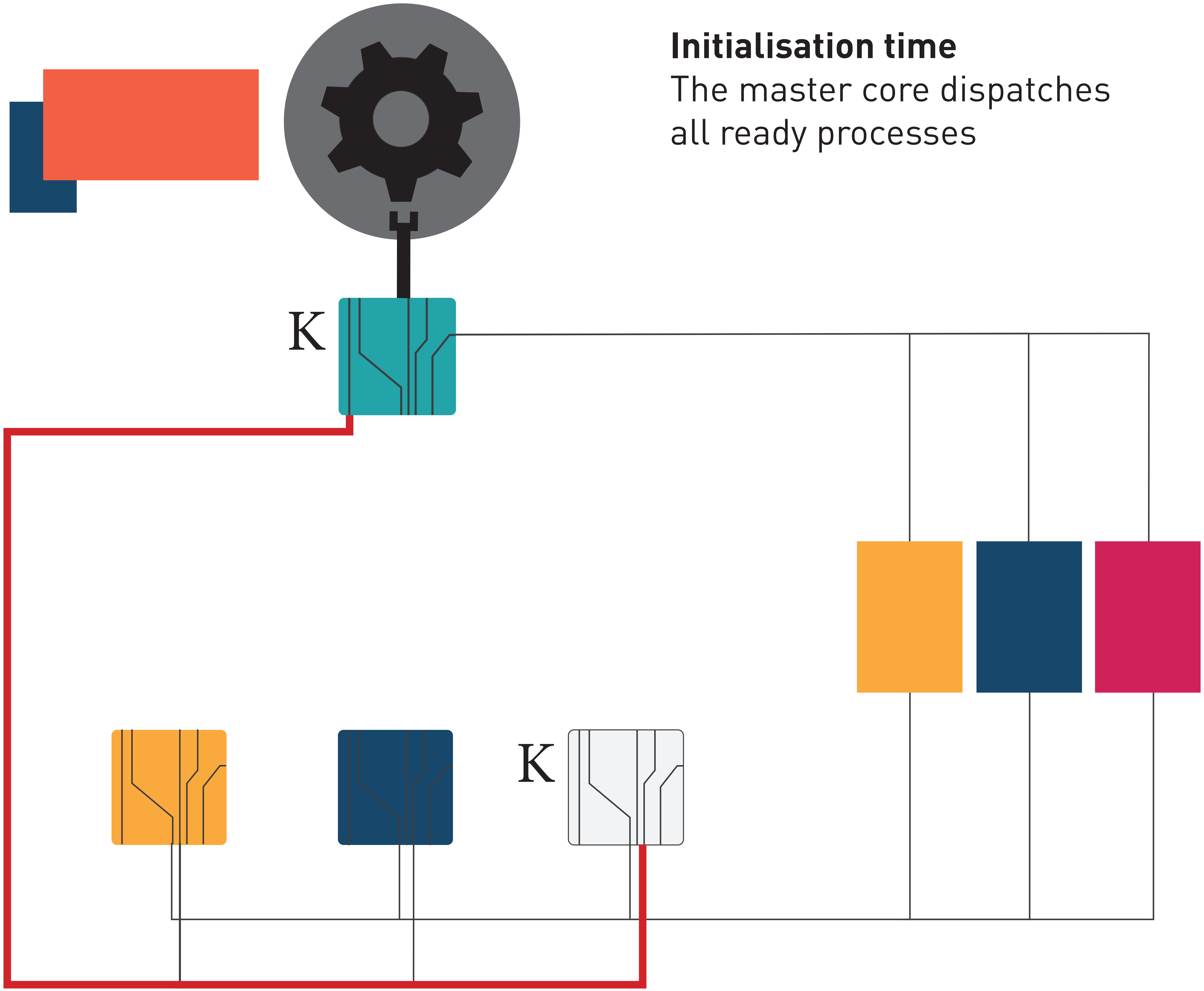

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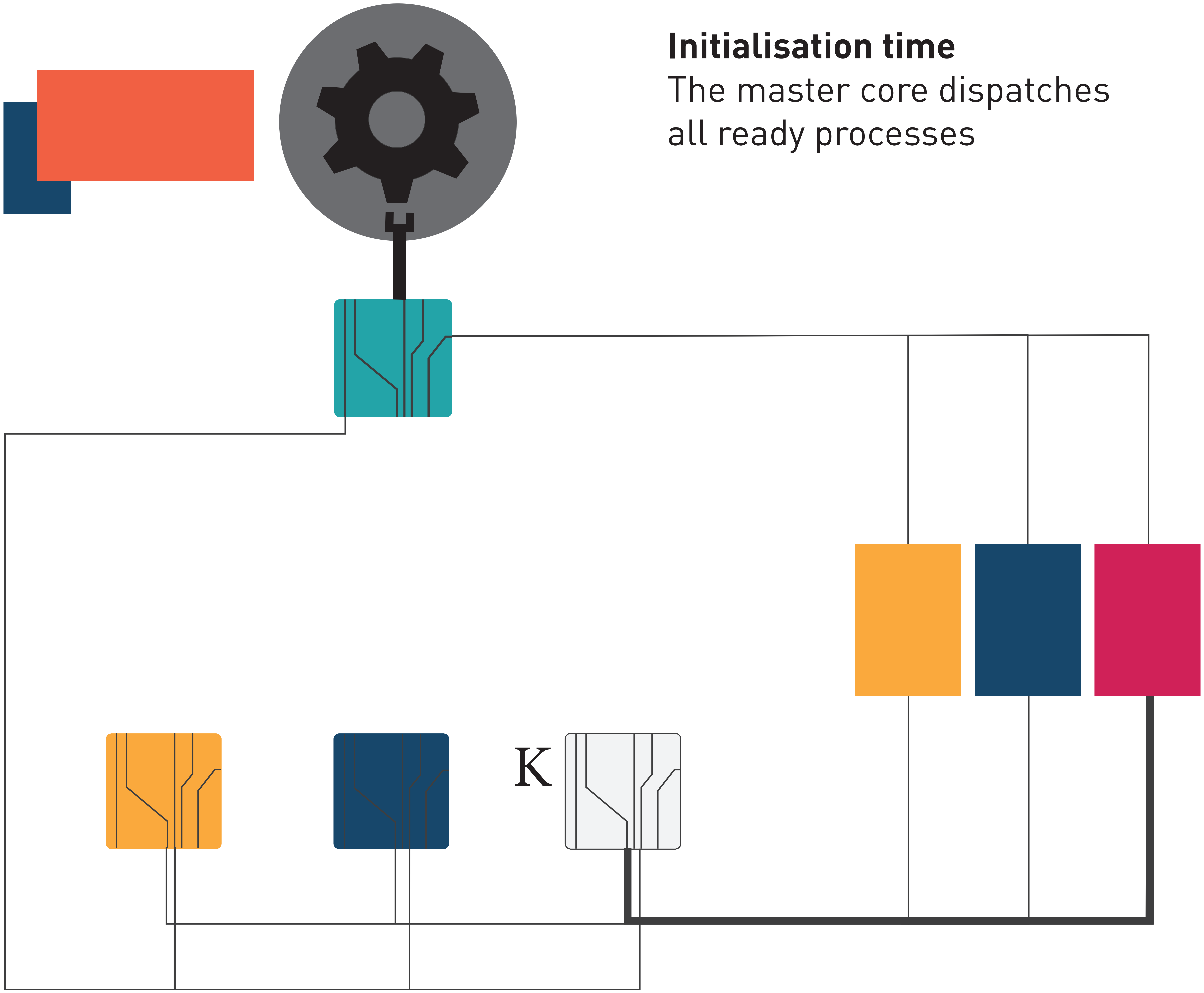

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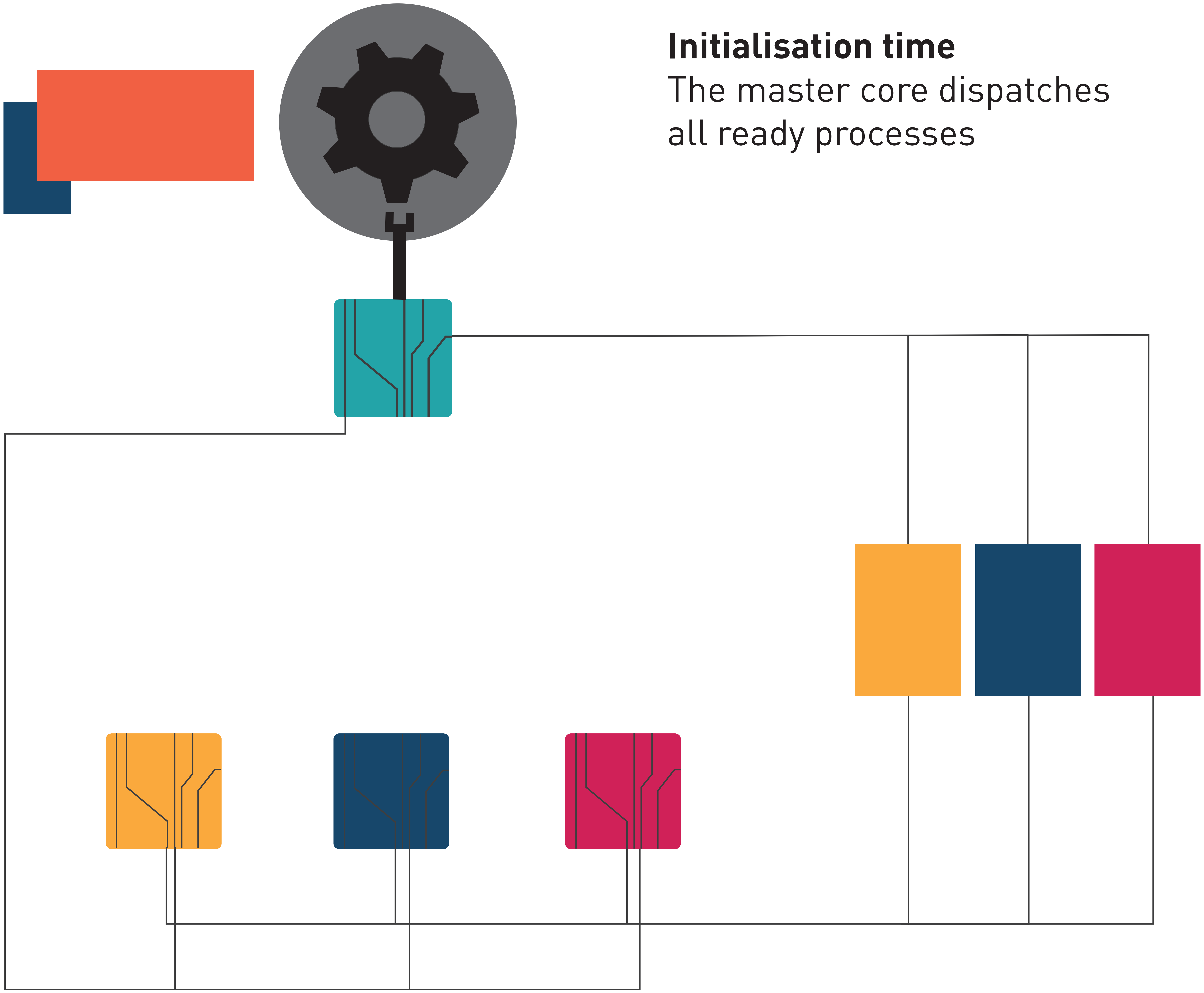

Initialisation time
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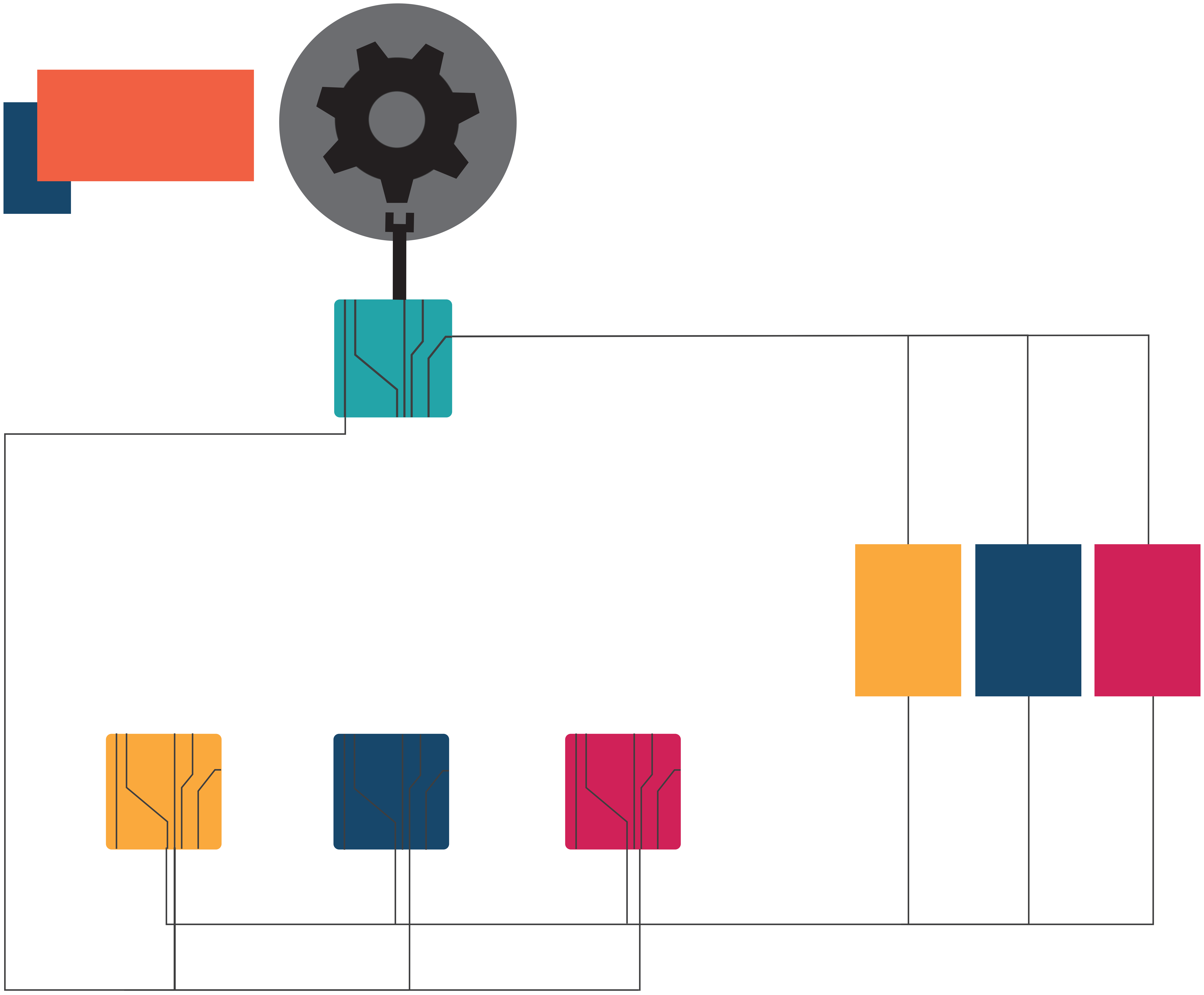
Expected benefits

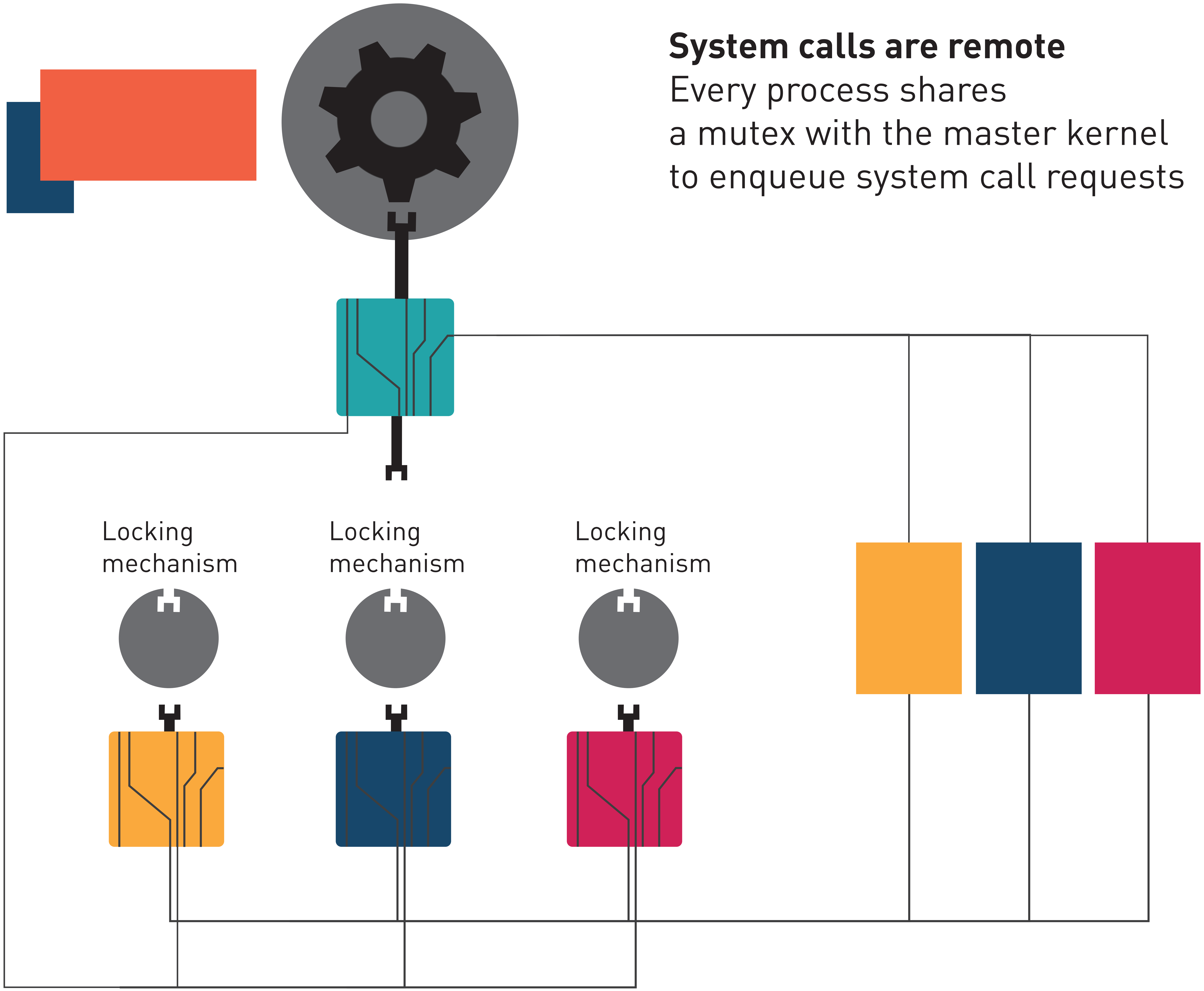
Easier design

Less contention → improved scalability

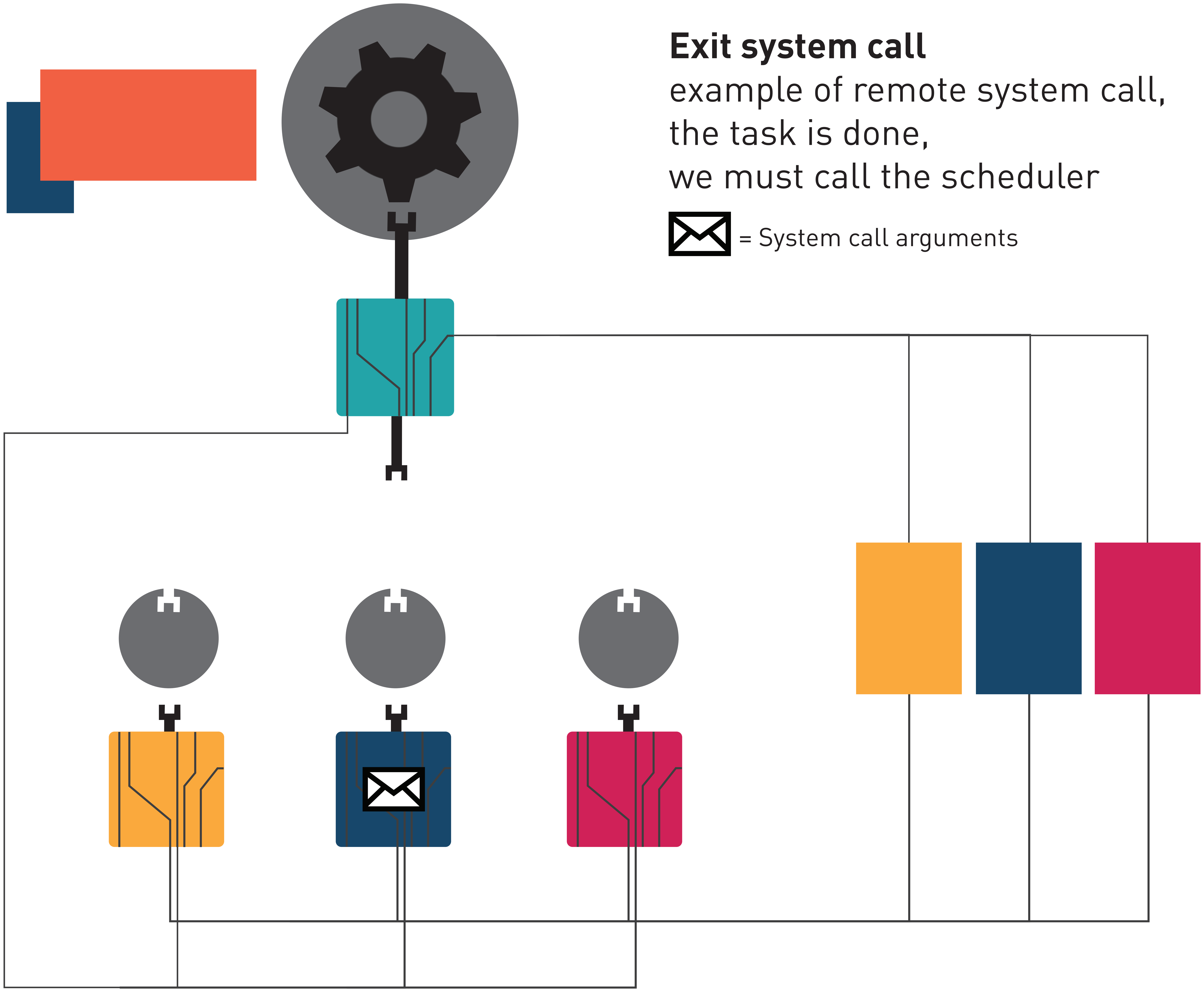
Private code and data → less cache issues

Remote system calls: `exit()`





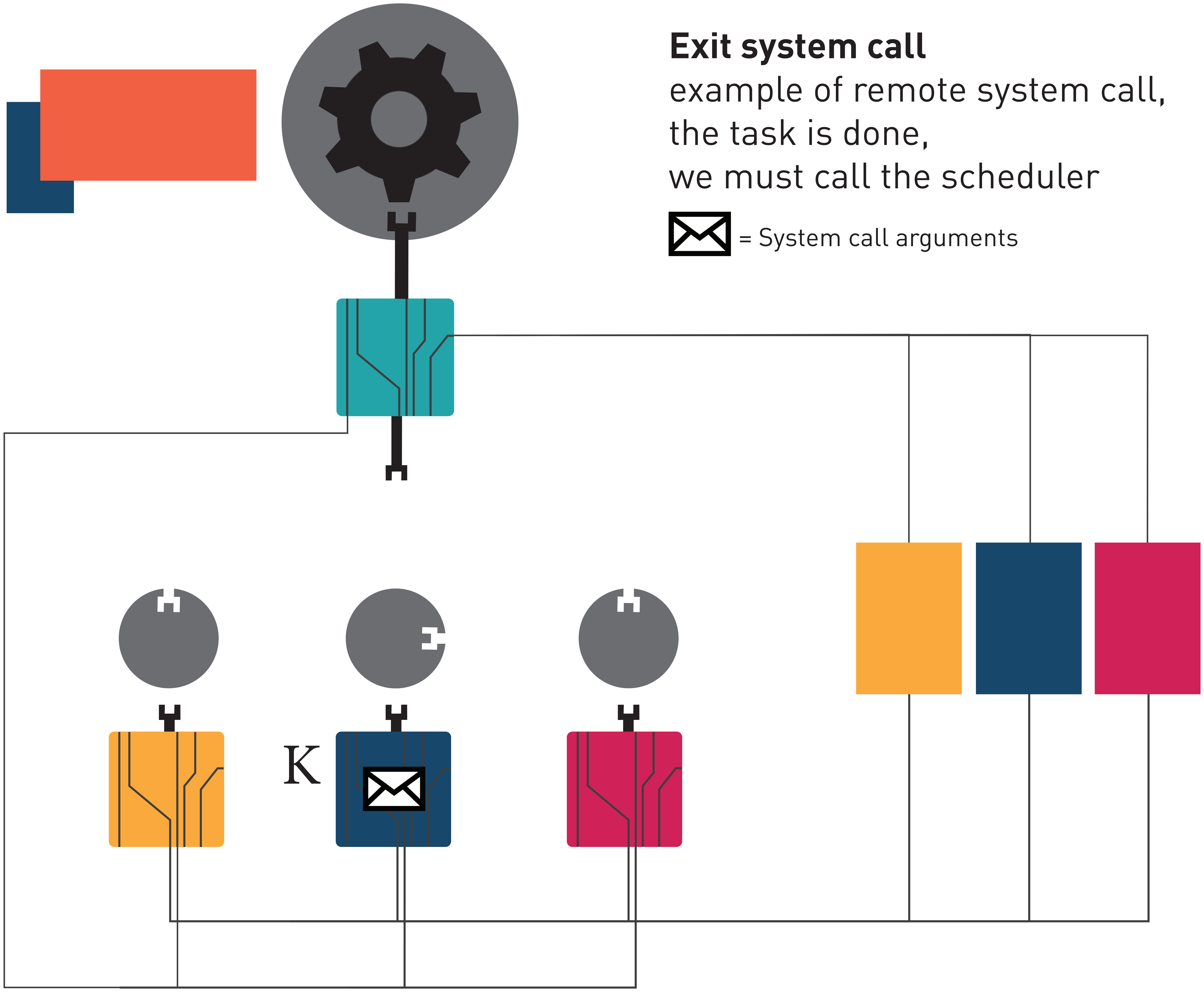
System calls are remote
Every process shares
a mutex with the master kernel
to enqueue system call requests



Exit system call

example of remote system call,
the task is done,
we must call the scheduler

✉ = System call arguments



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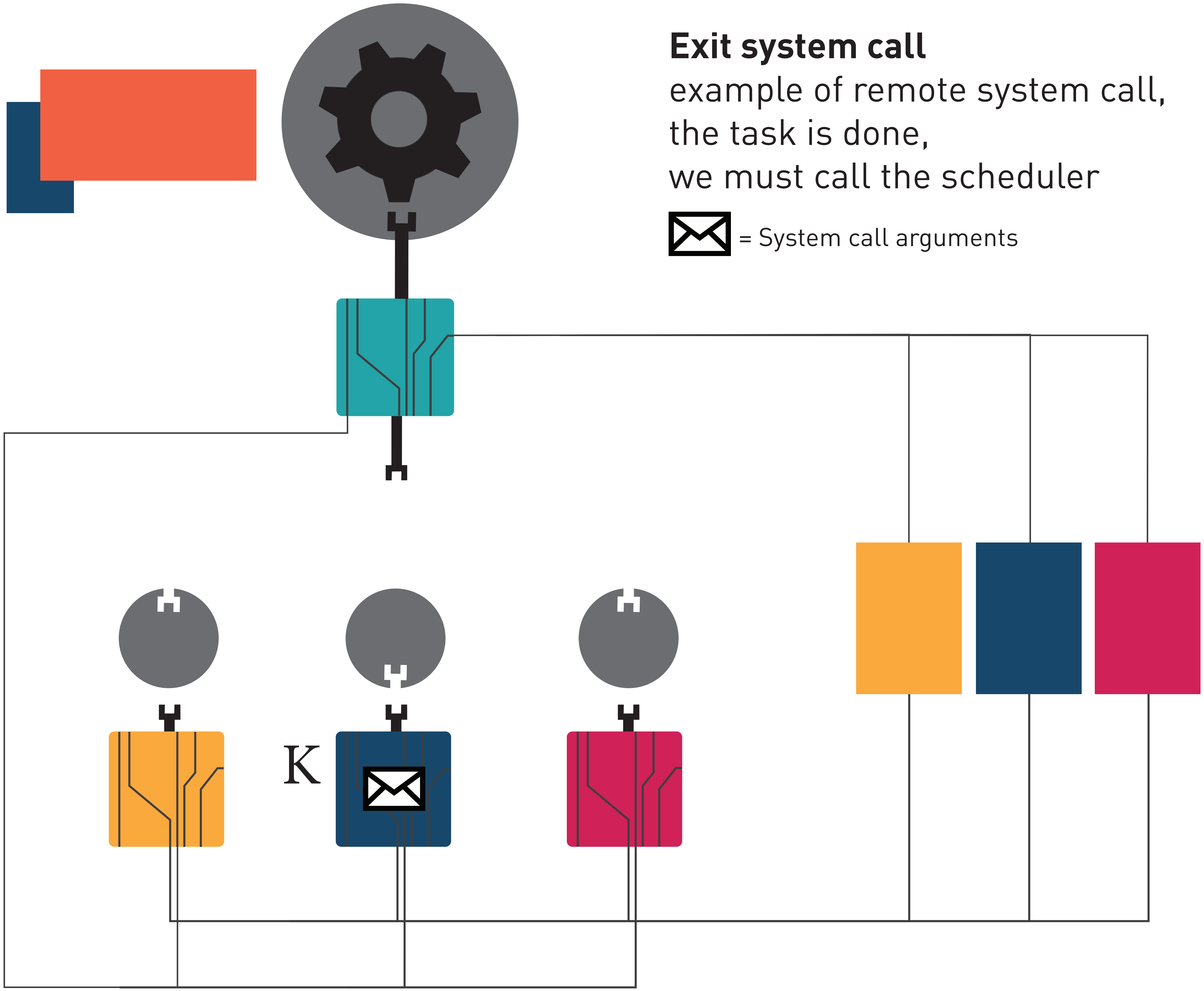

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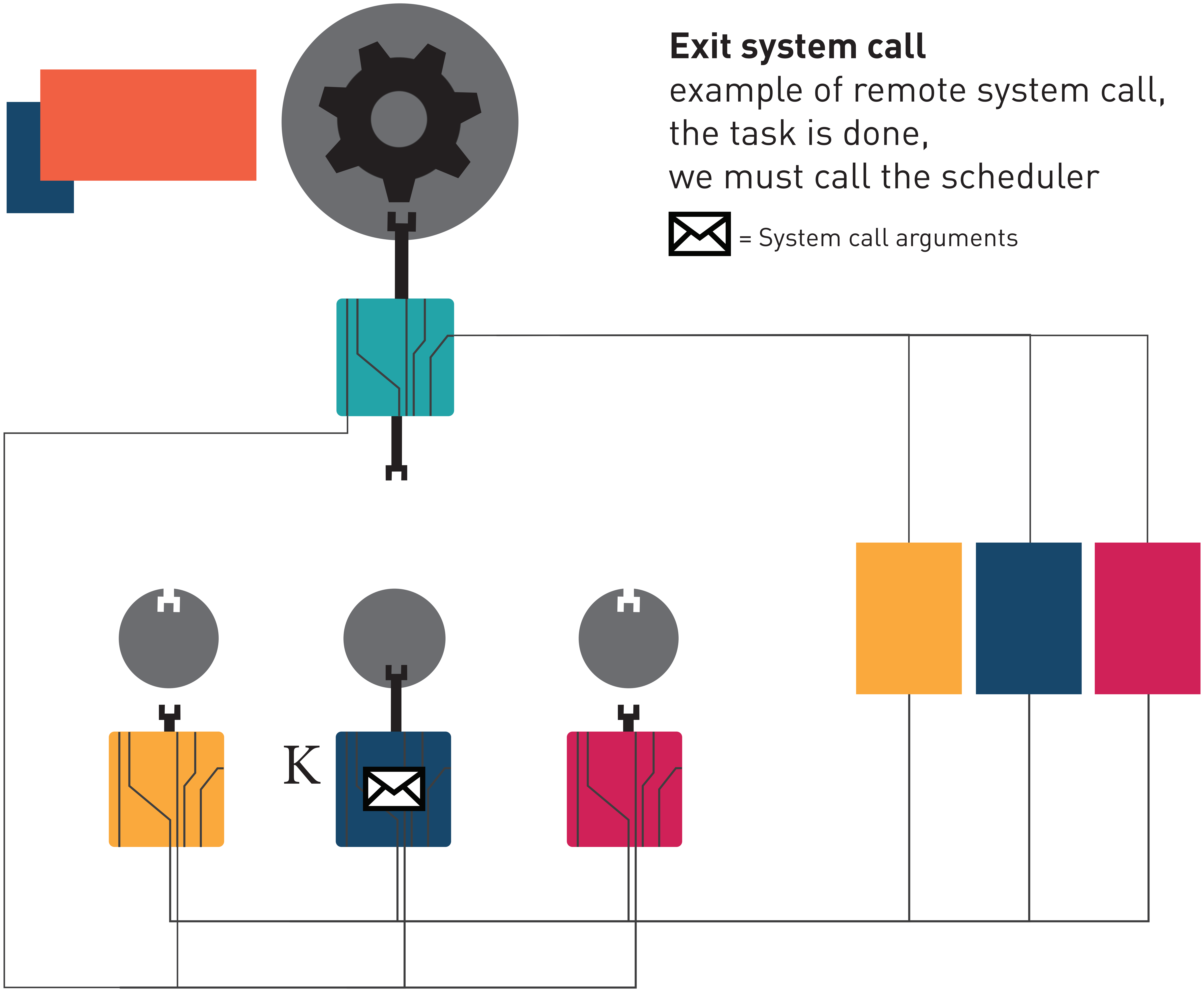

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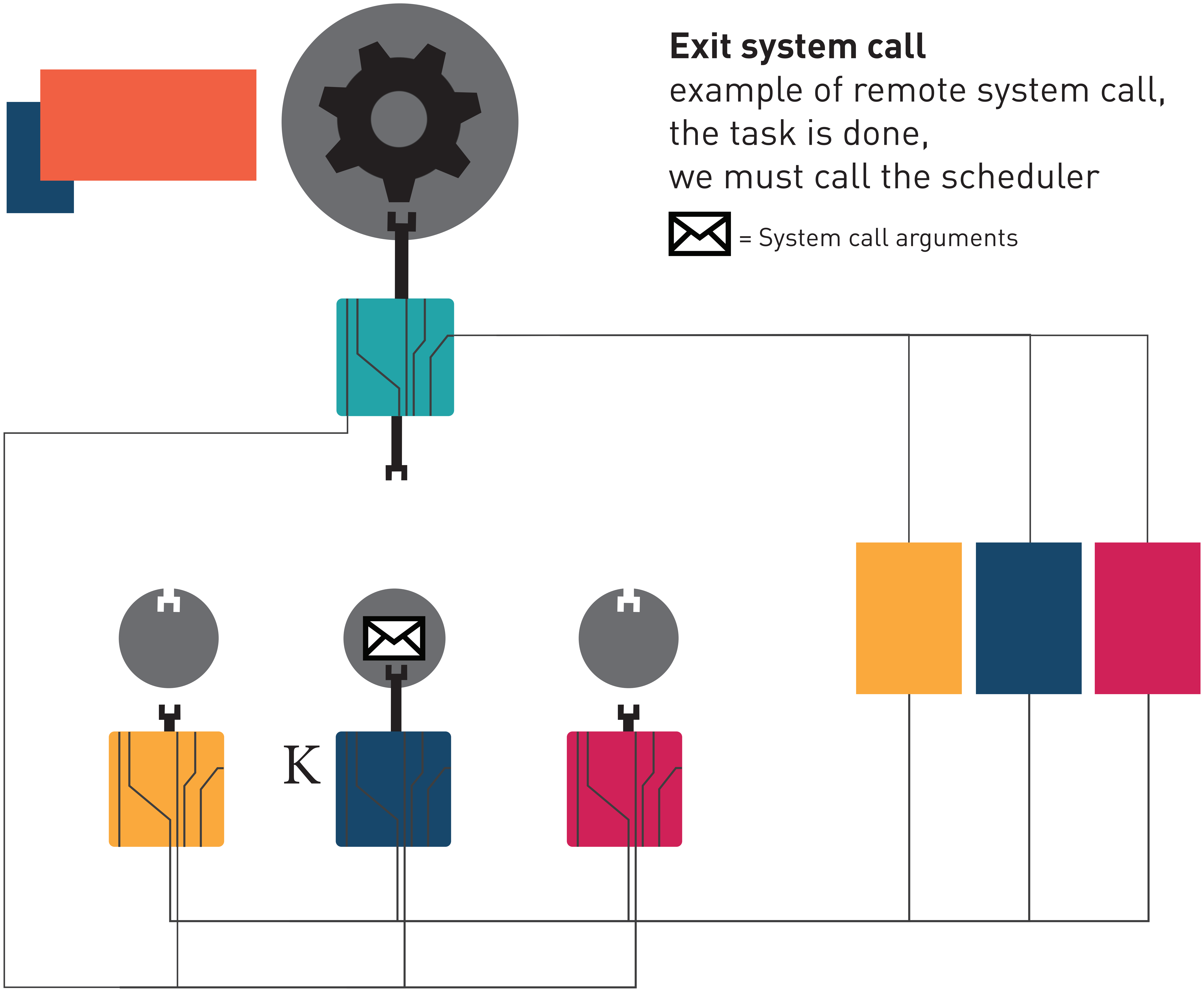

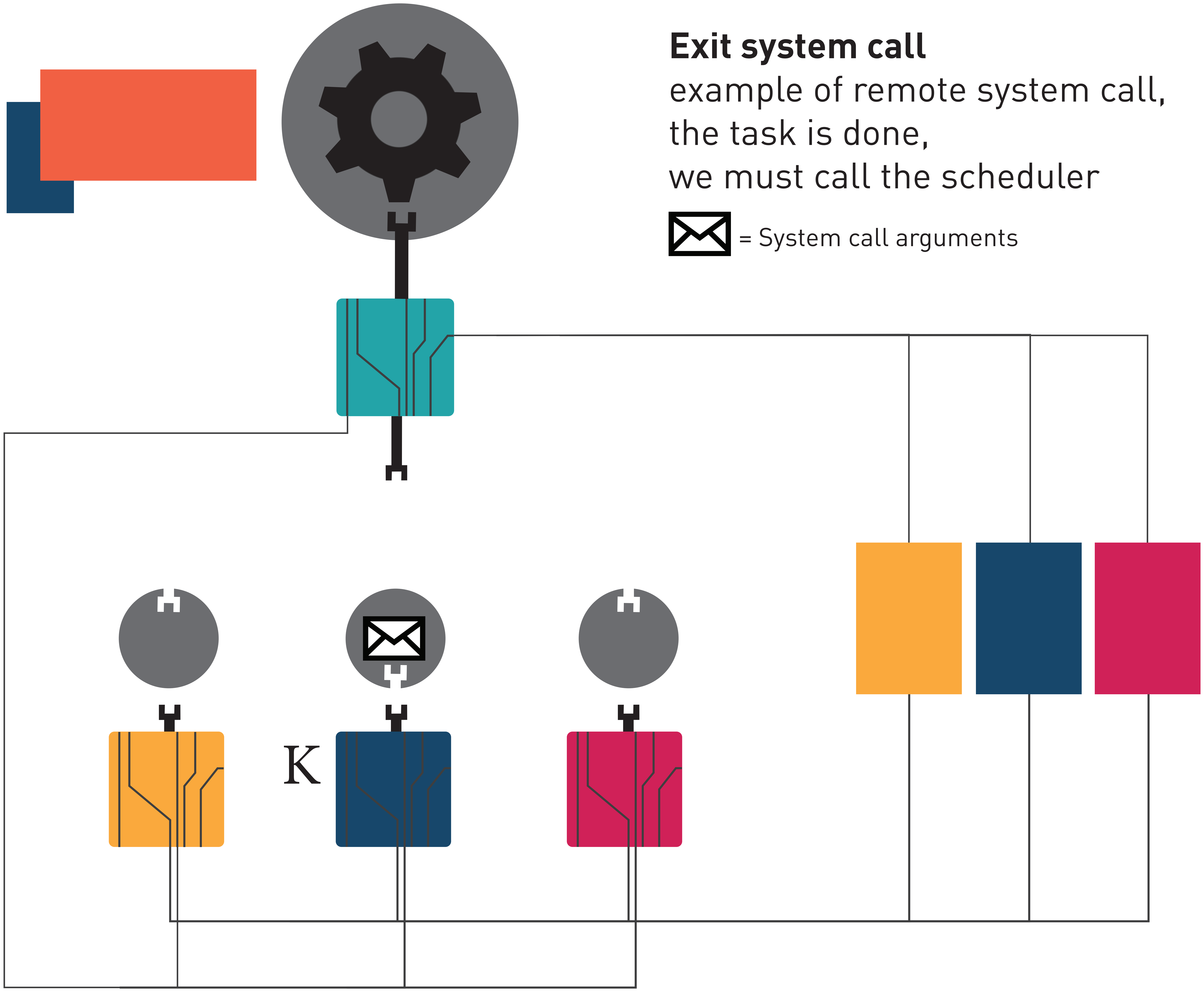

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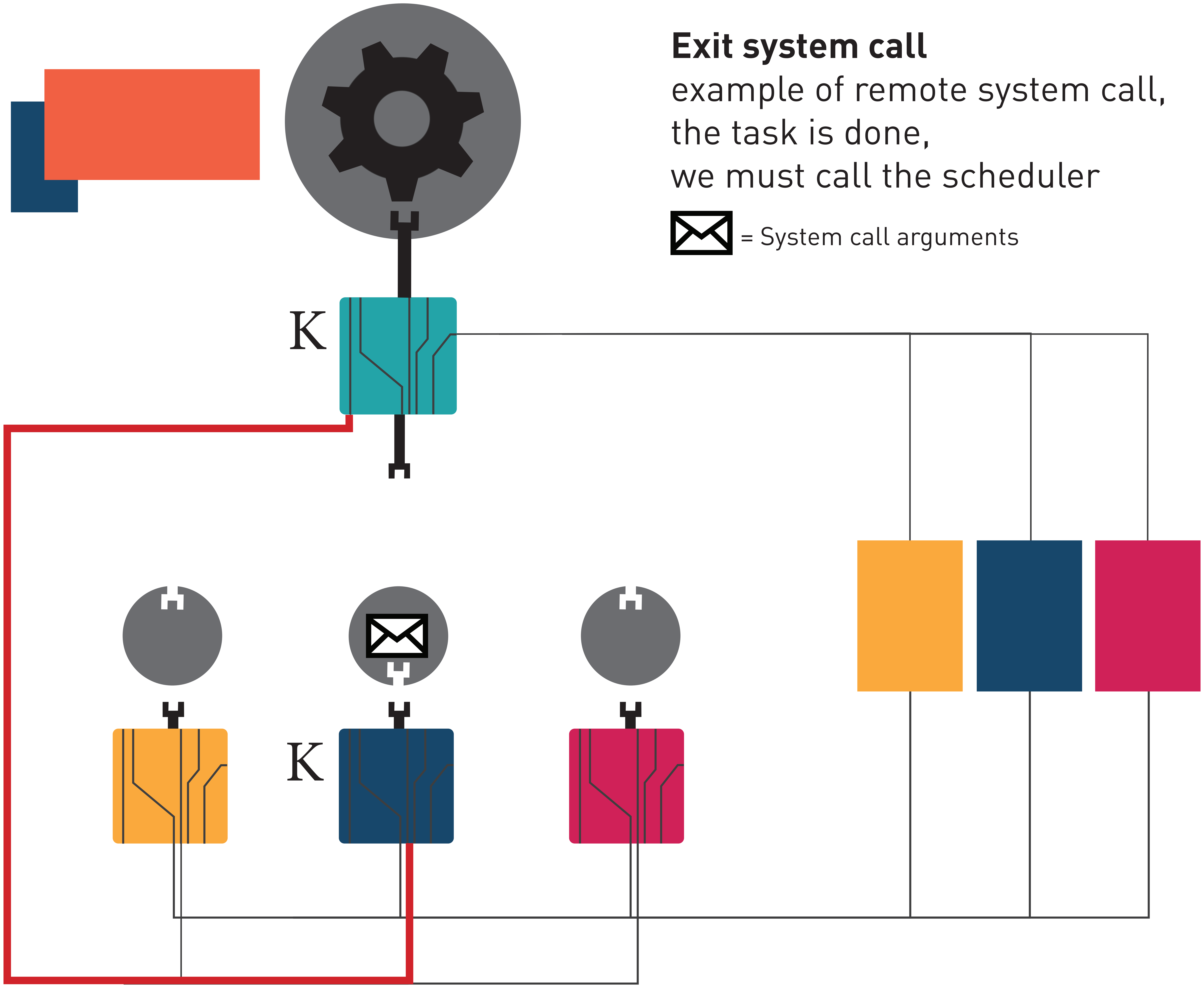

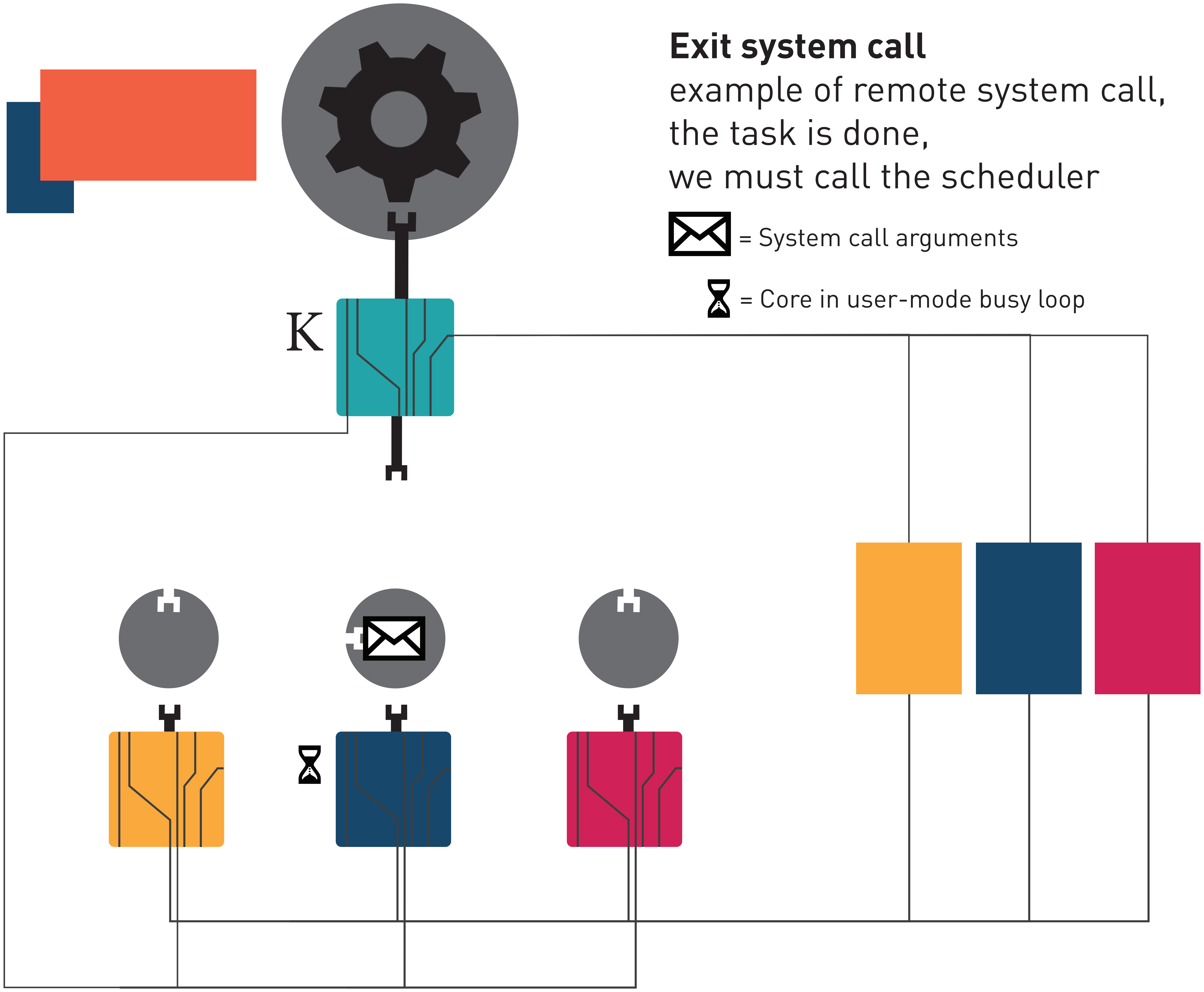

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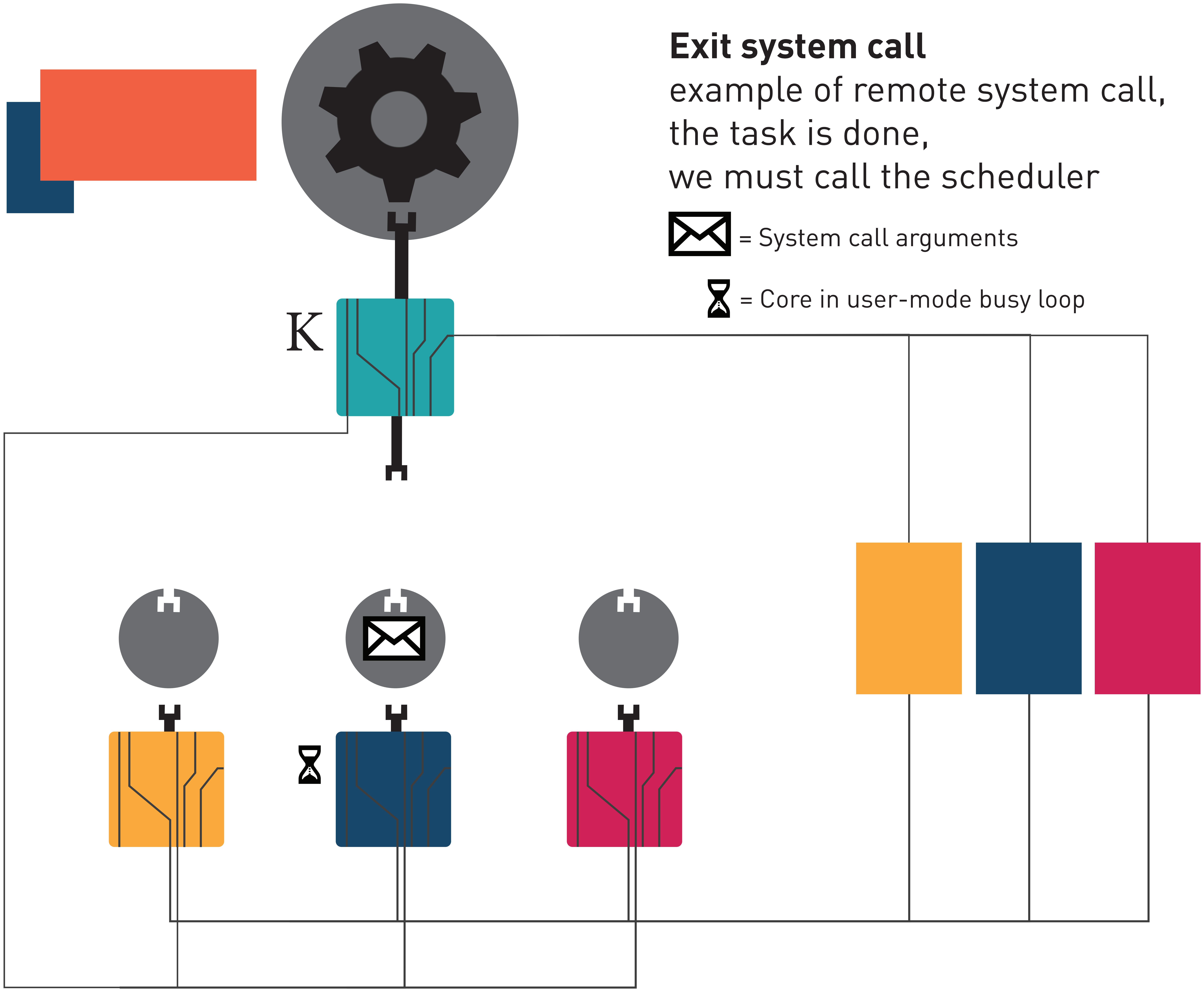

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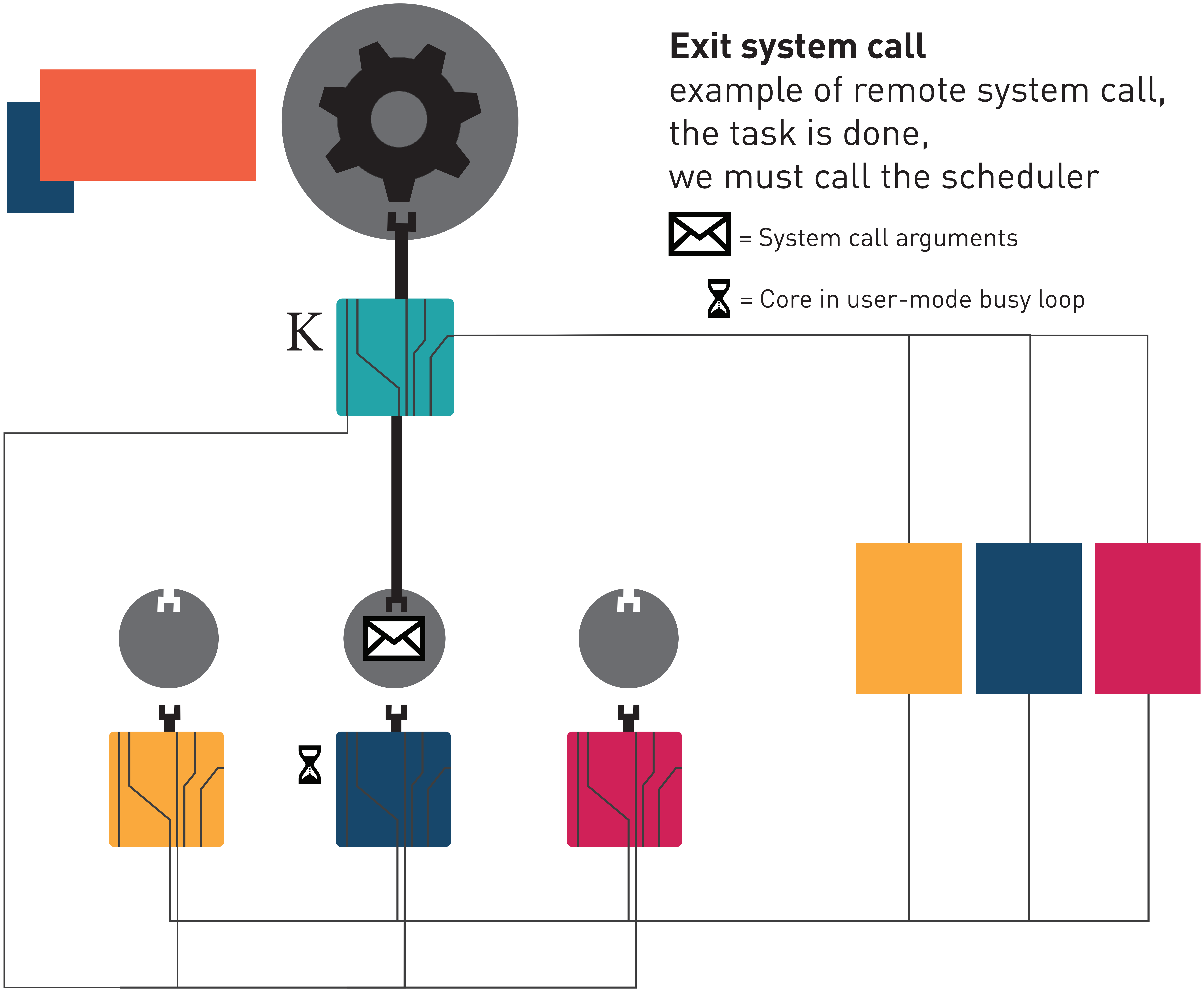

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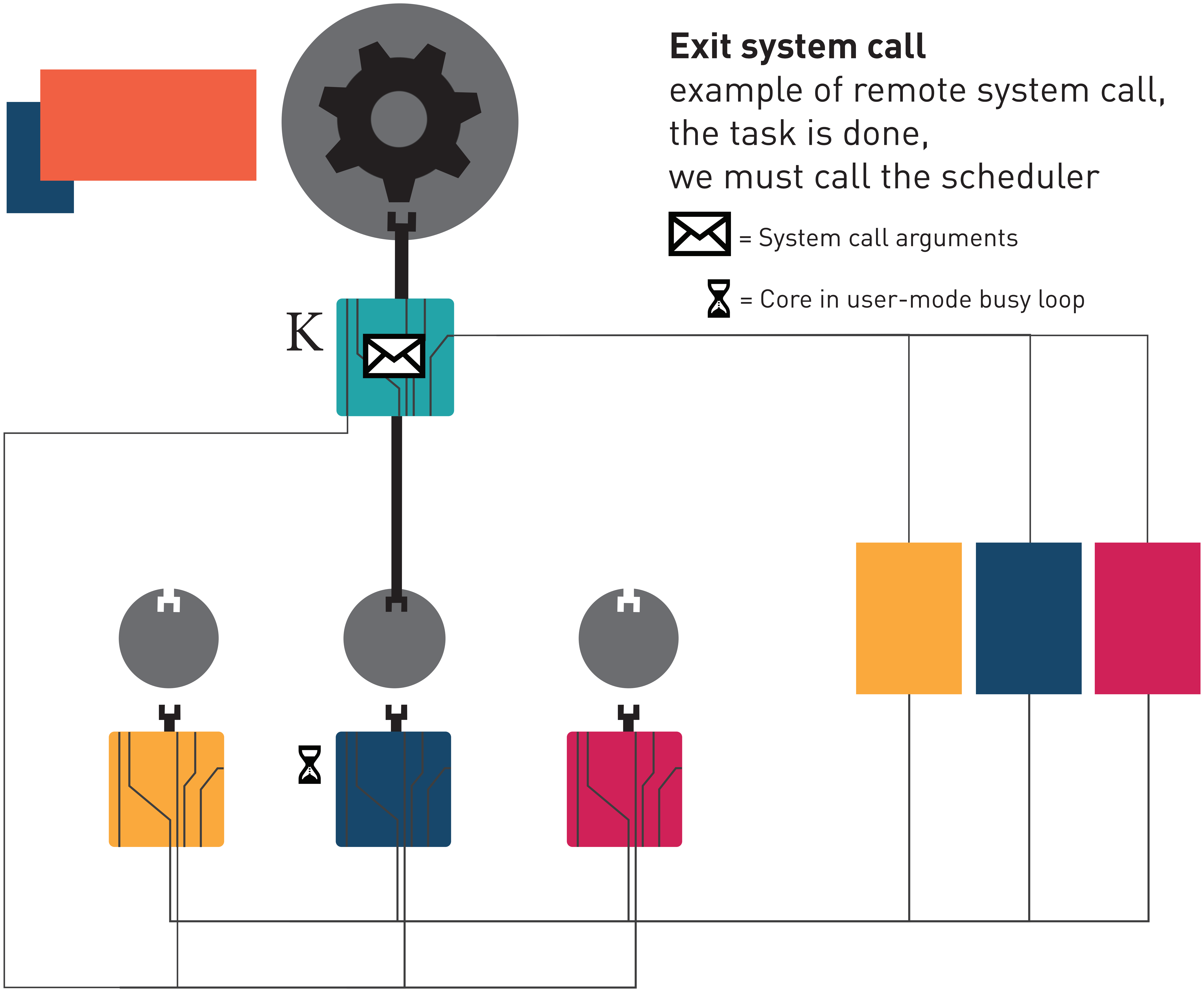

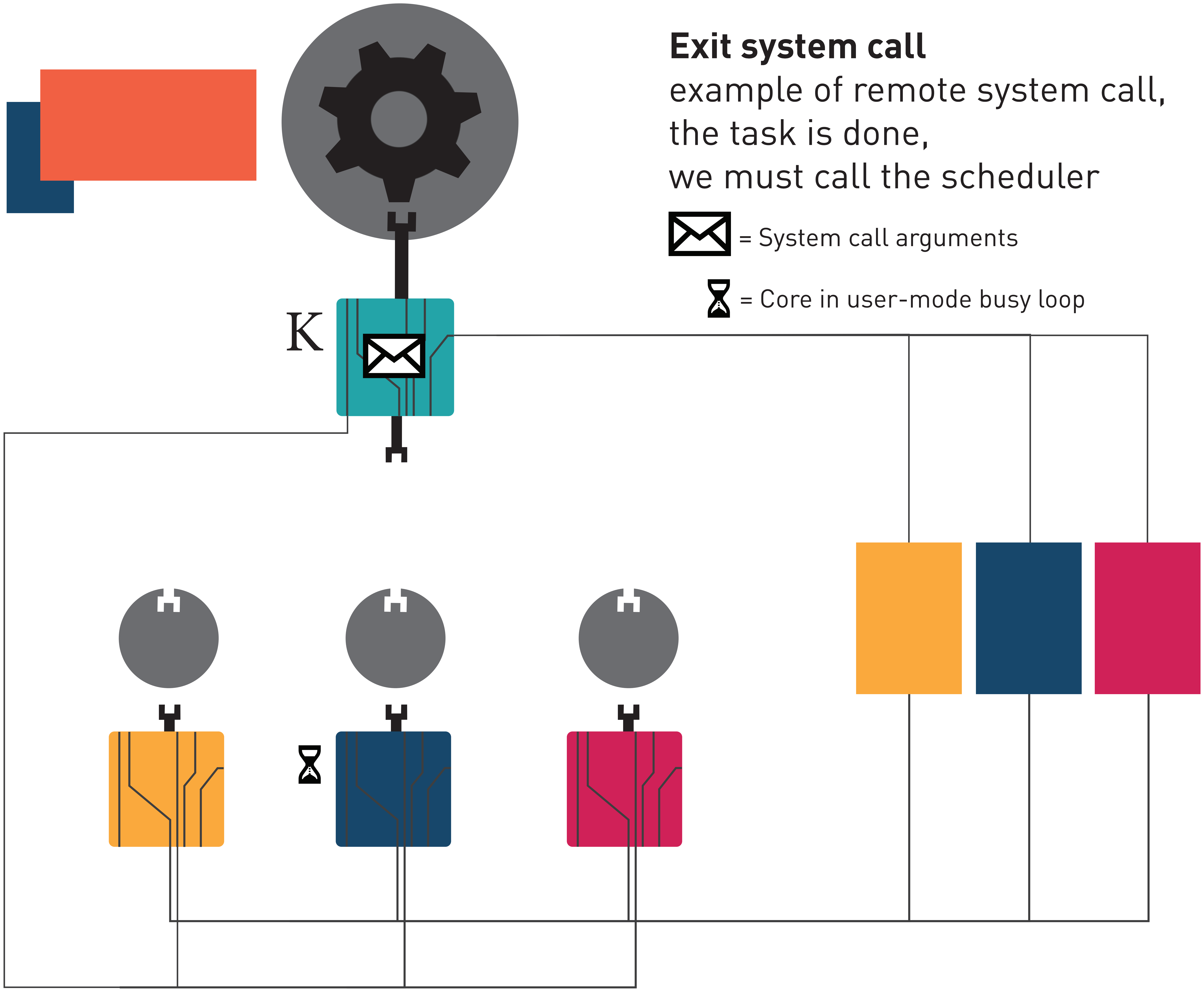

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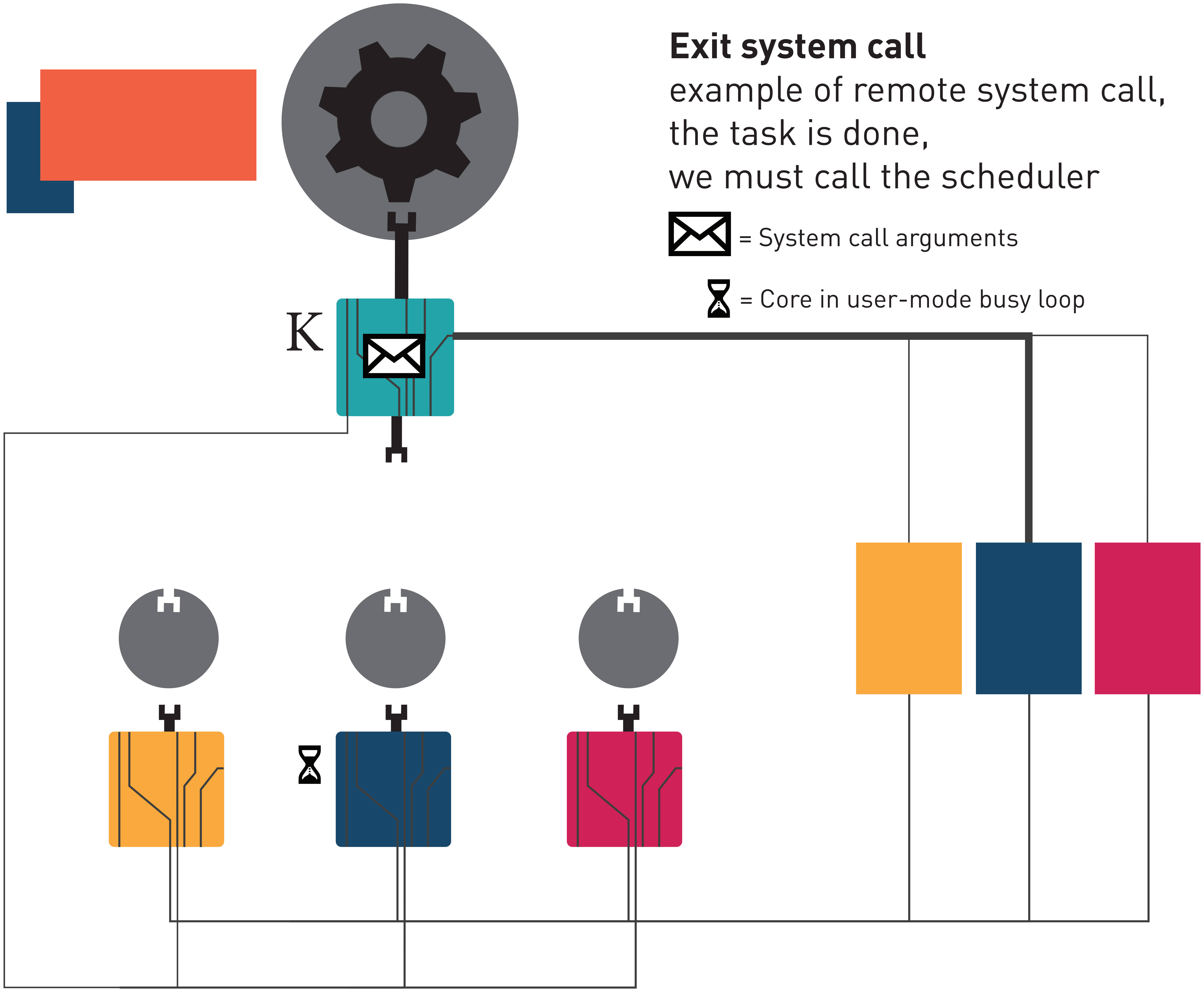

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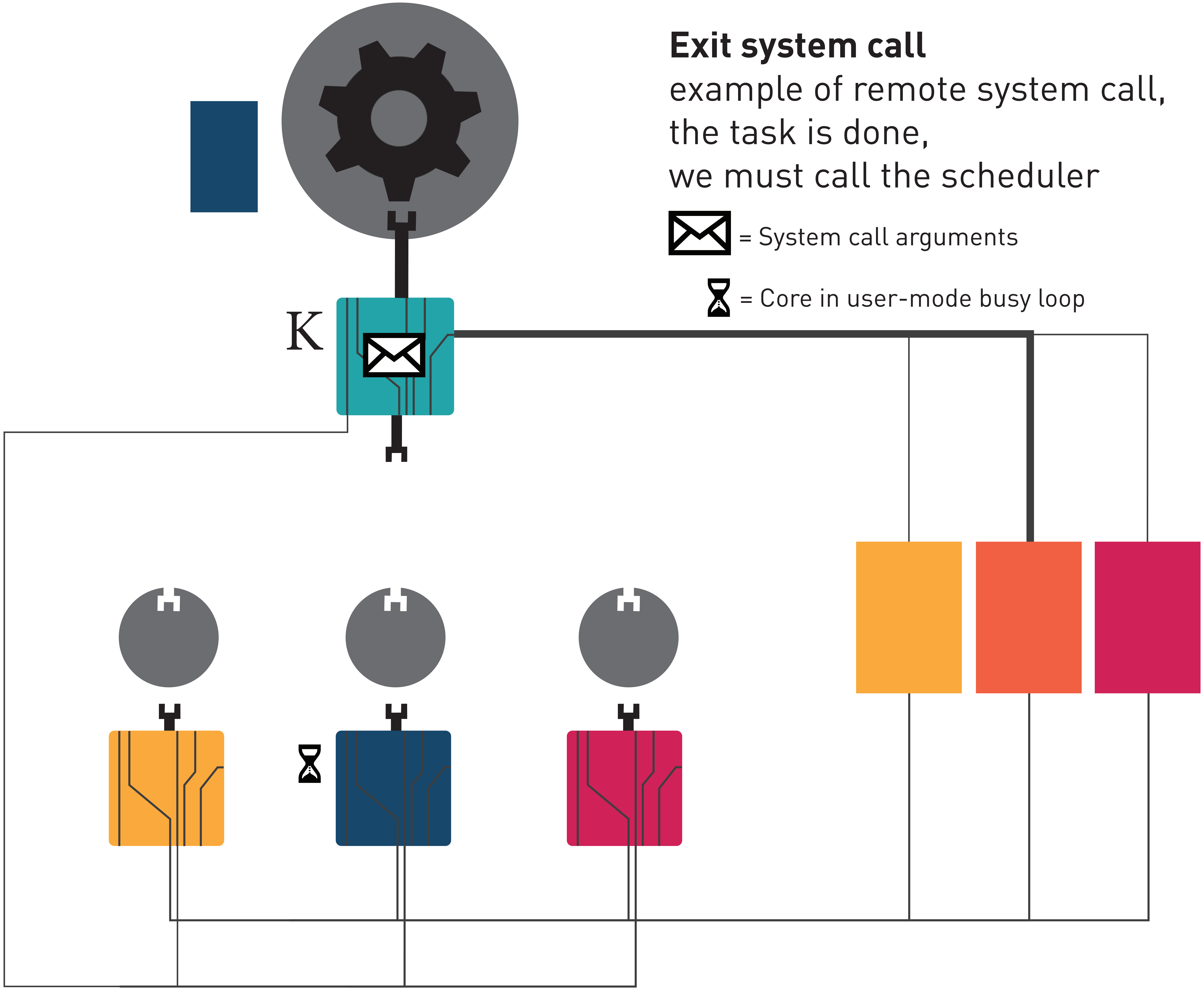

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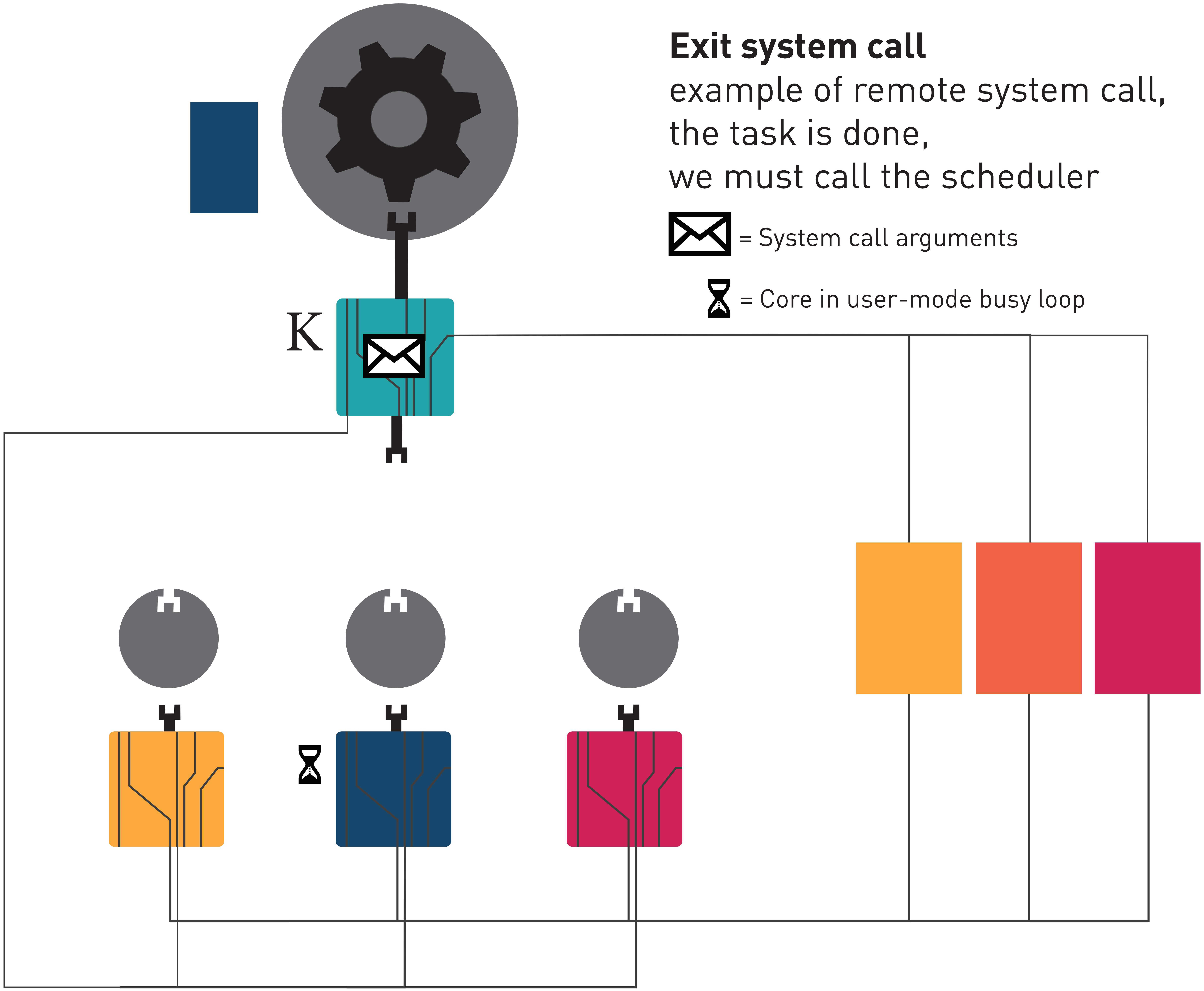

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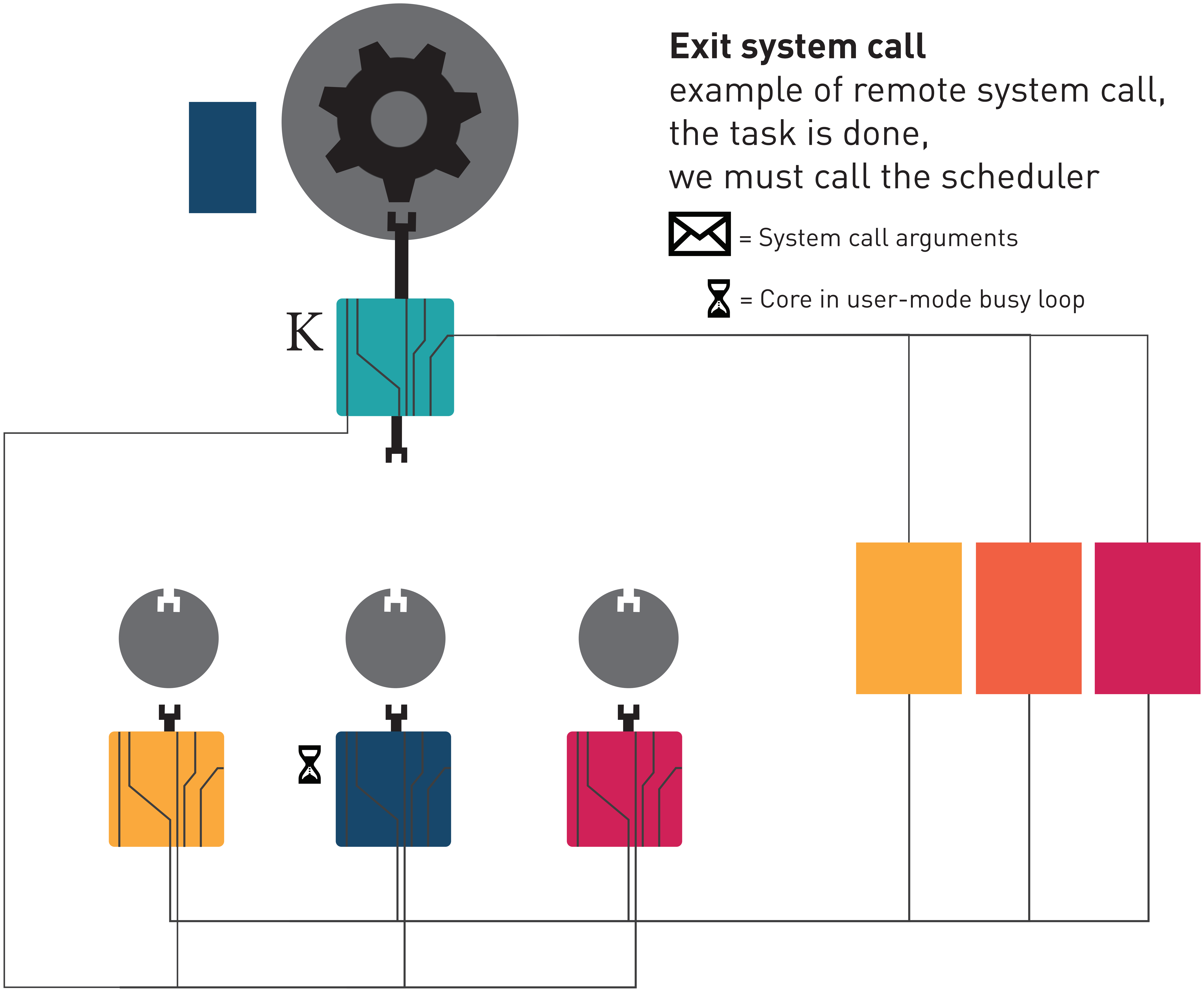
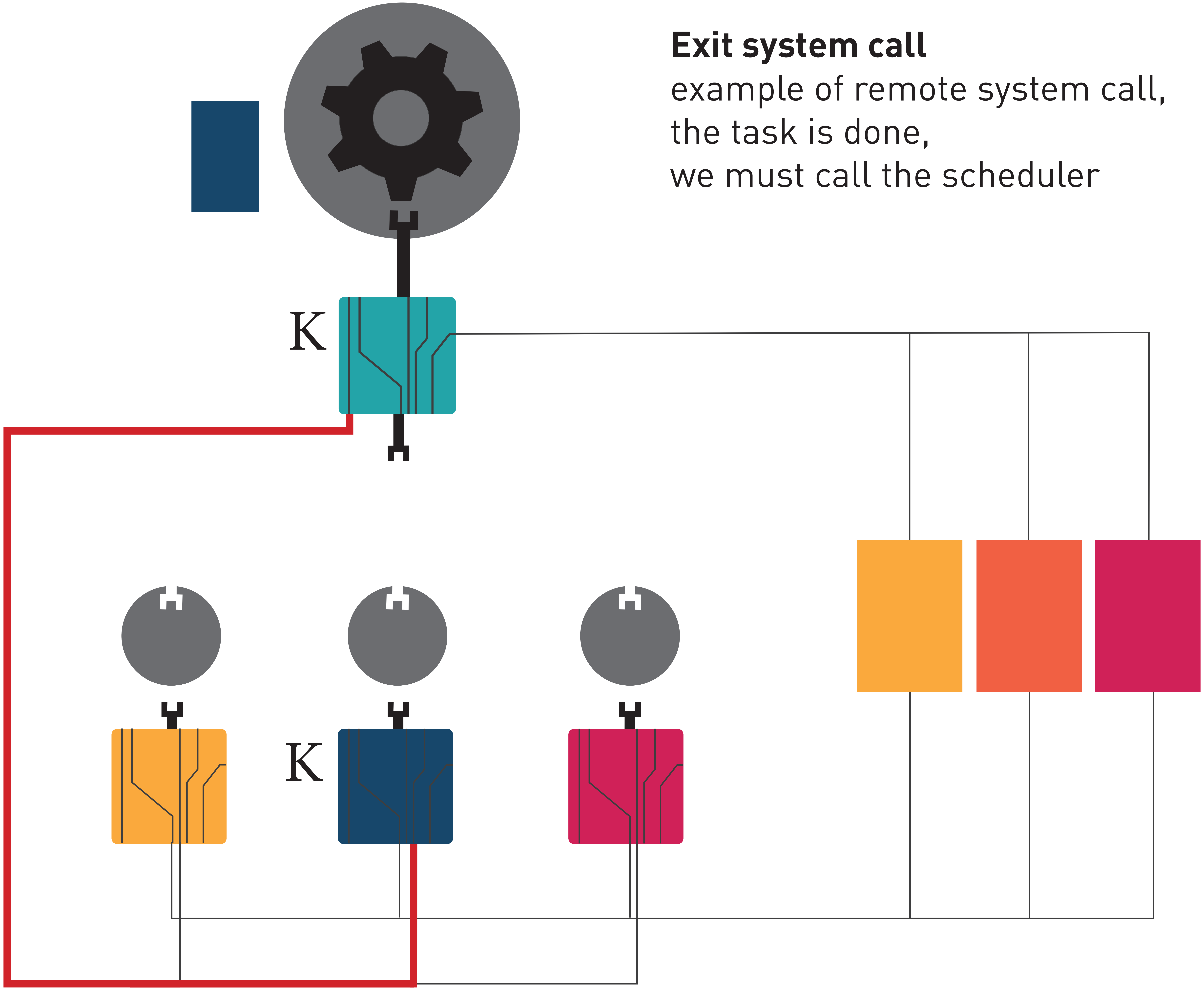
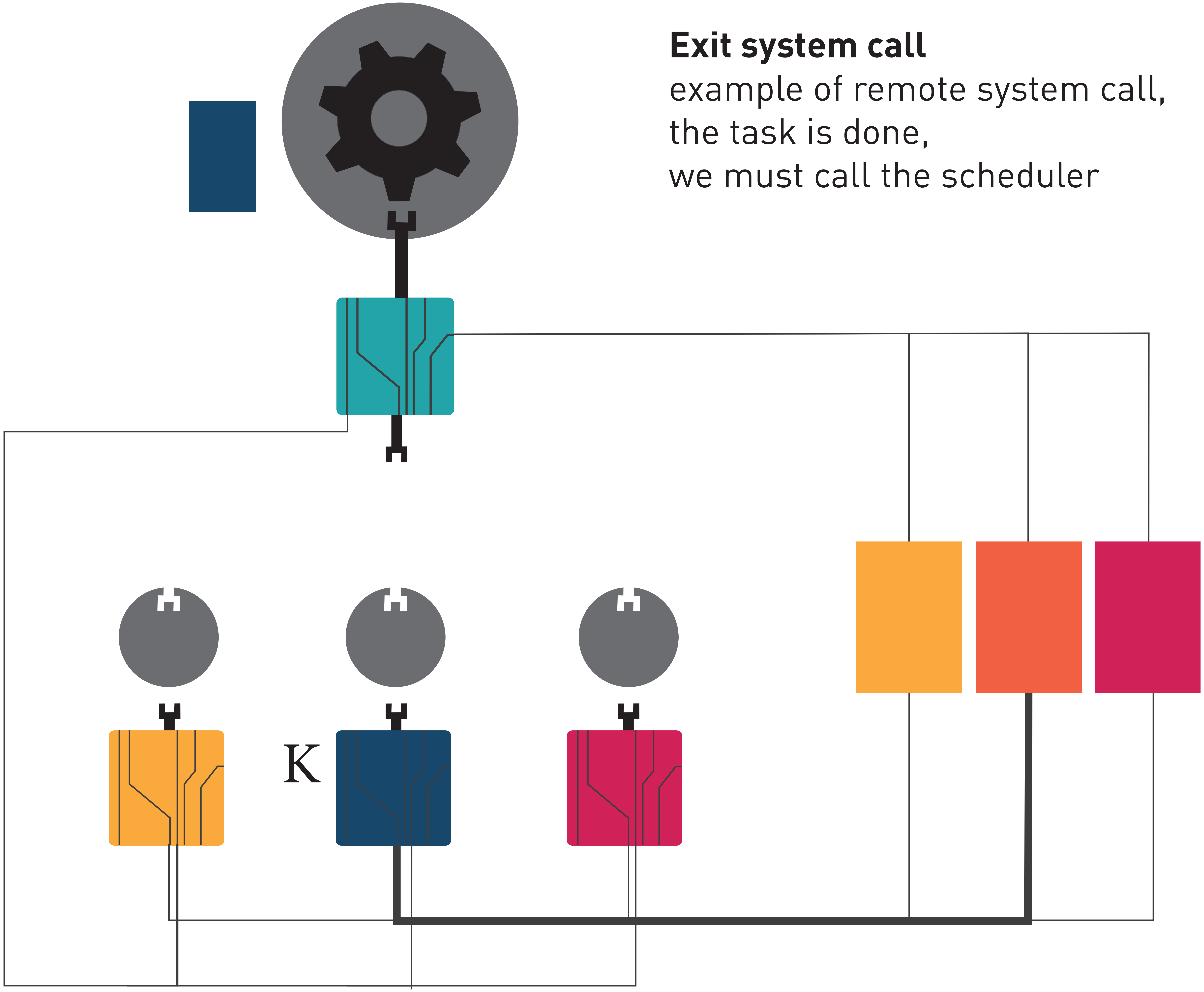


Exit system call

example of remote system call,
the task is done,
we must call the scheduler





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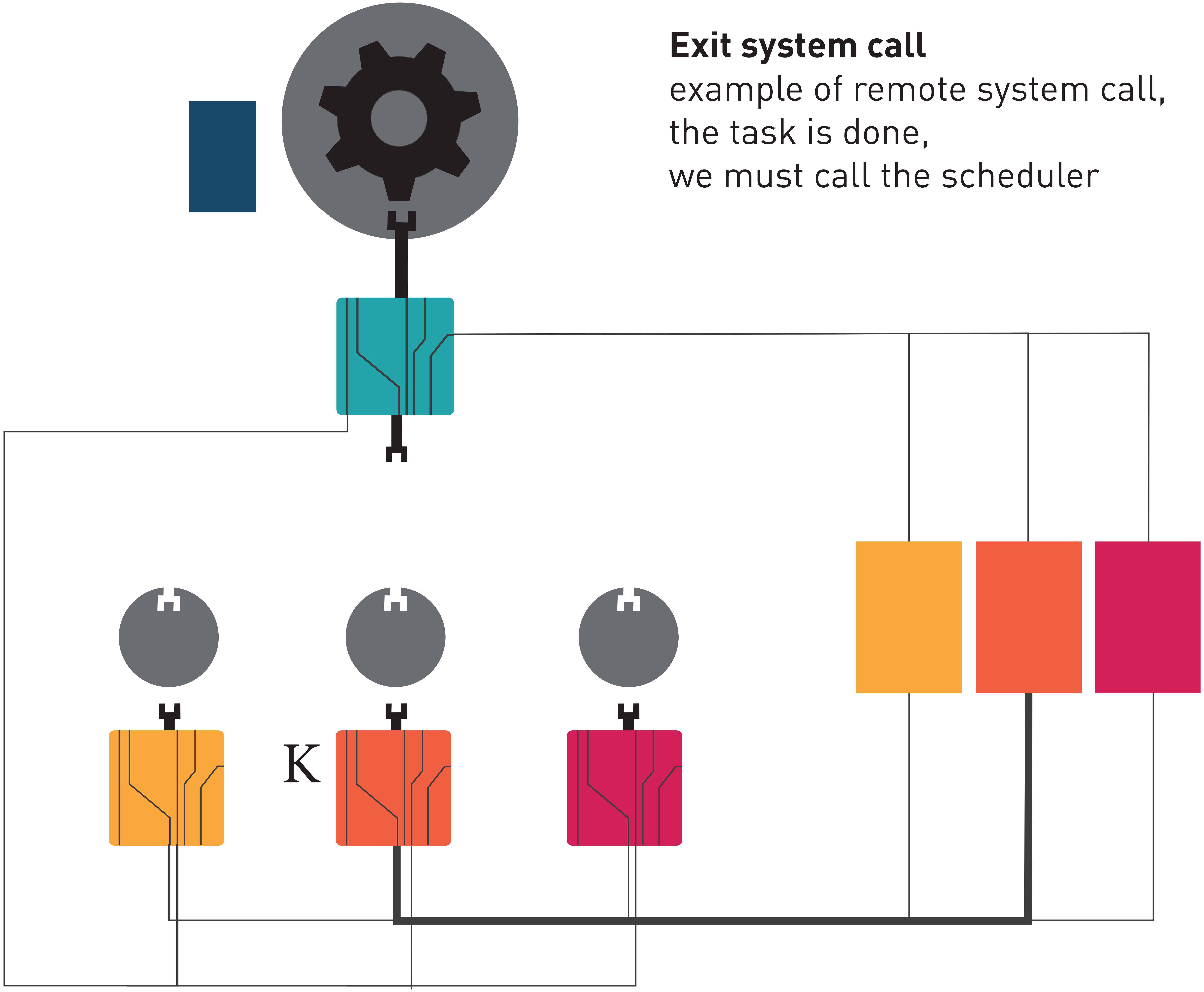

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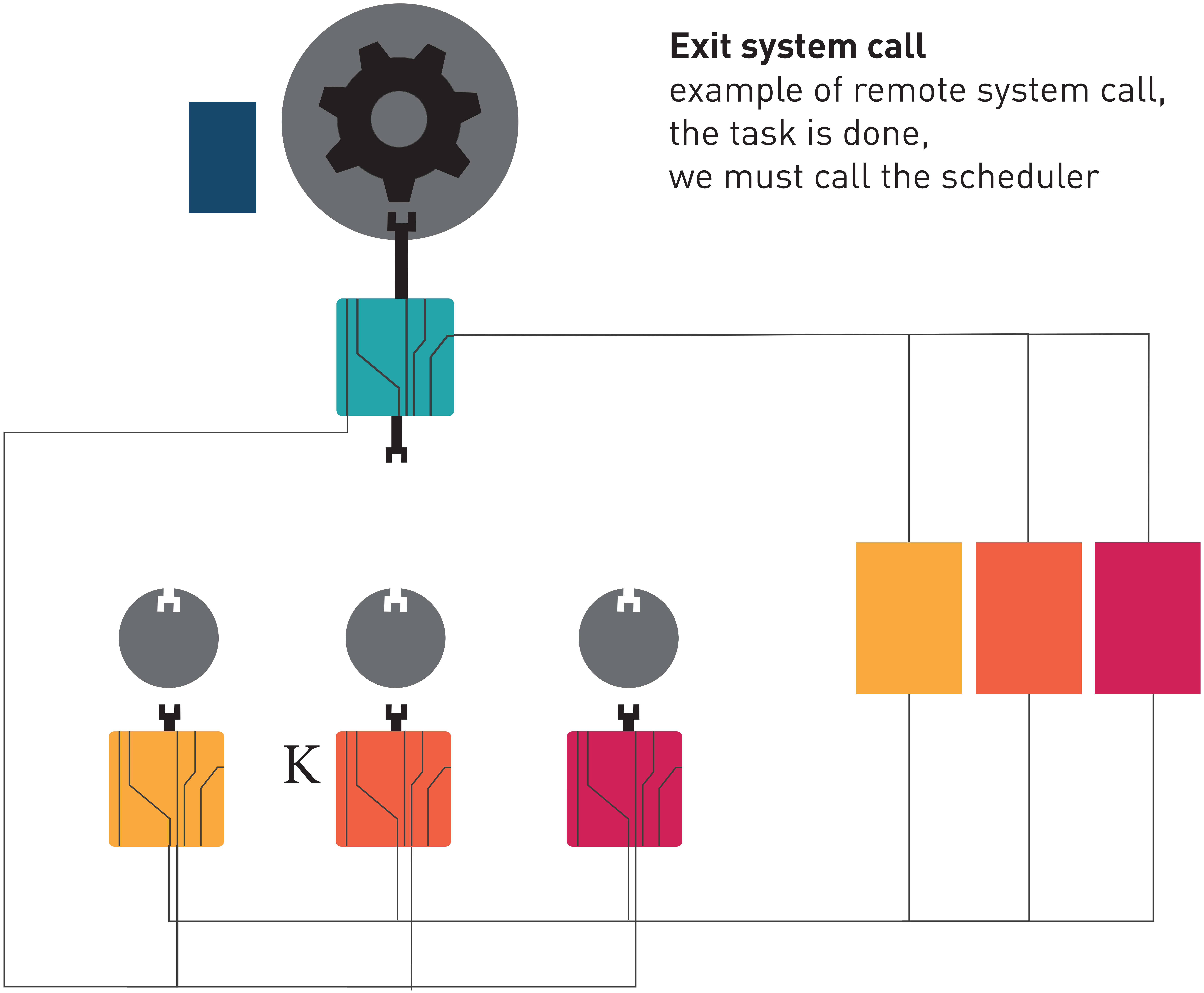

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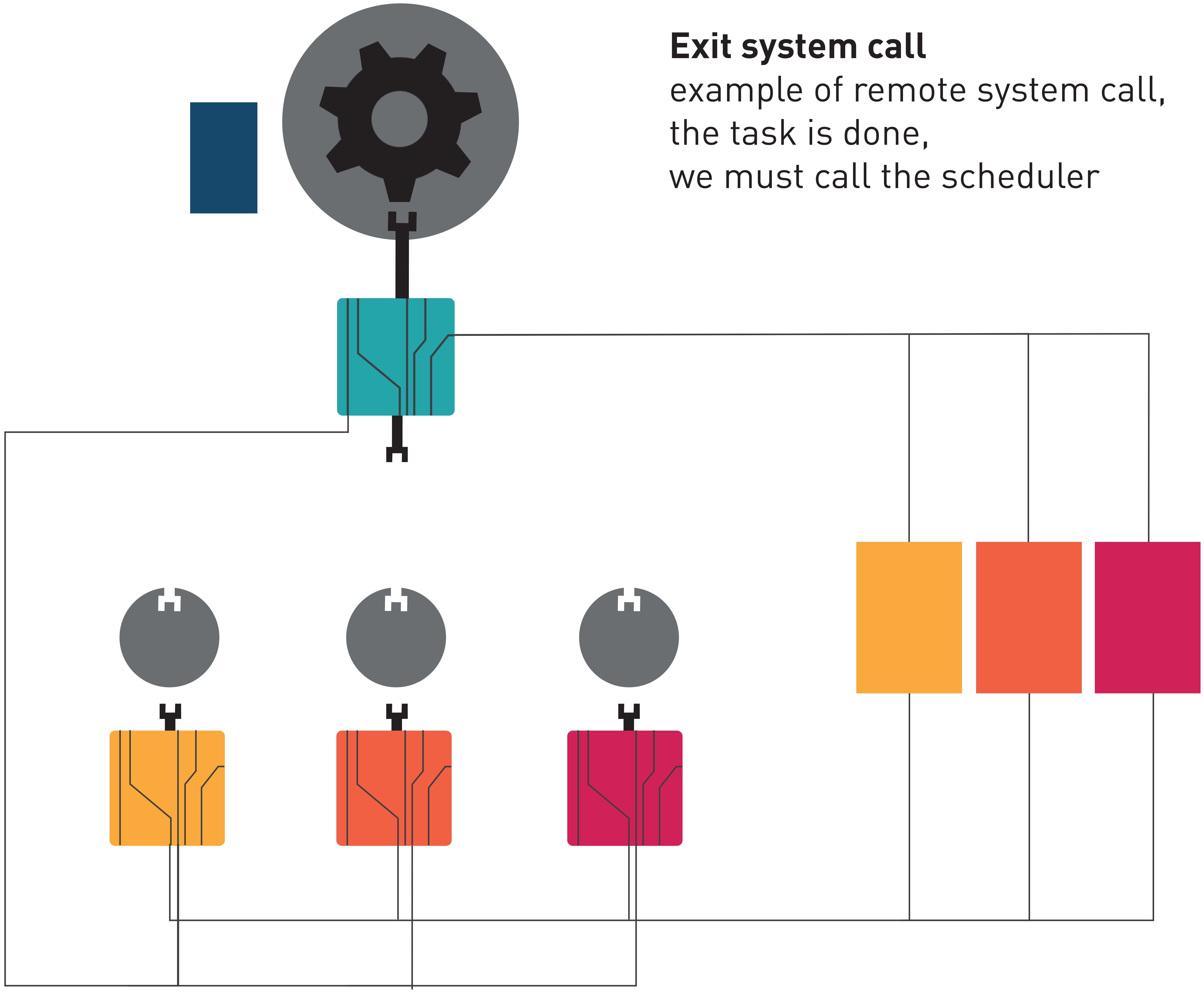
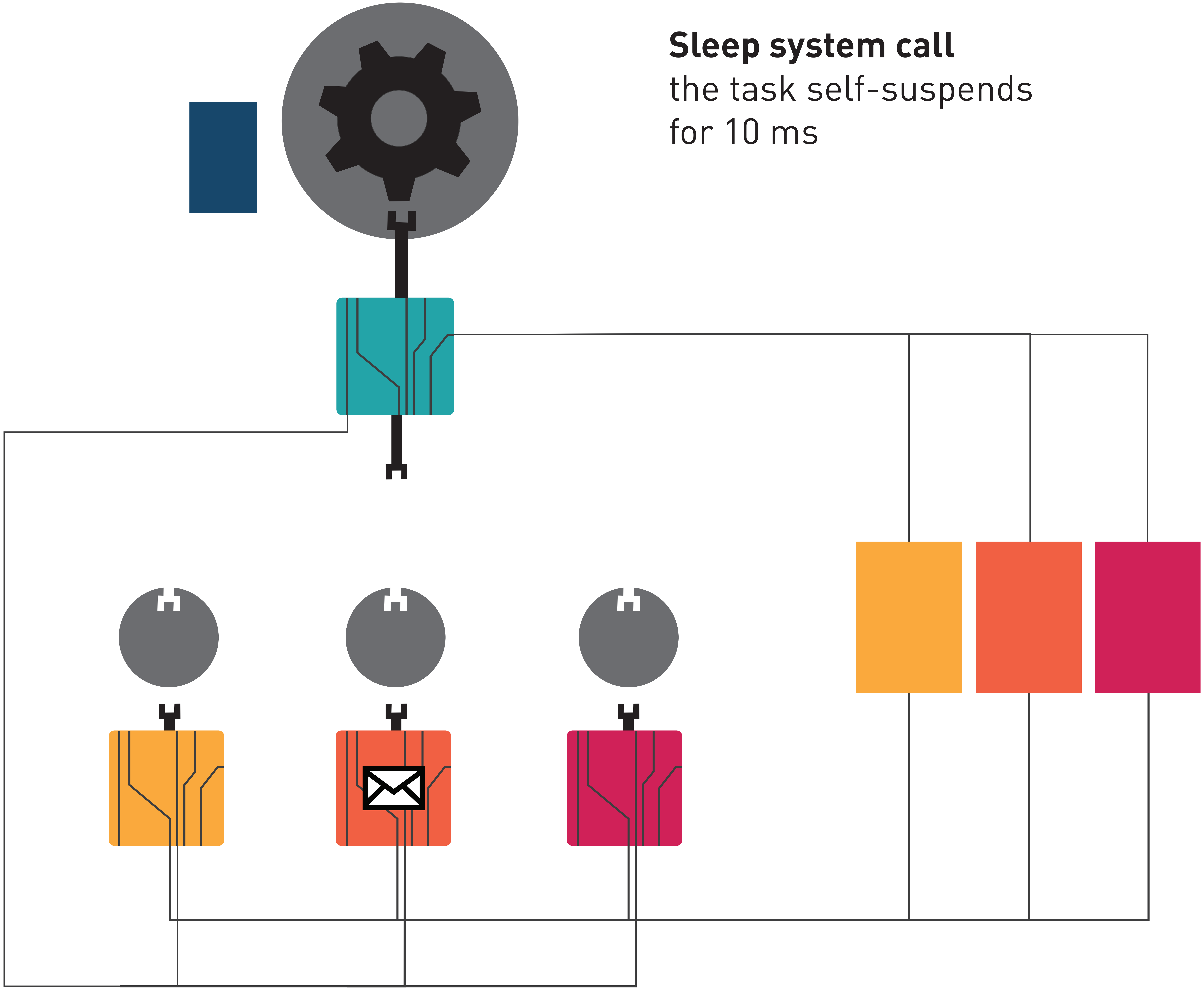
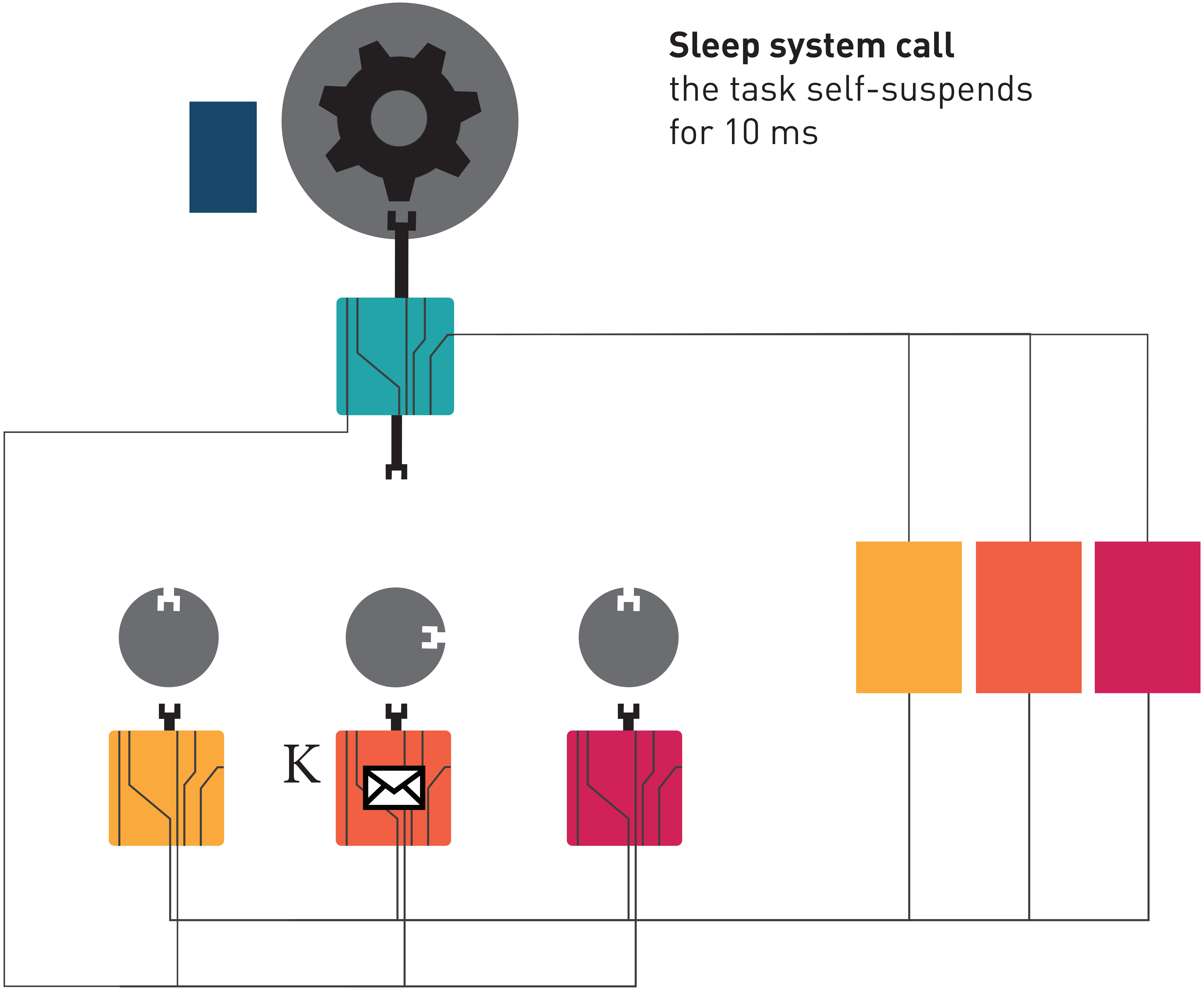


Exit system call
example of remote system call,
the task is done,
we must call the scheduler

Remote system calls: `sleep(10)`



Sleep system call
the task self-suspends
for 10 ms



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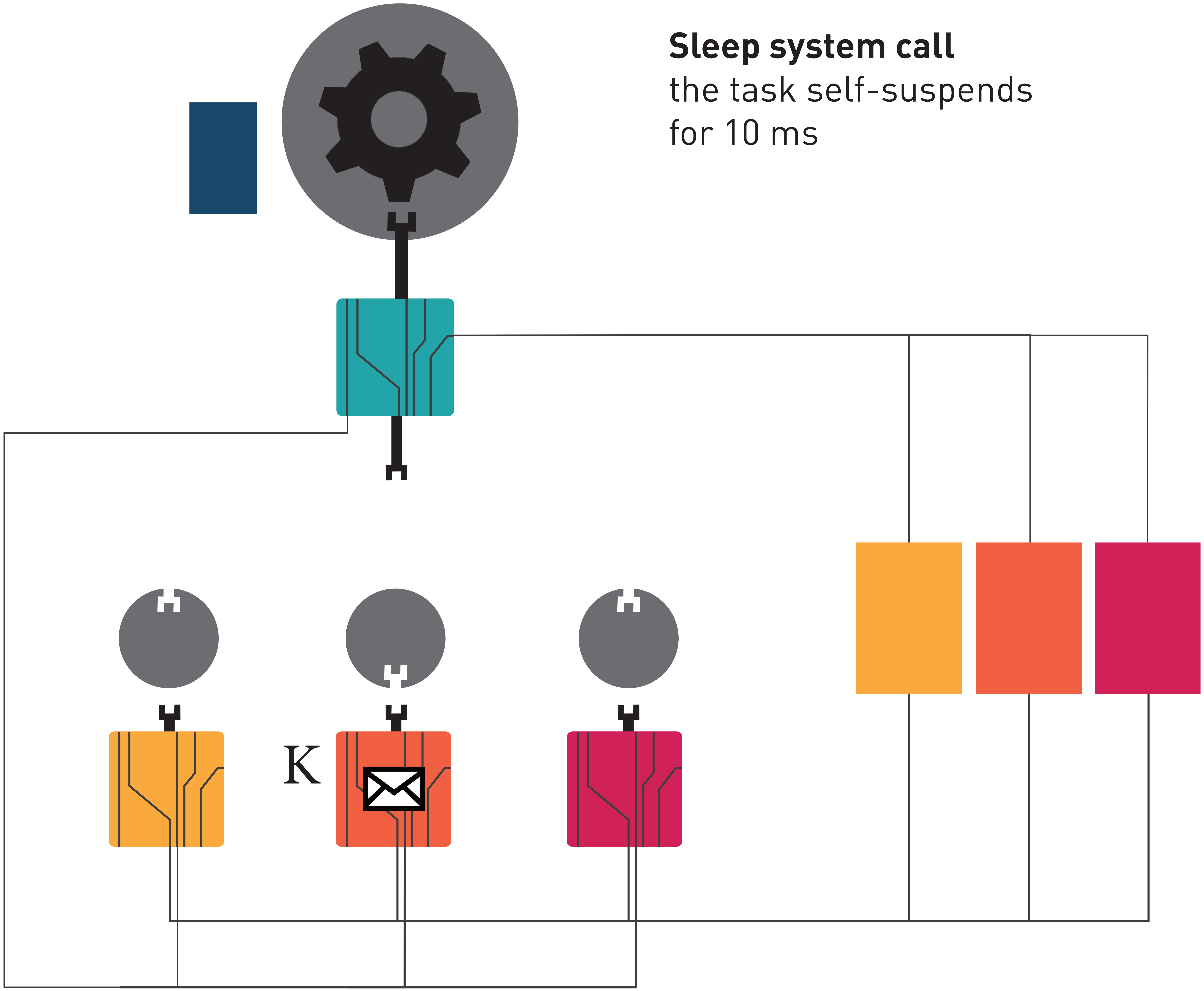

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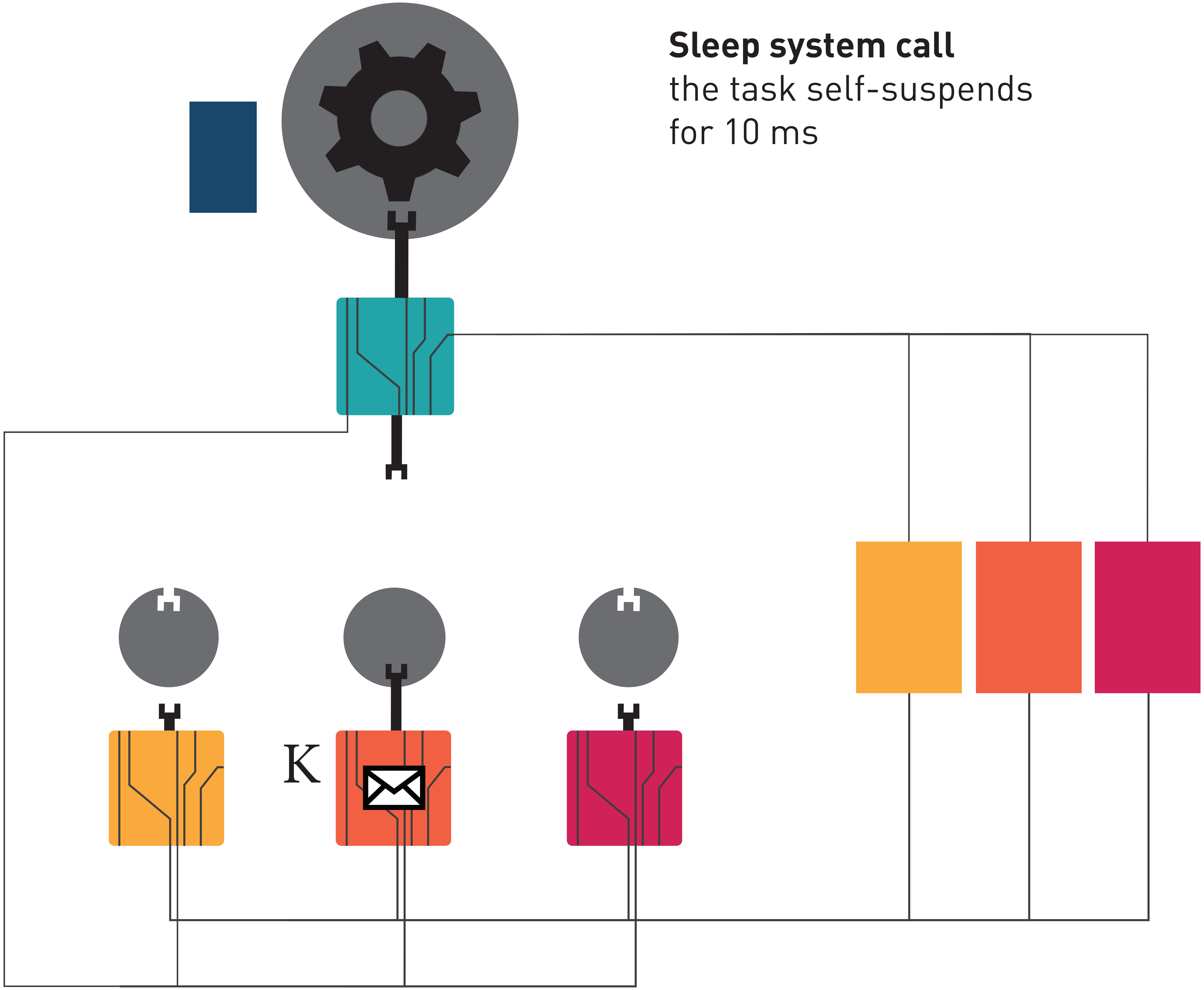

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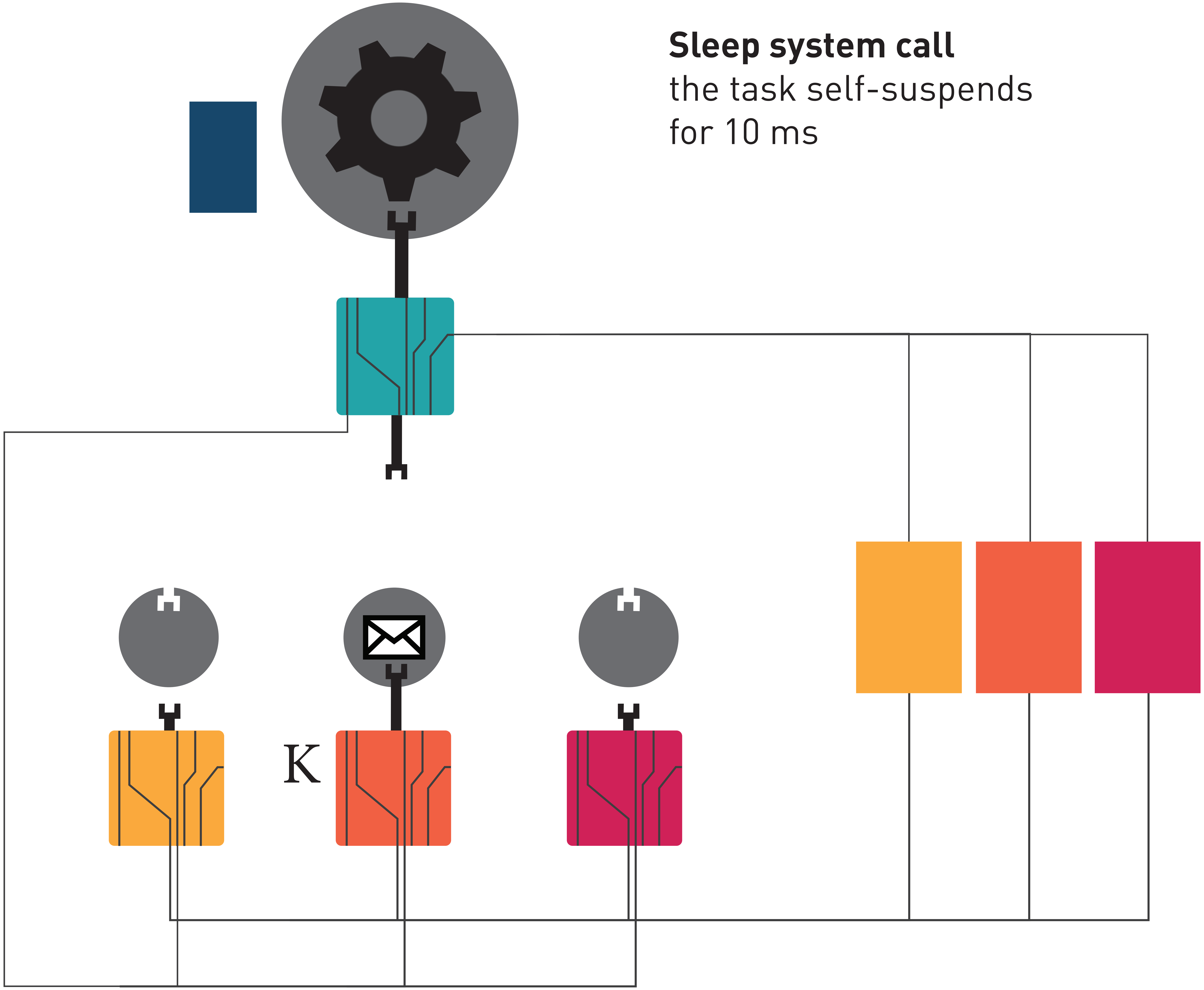

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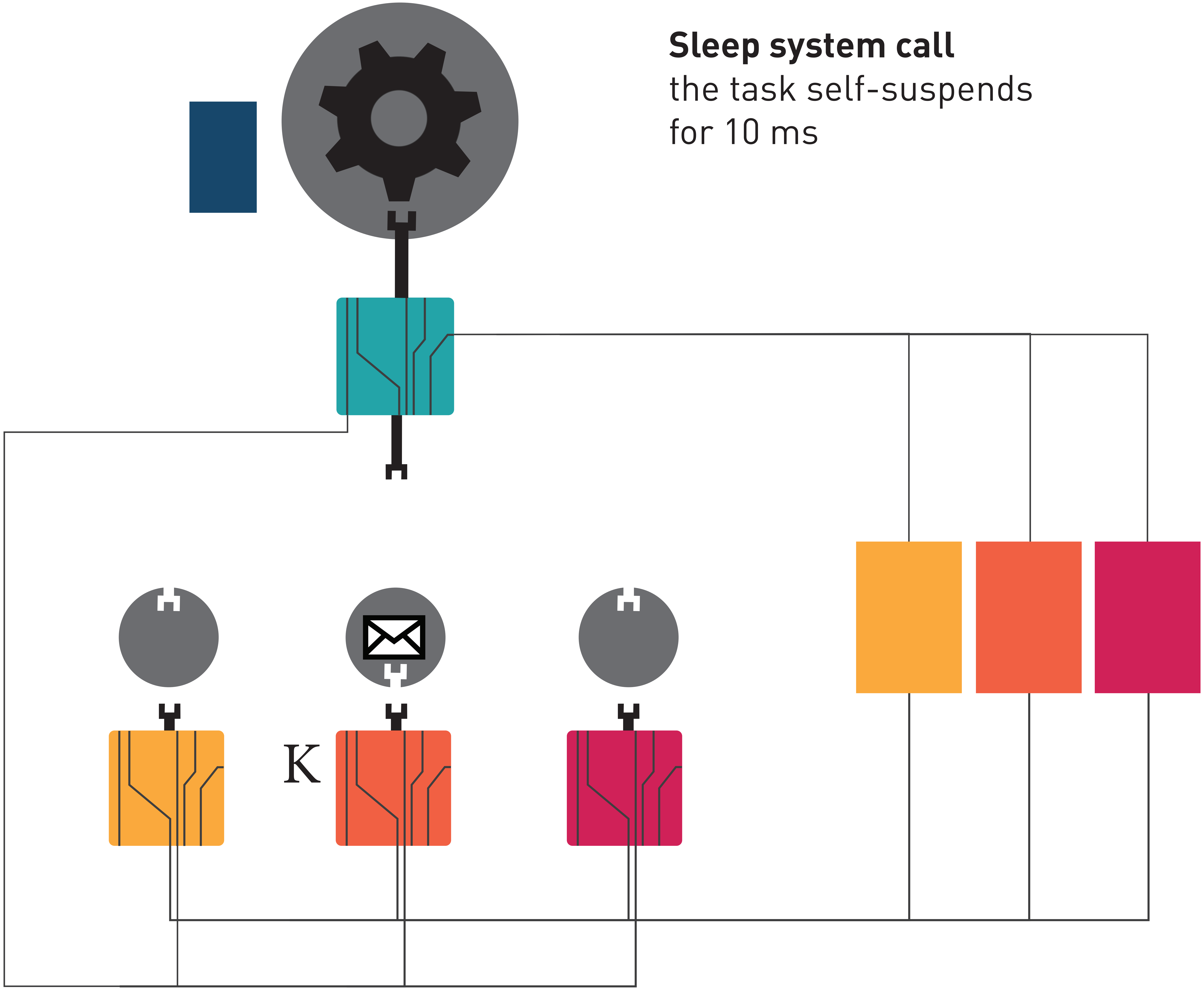

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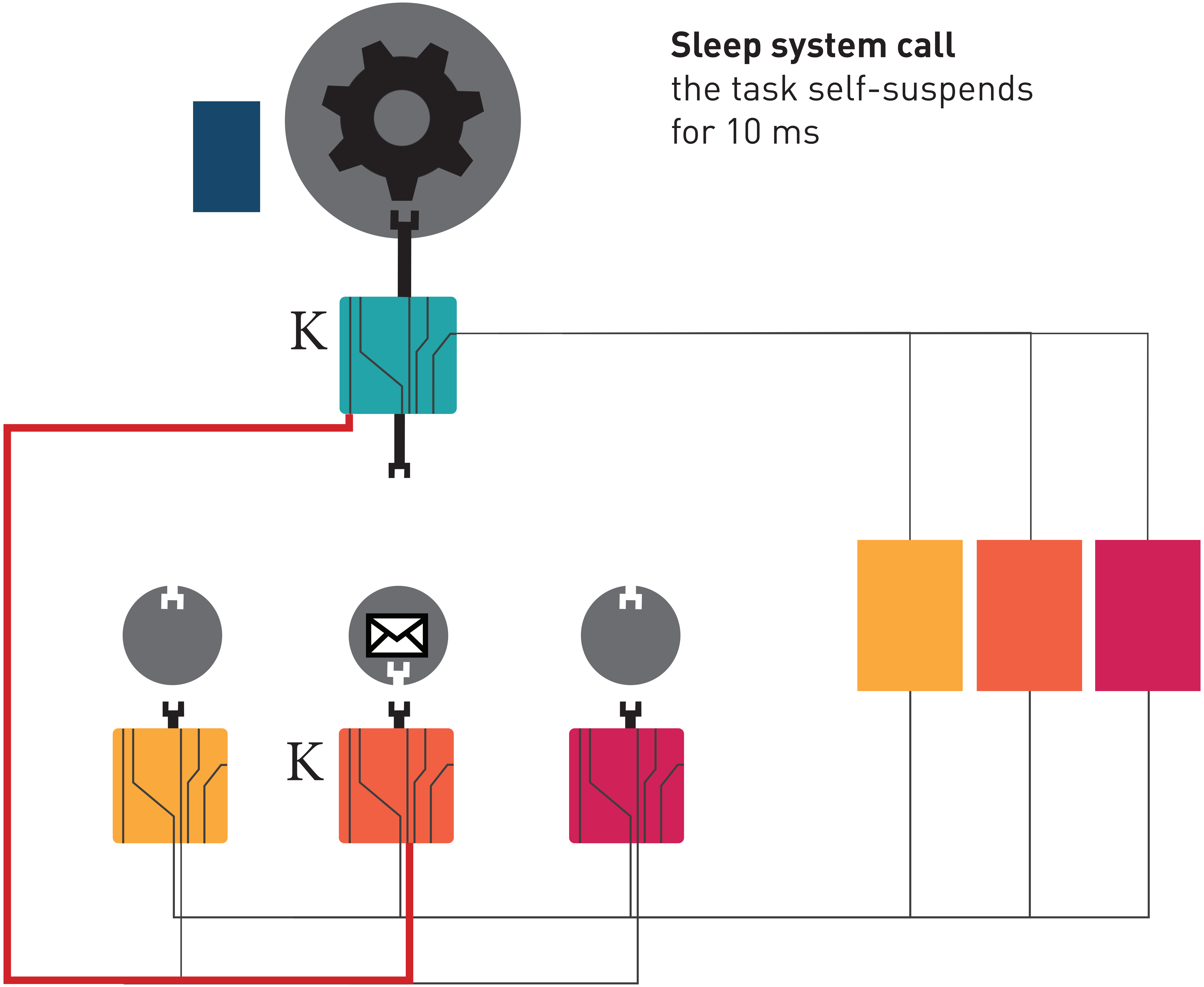

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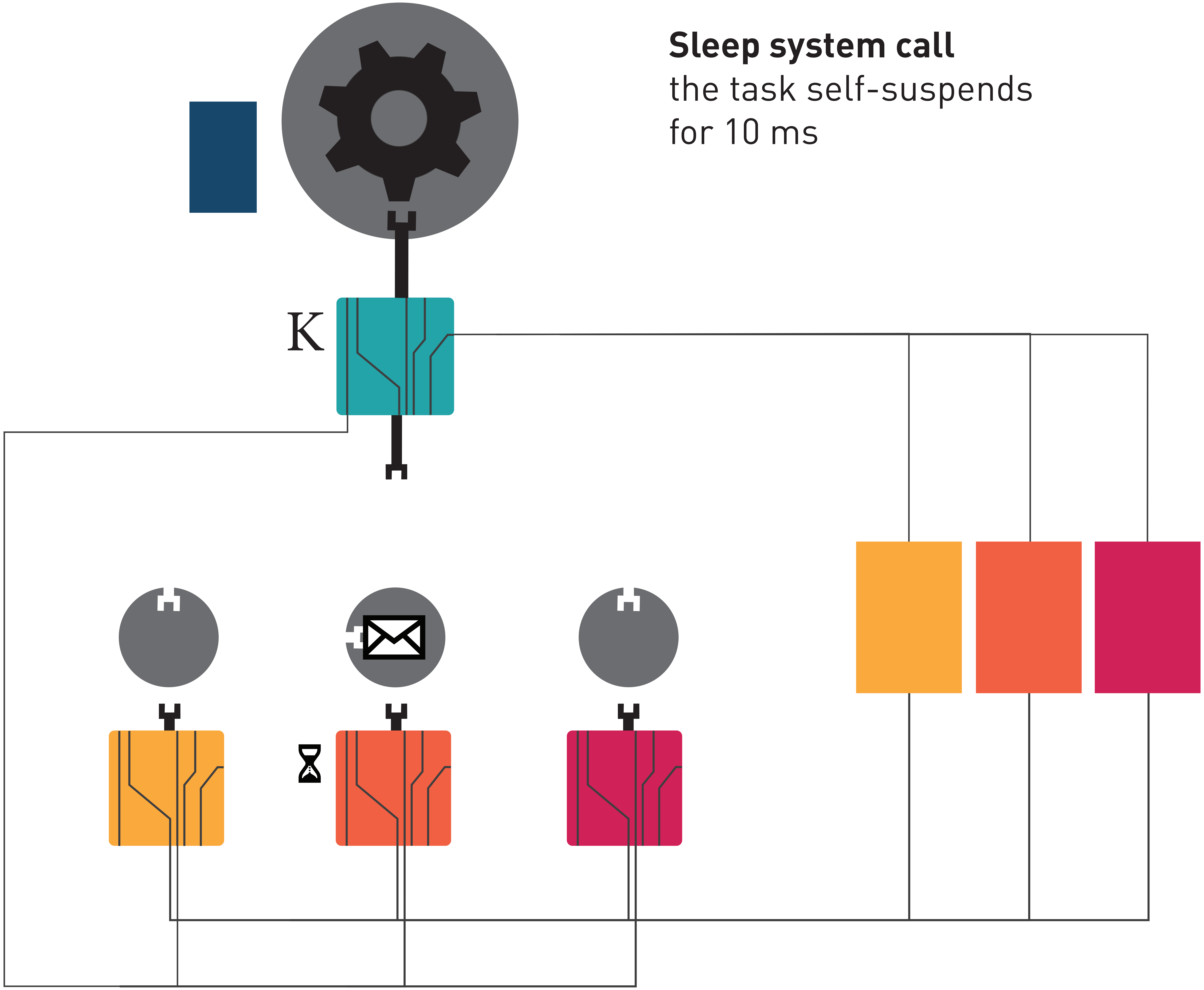

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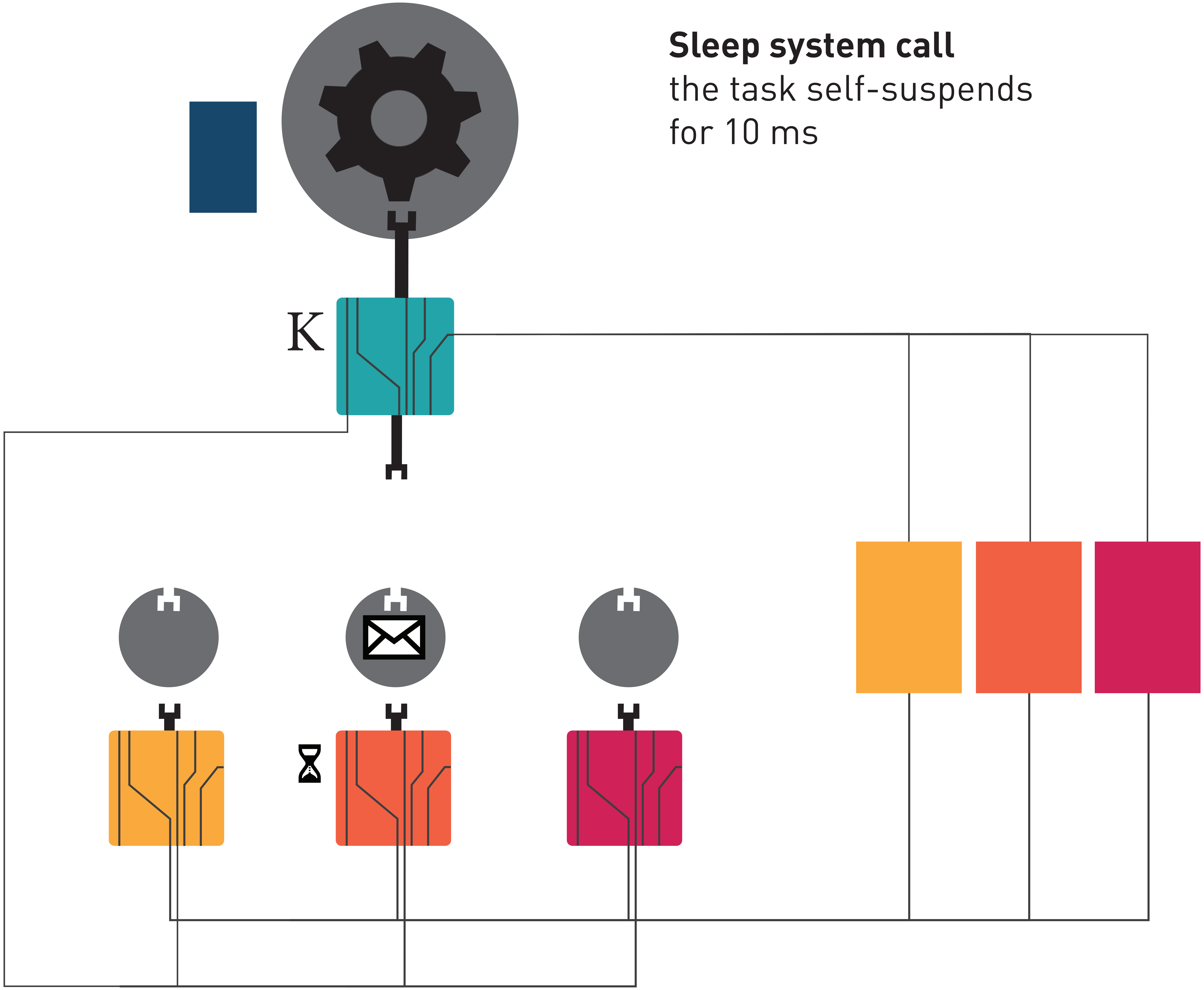

Sleep system call
the task self-suspends
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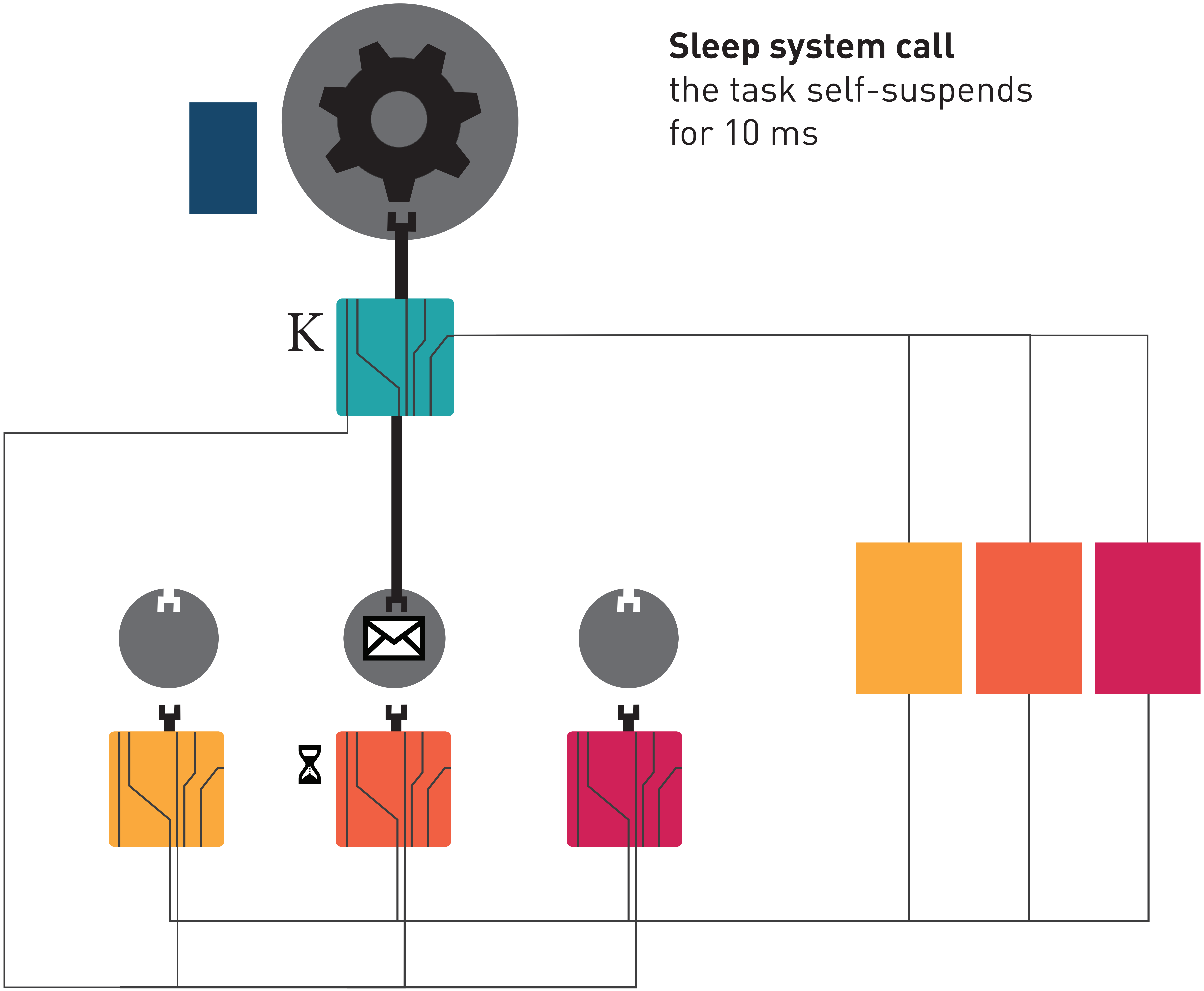

Sleep system call
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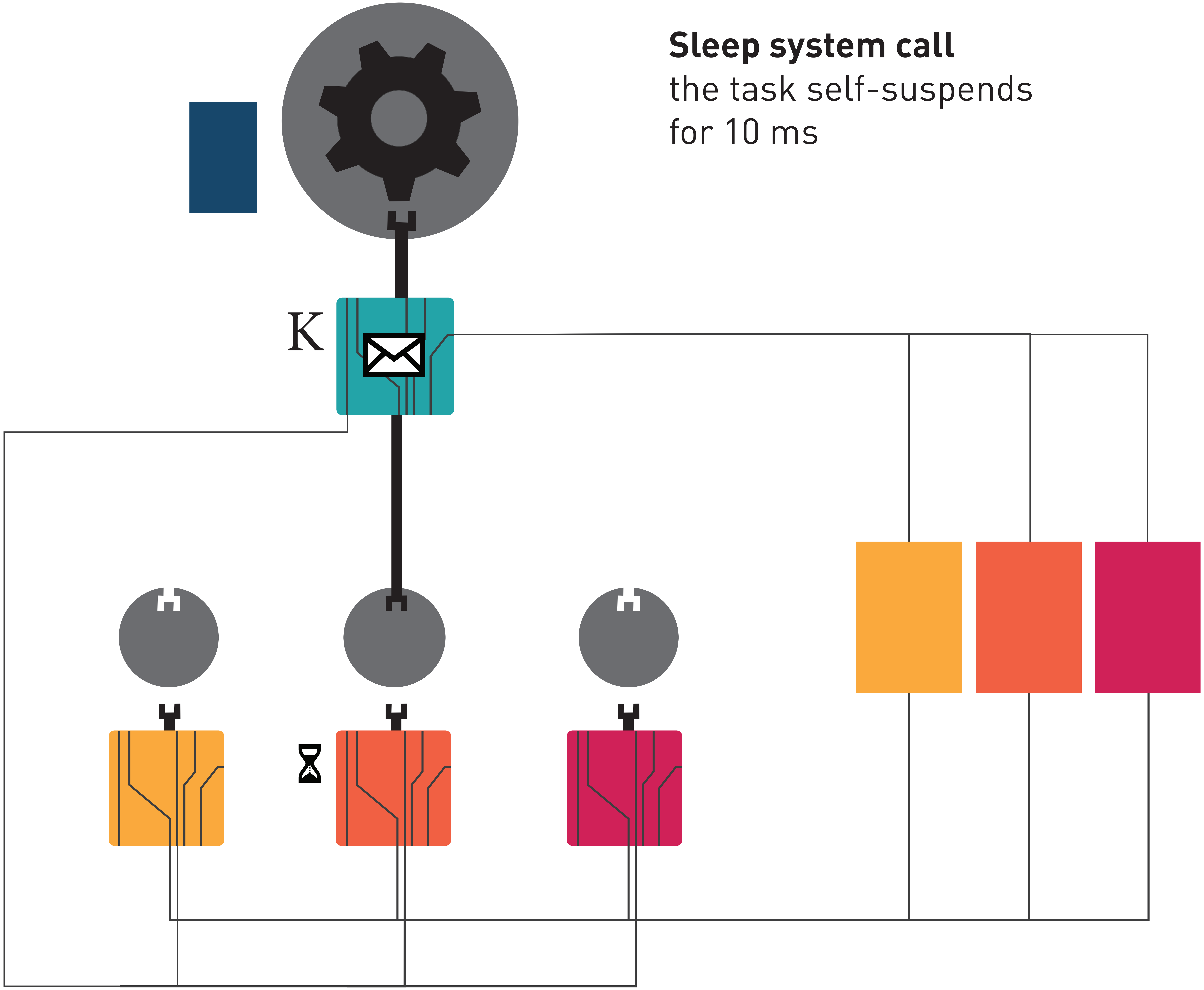

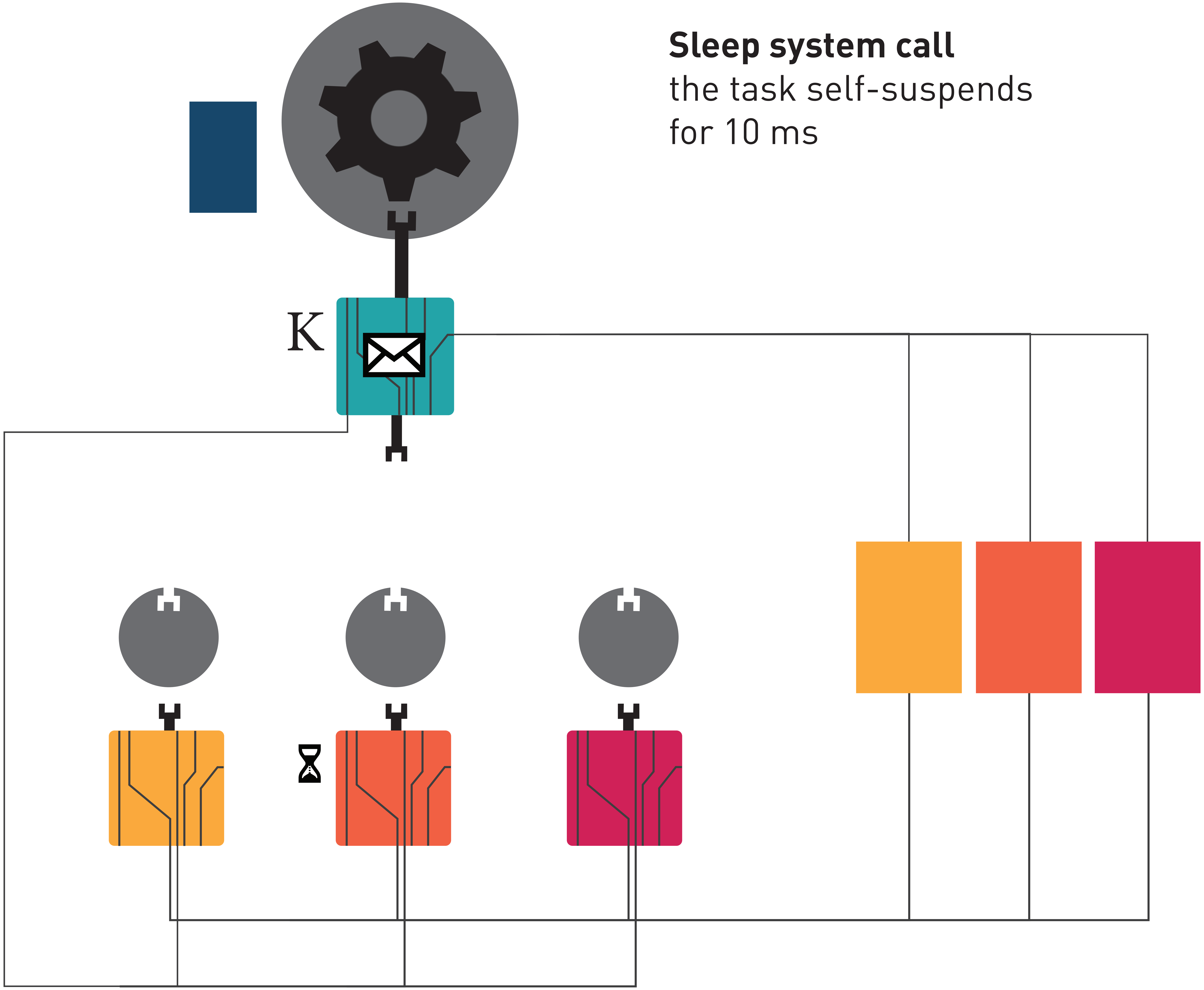

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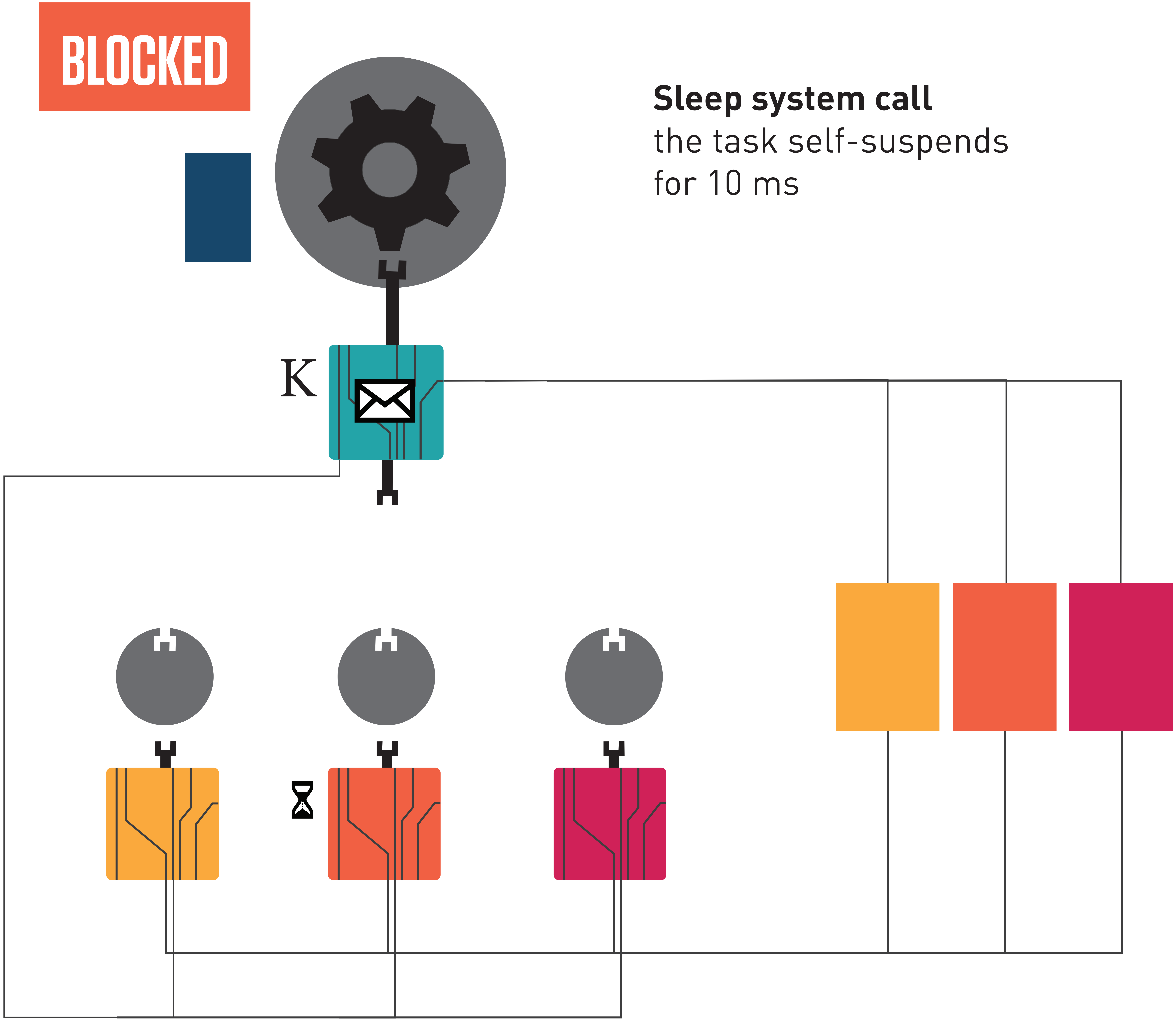

Sleep system call
the task self-suspends
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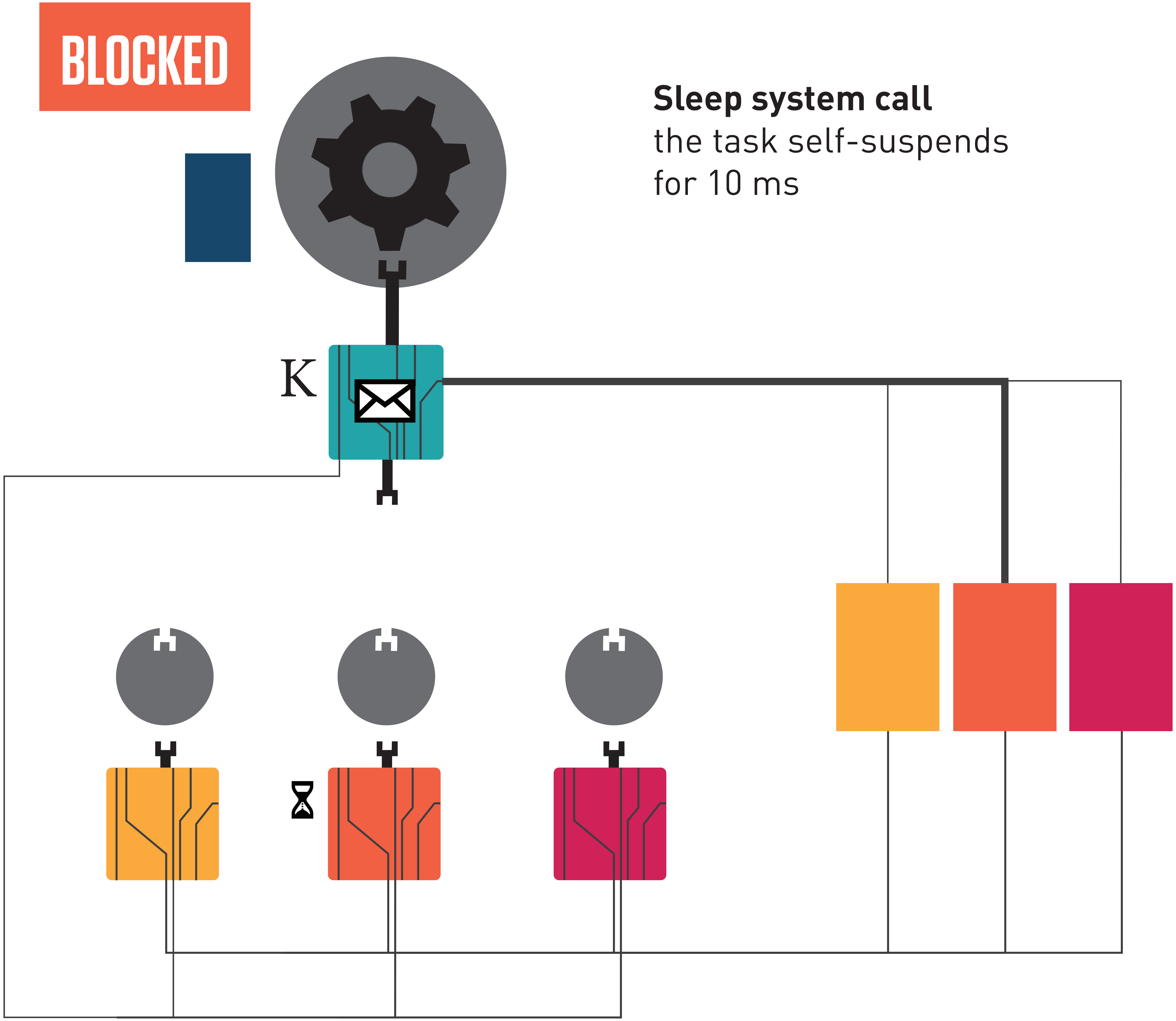

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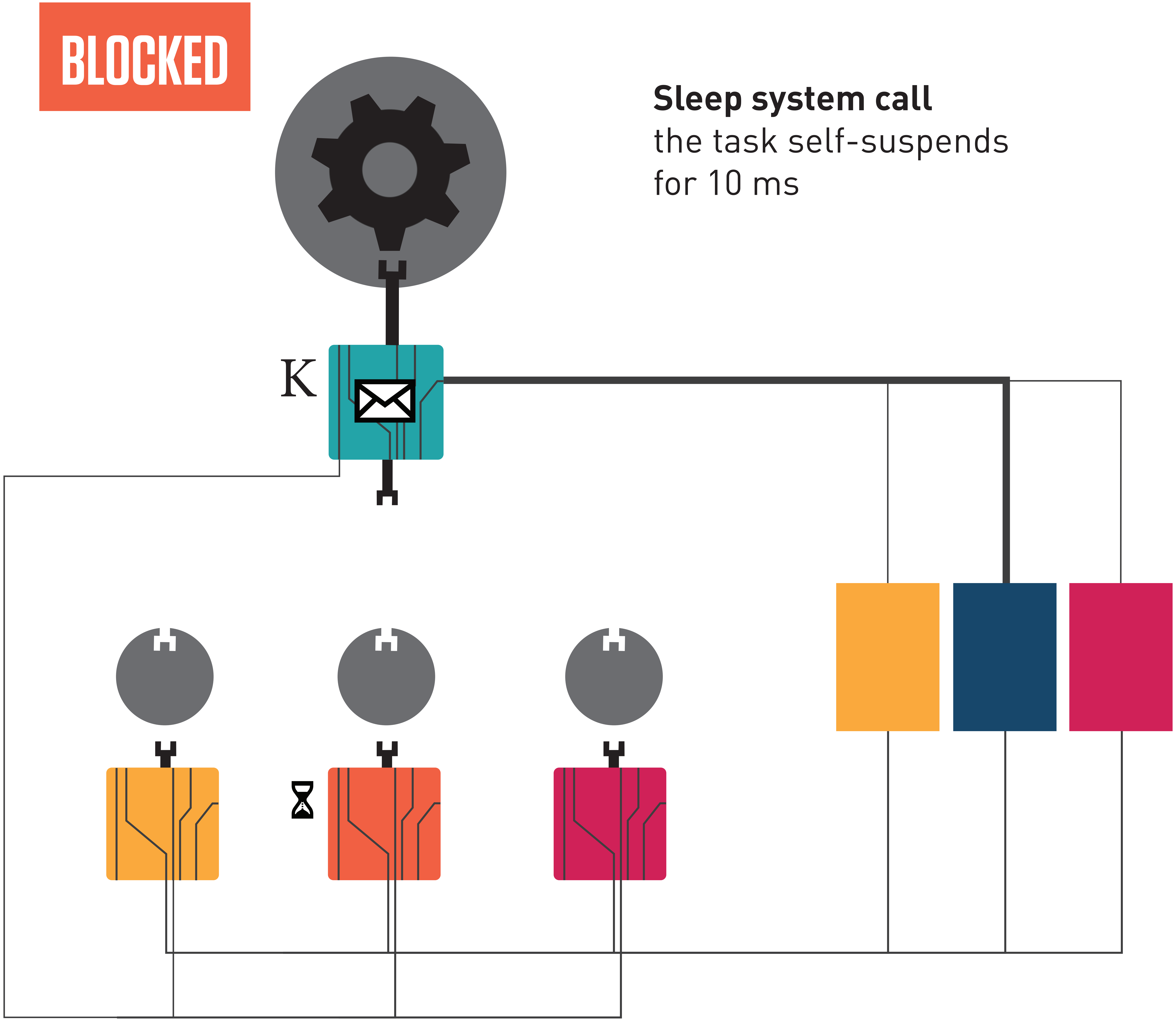
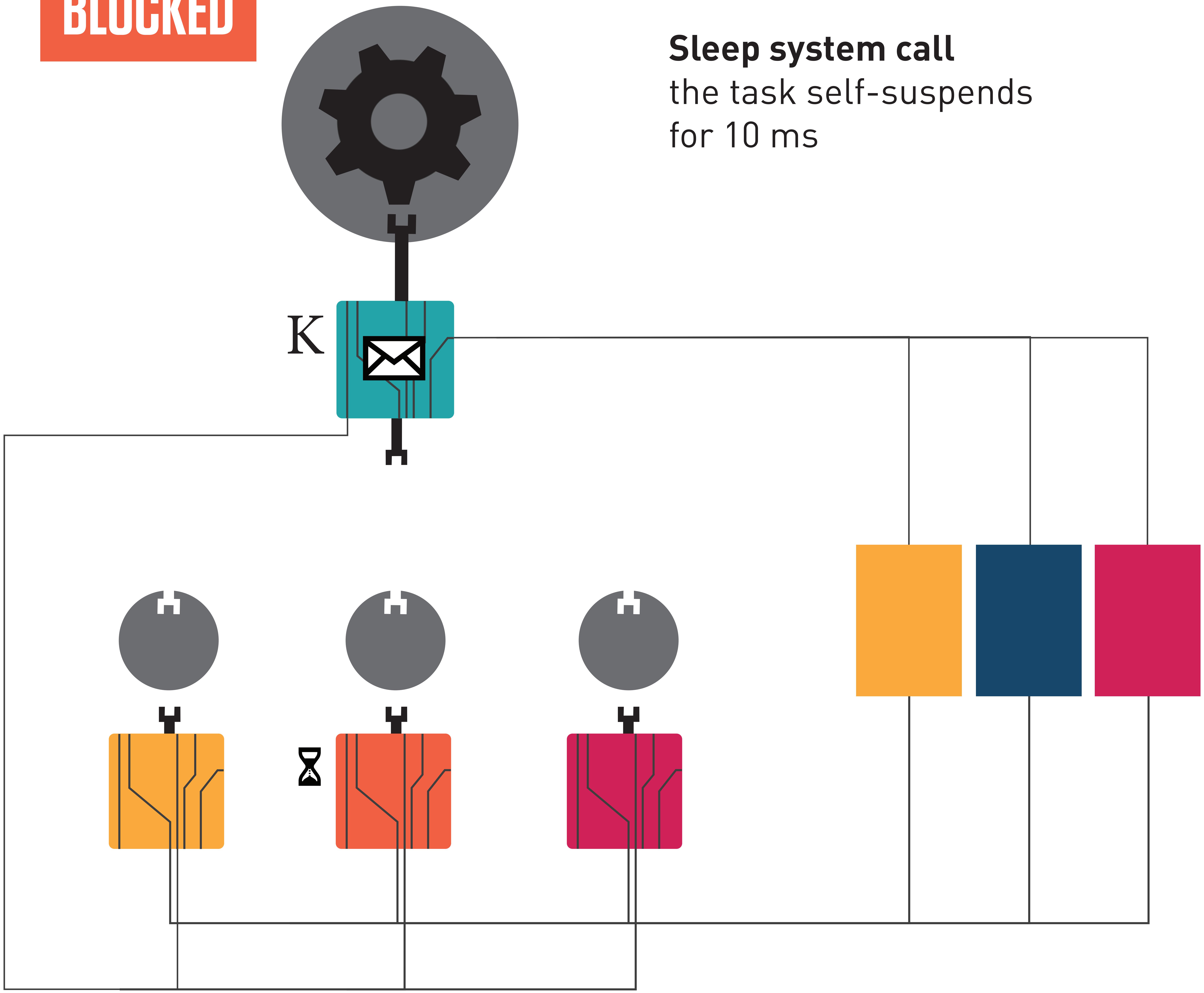


Sleep system call
the task self-suspends
for 10 ms

BLOCKED



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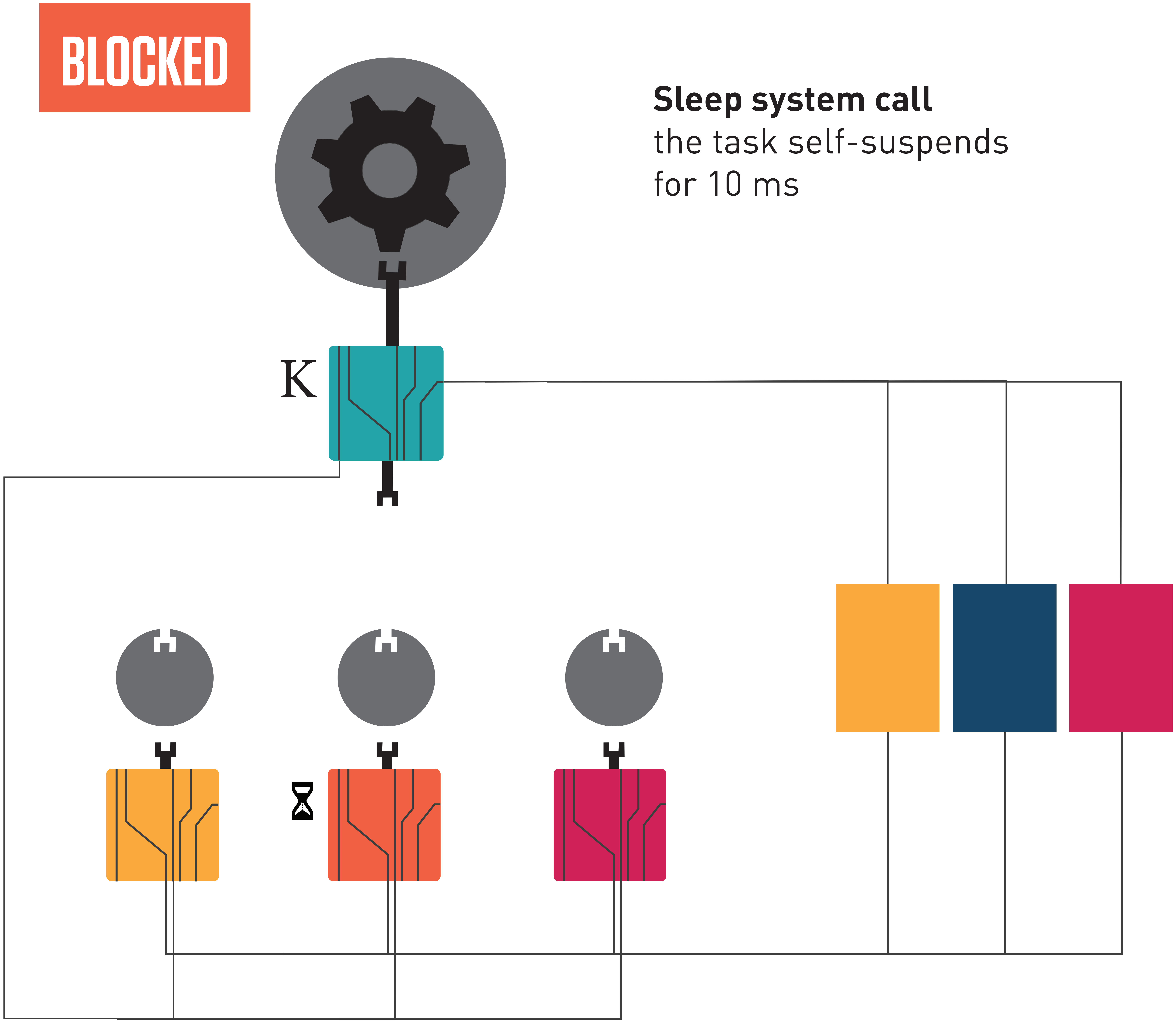

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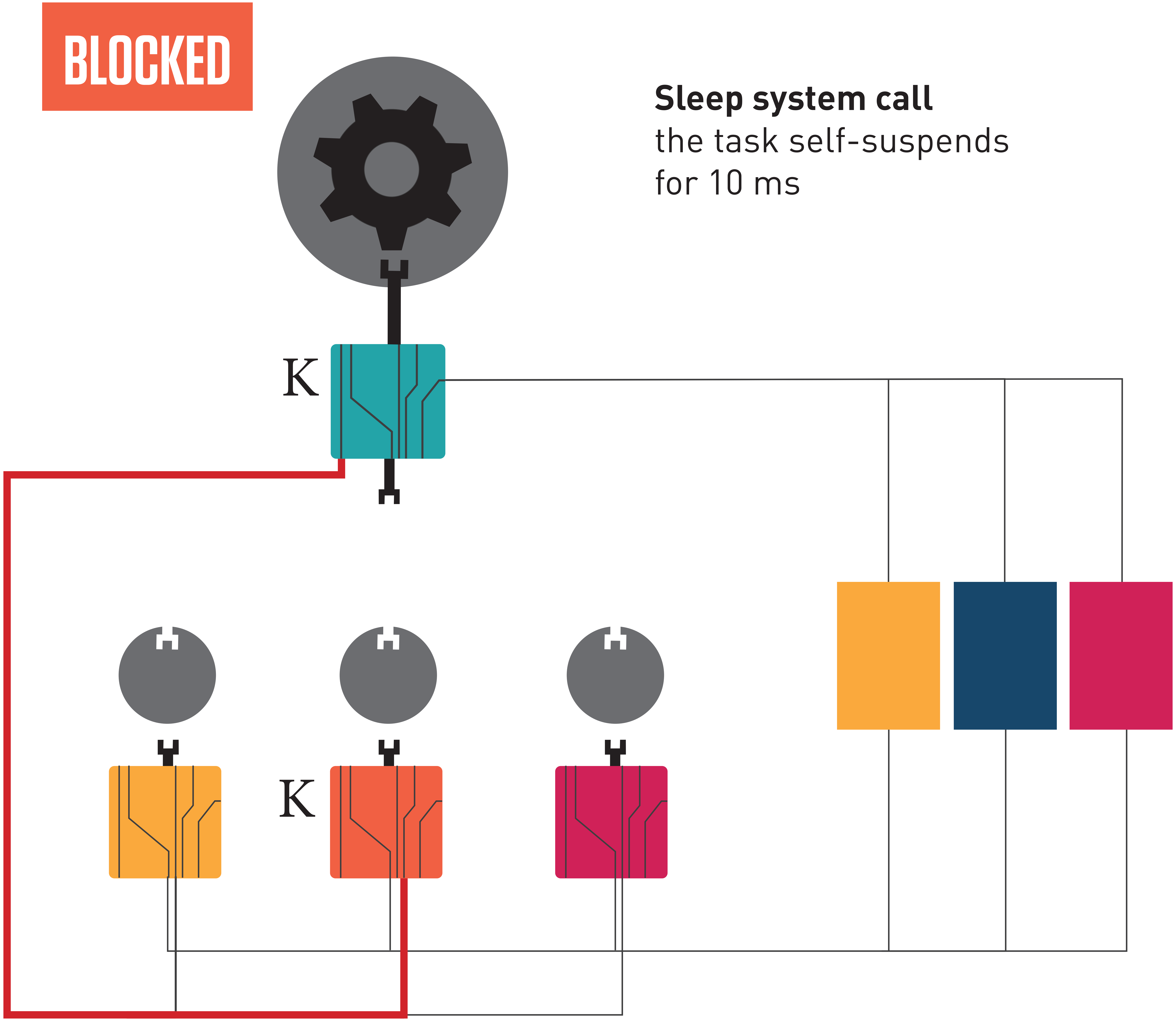

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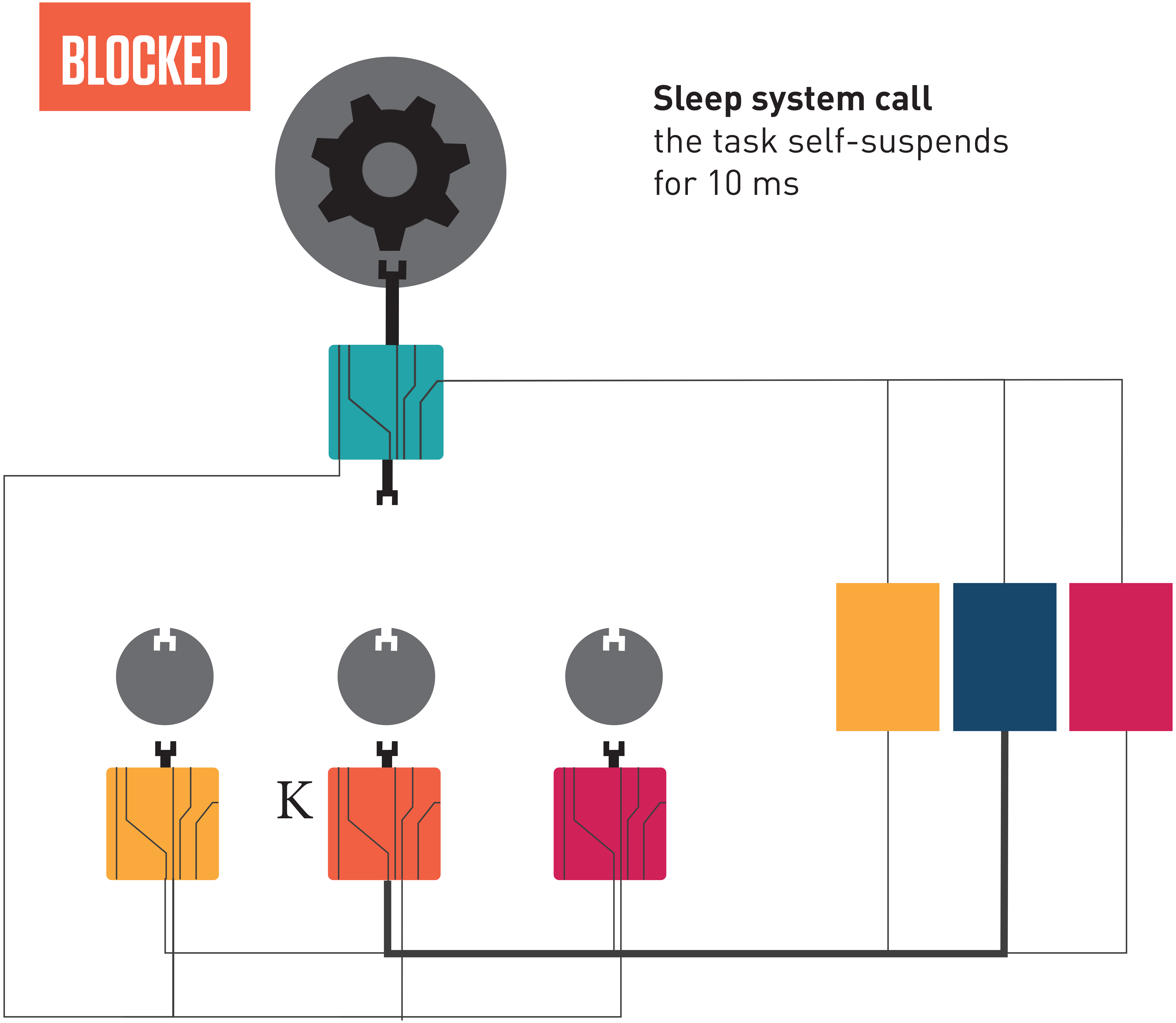

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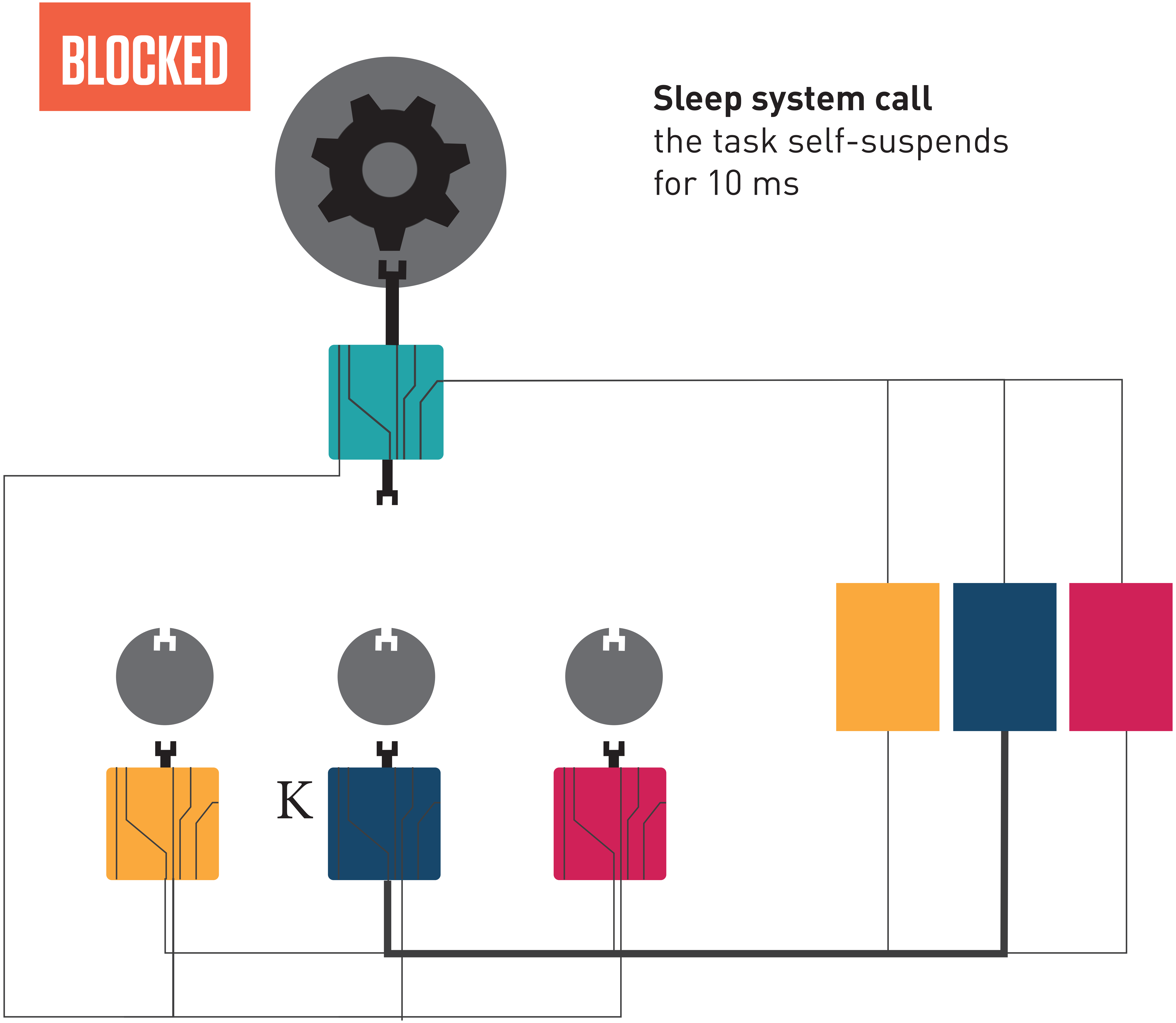

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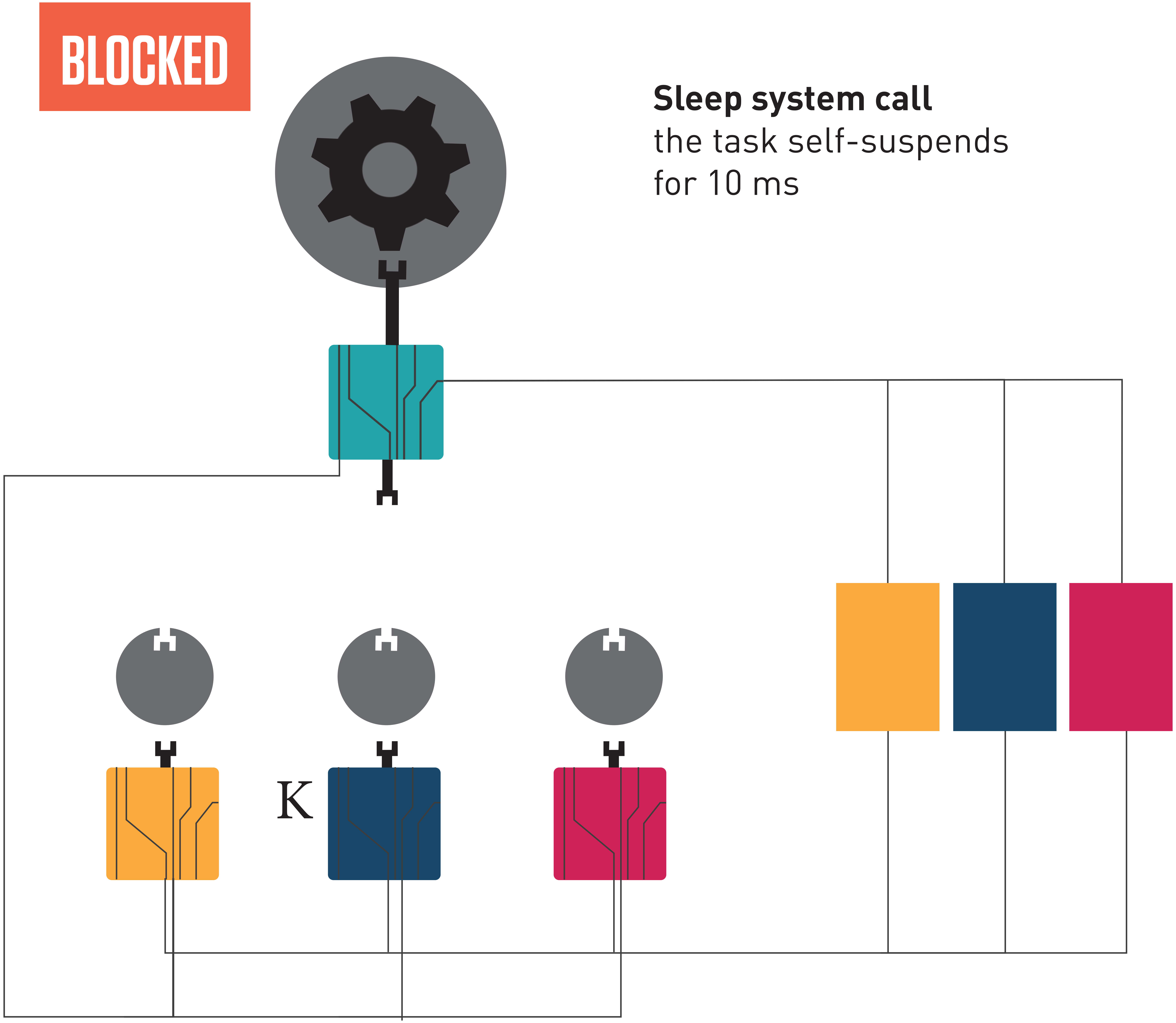

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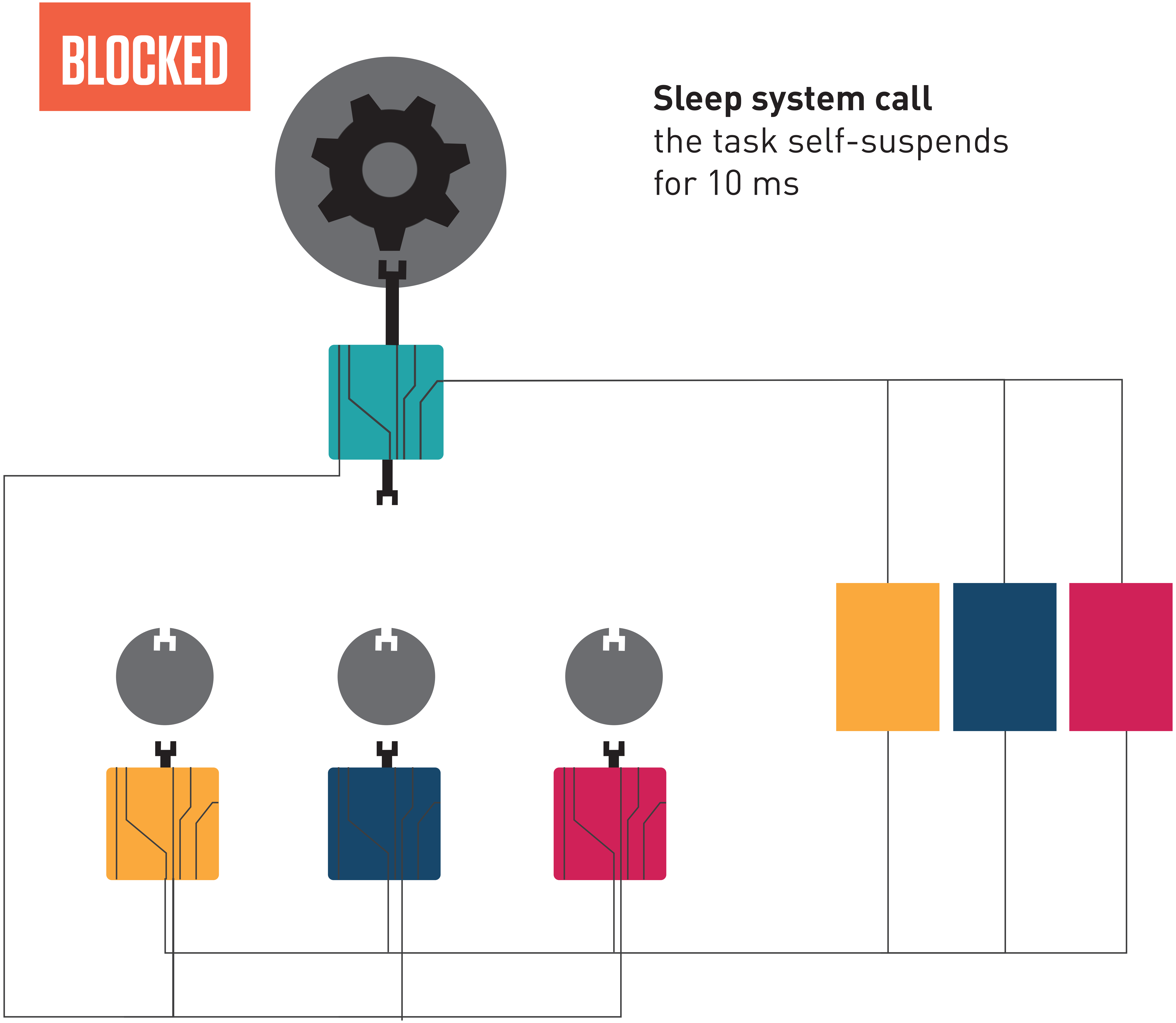

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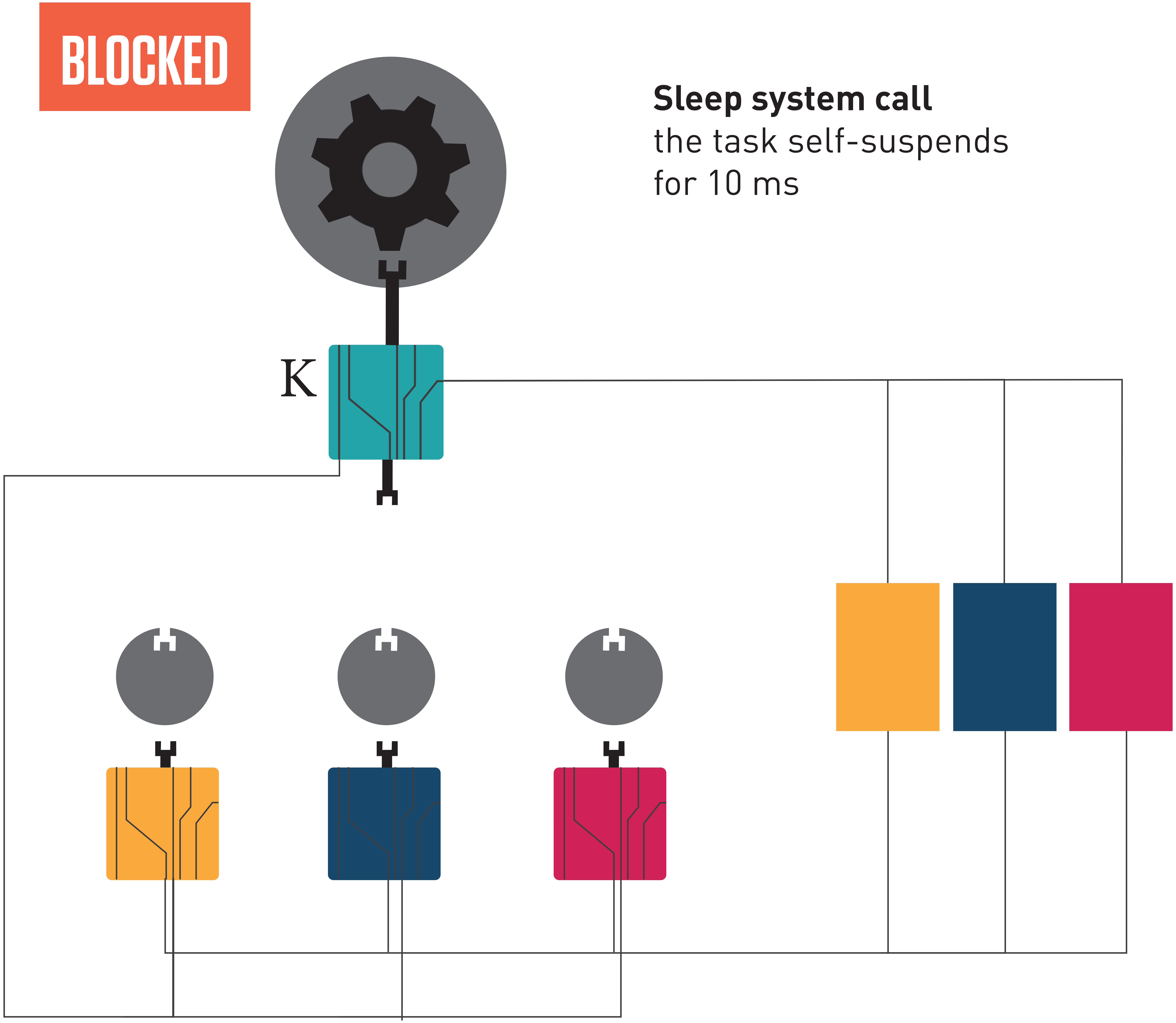

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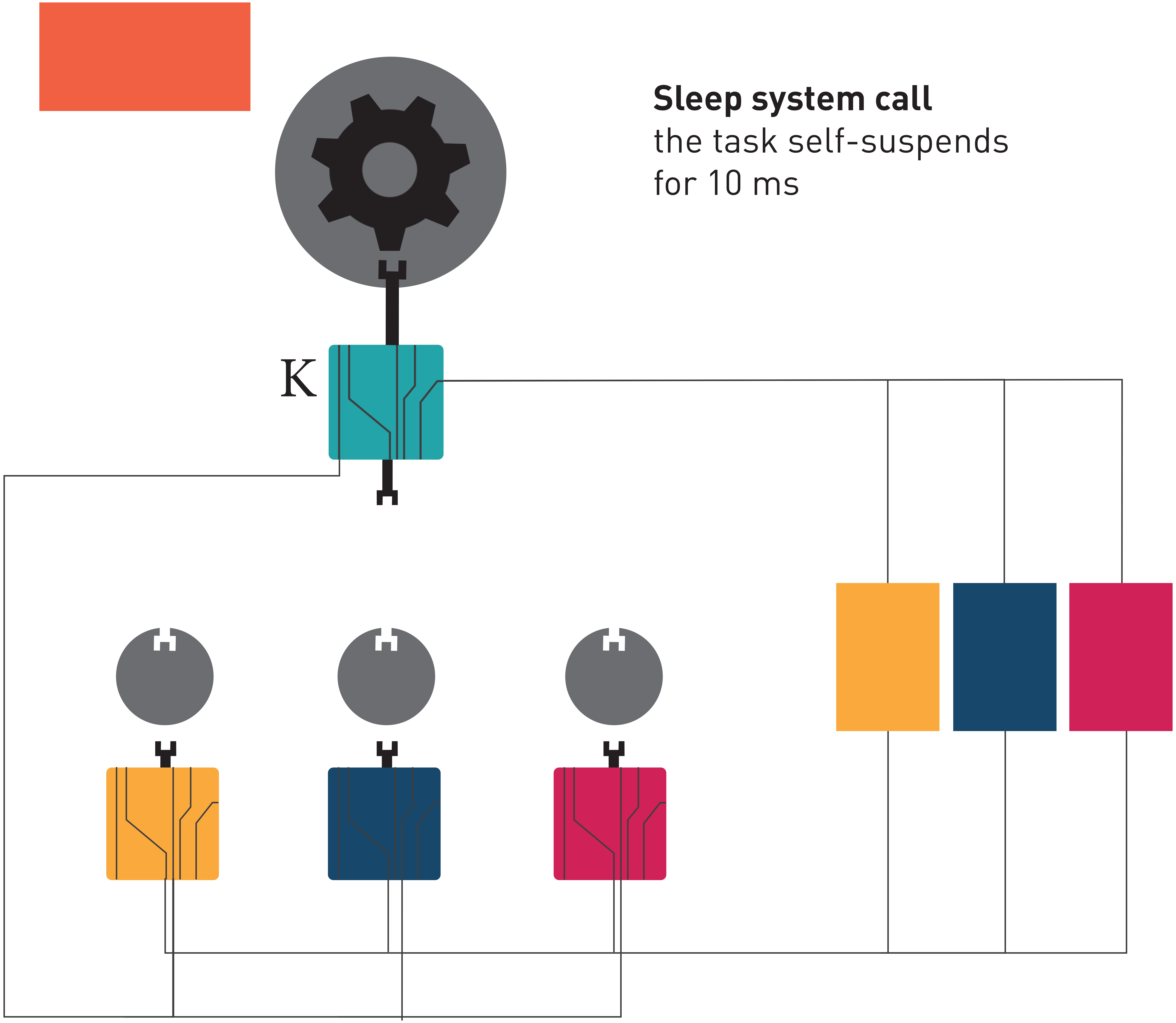

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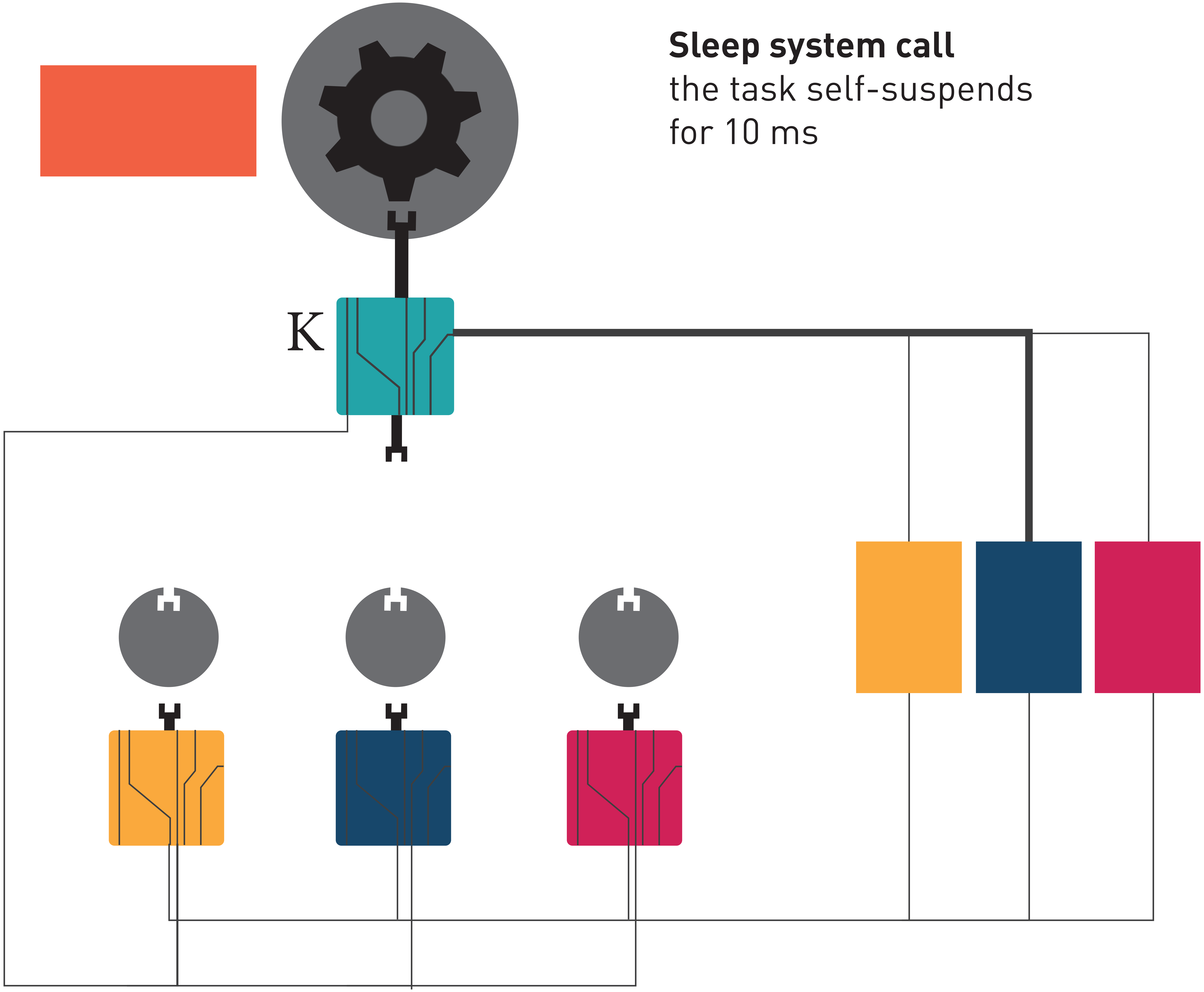

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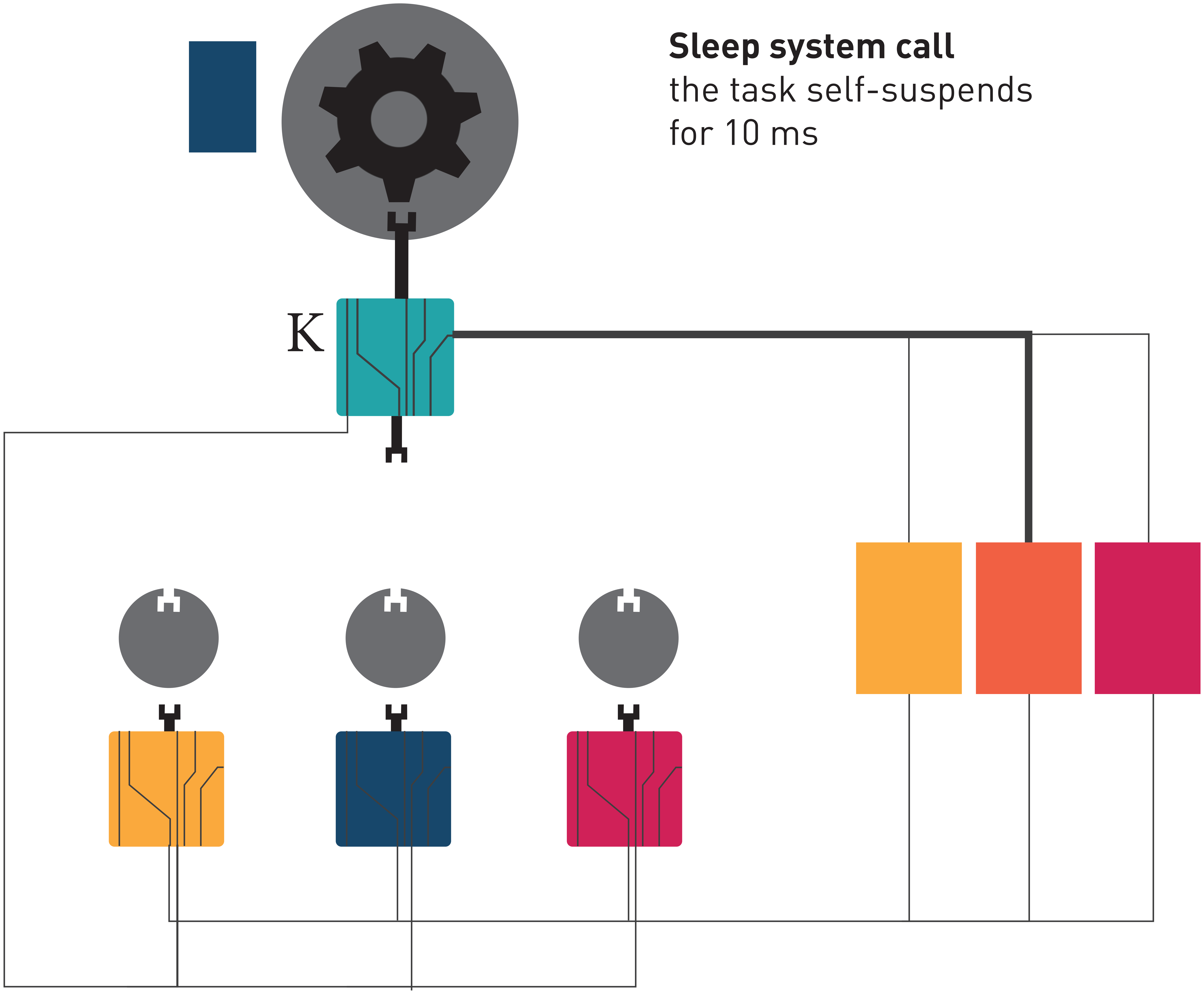

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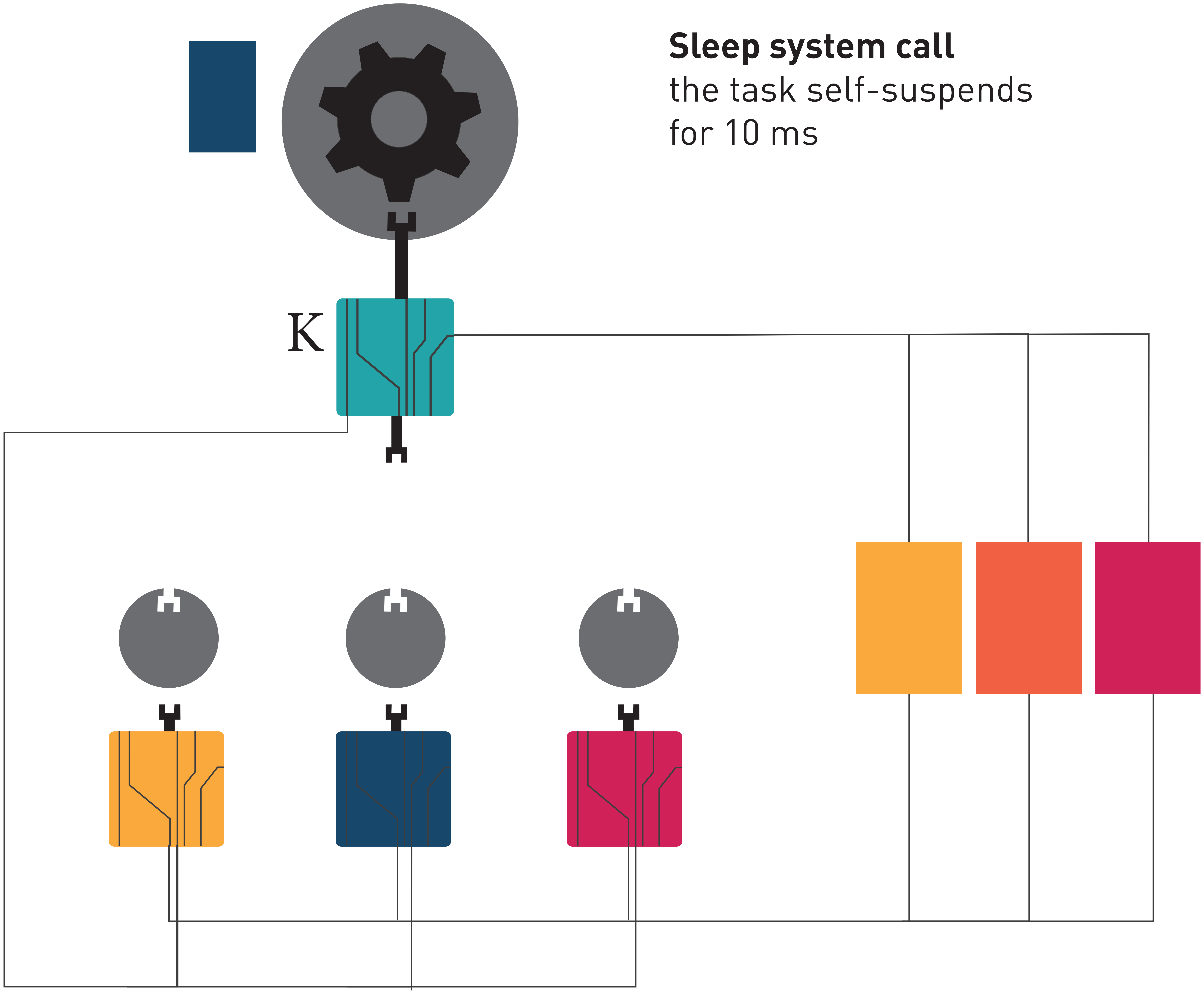

Sleep system call
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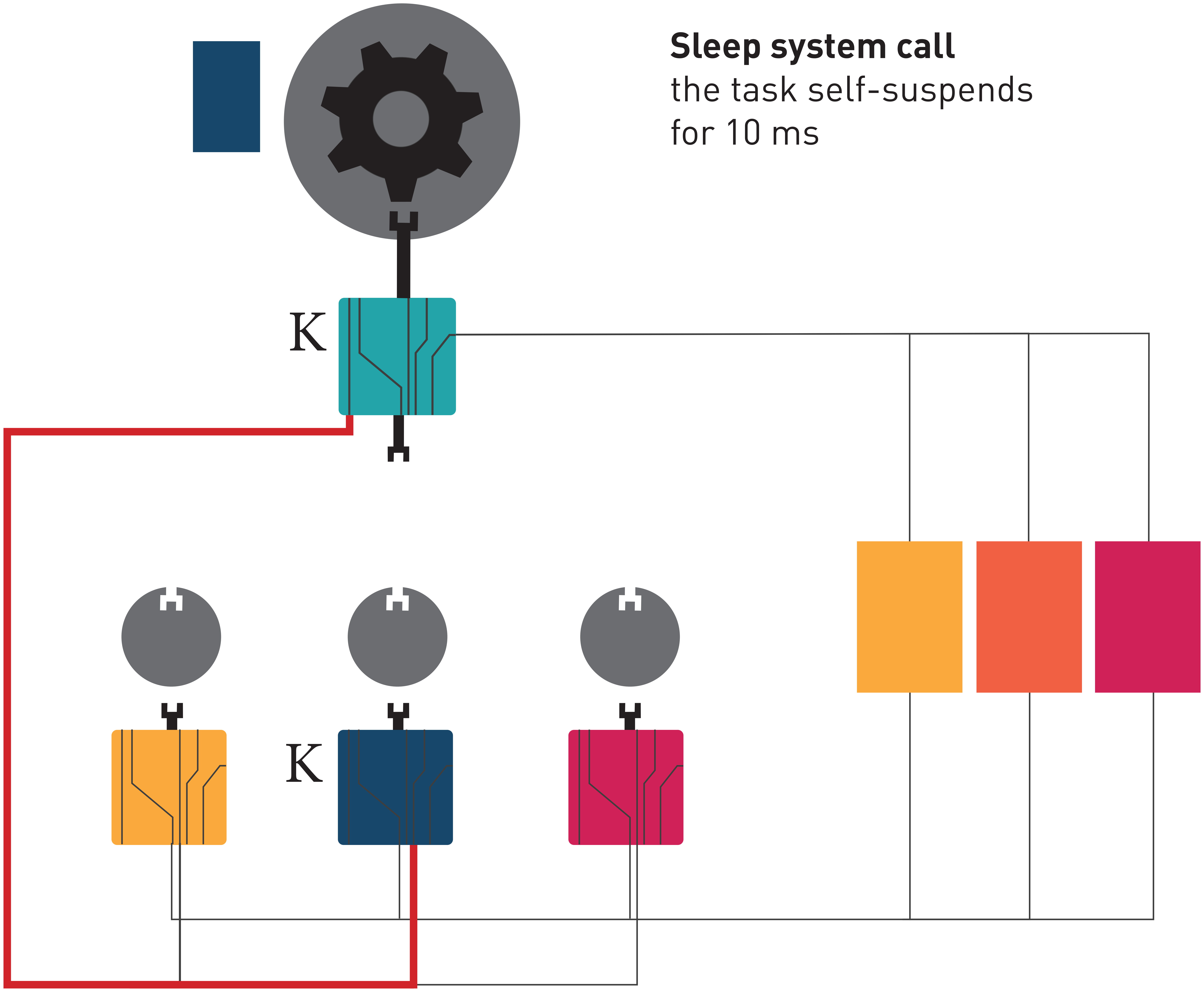

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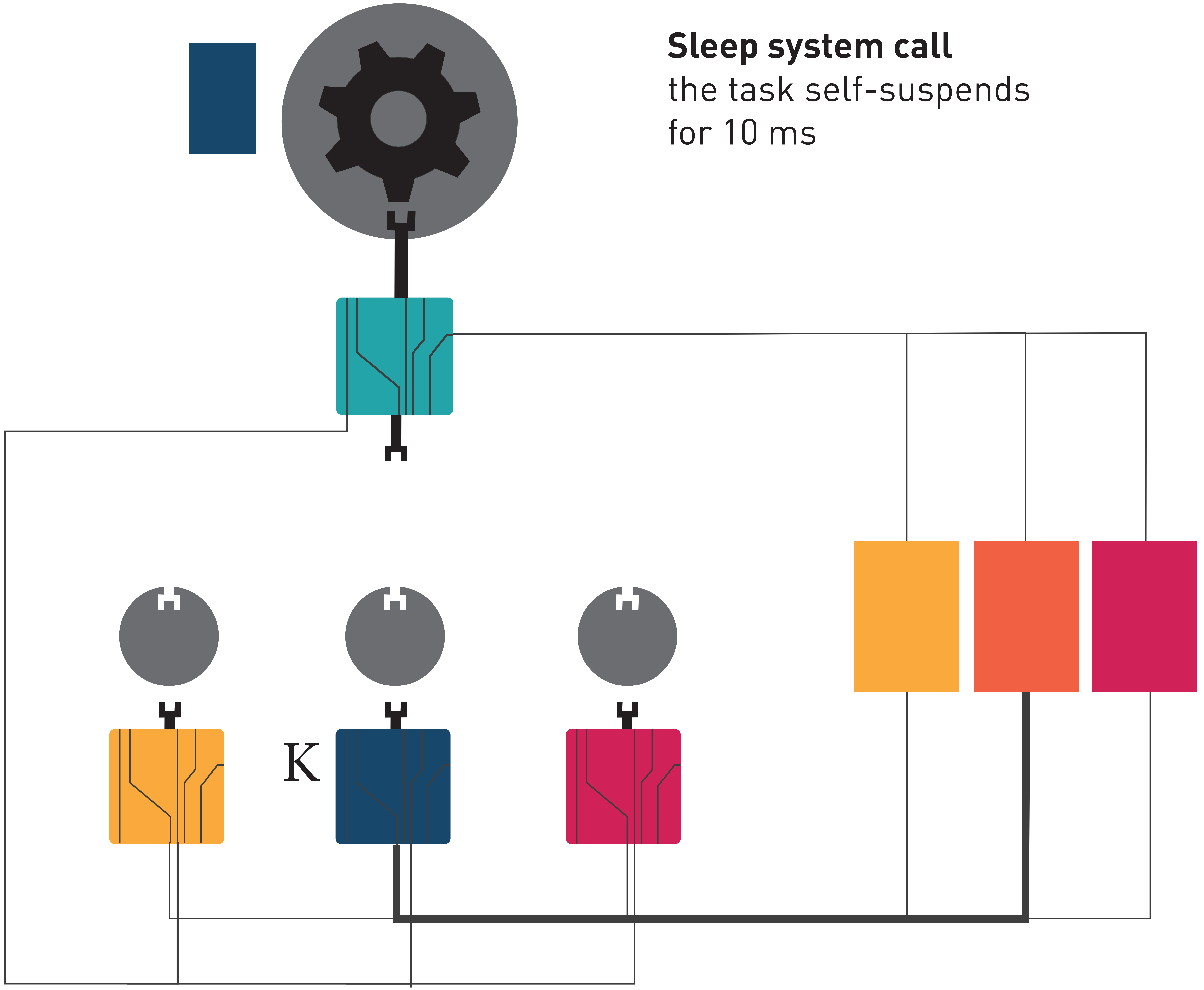

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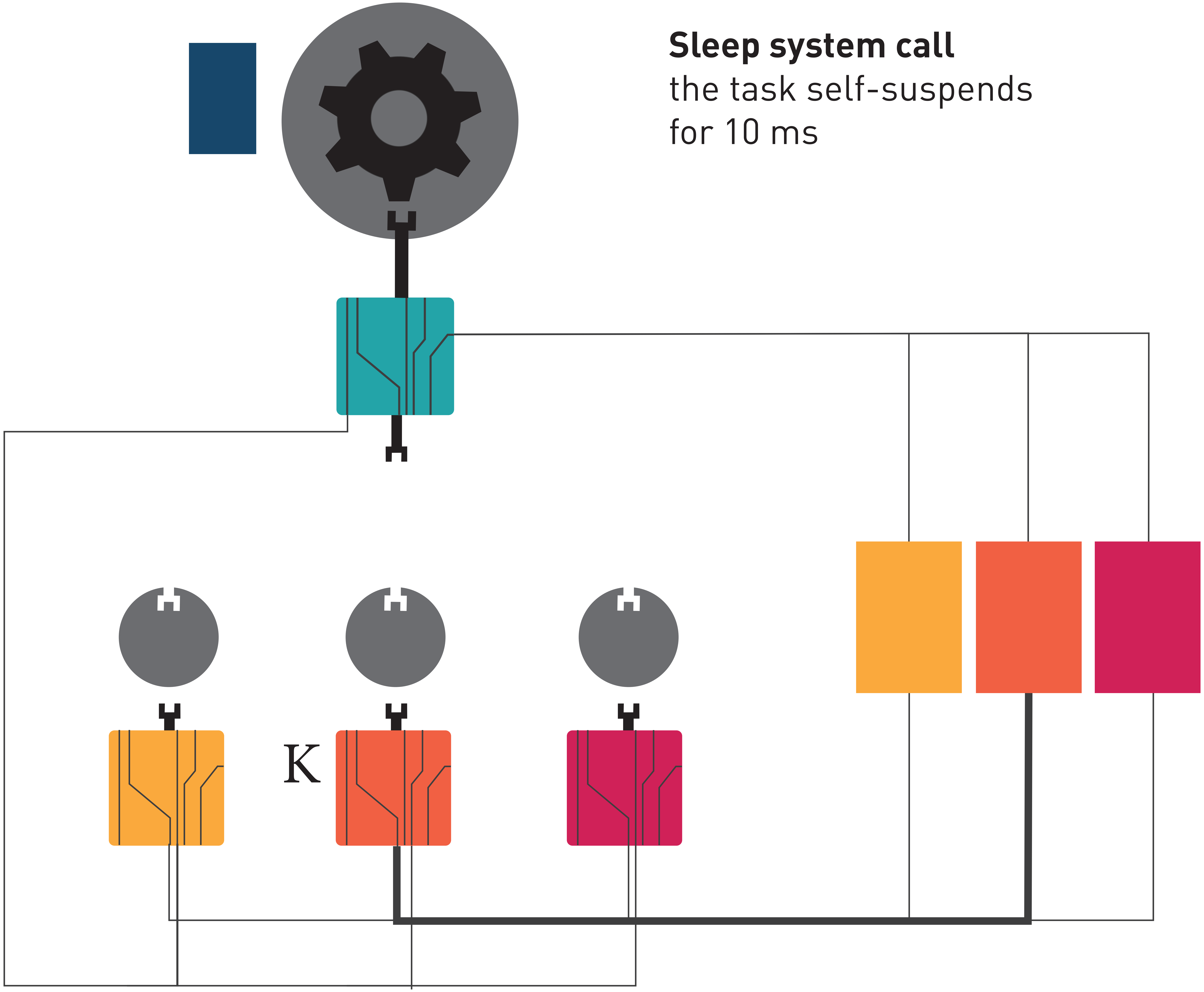

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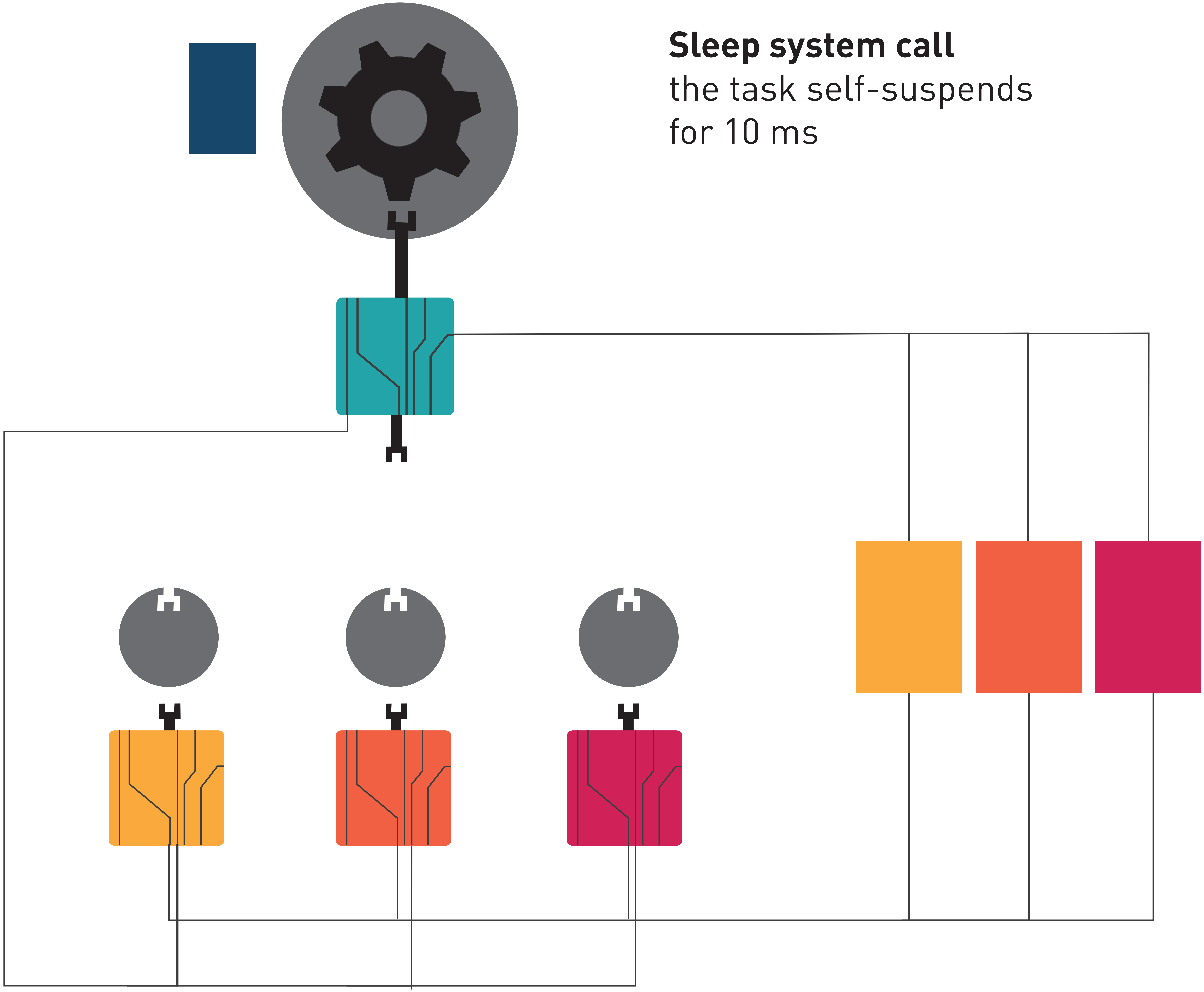


Sleep system call
the task self-suspends
for 10 ms

Inter Process Communication mechanism: **`send()`** and **`recv()`**

IPC: message passing between processes

Implemented UDP-like API
(**`send()`**, **`recv()`**, port-based)

It affects process states
→ must be based on remote system calls

IPC protocol: performance issues

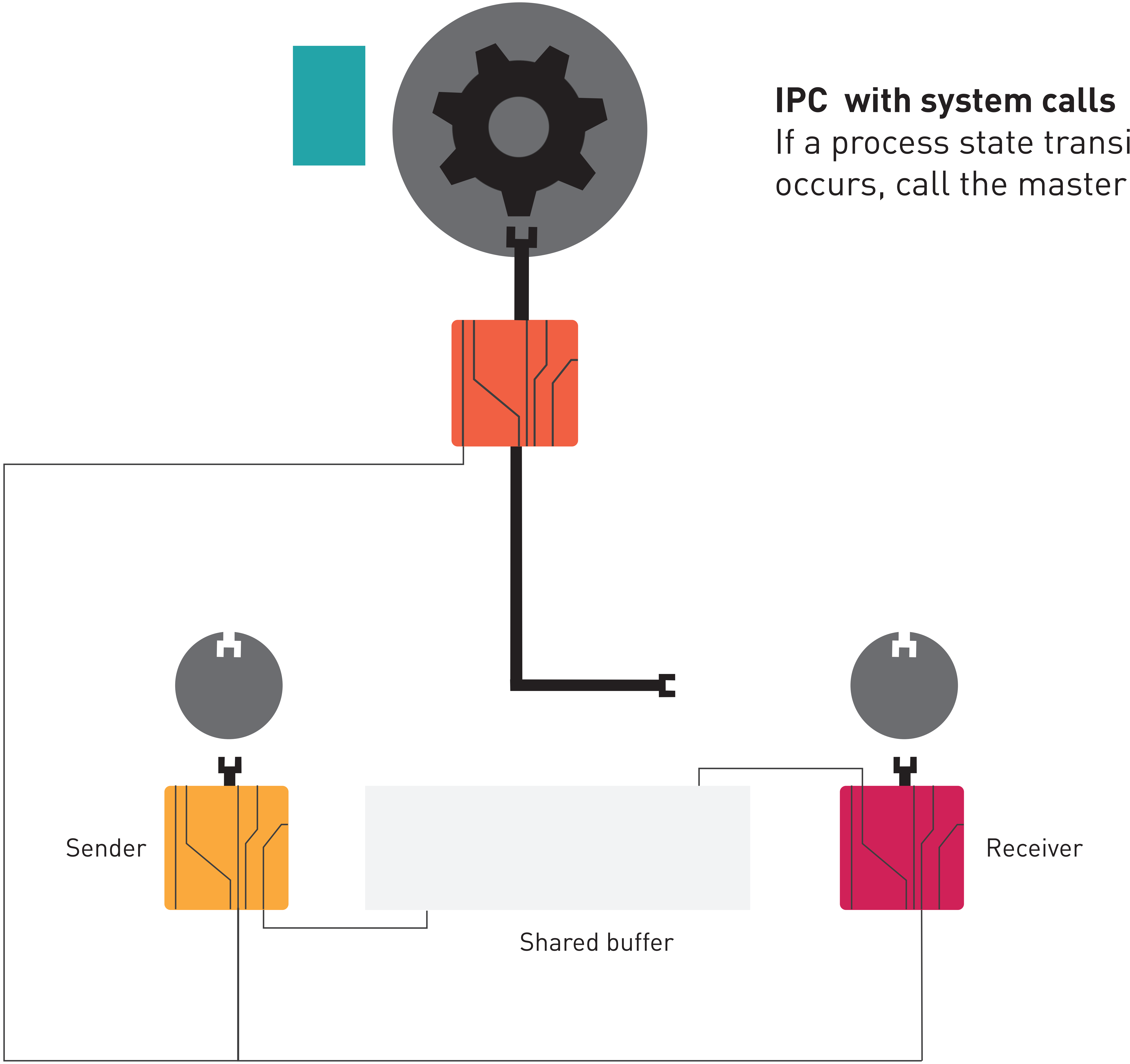
Micro-kernel → IPC requires high efficiency

Avoid to overload the master core

The challenge is many-to-one IPC in multicore

IPC with system calls

If a process state transition occurs, call the master

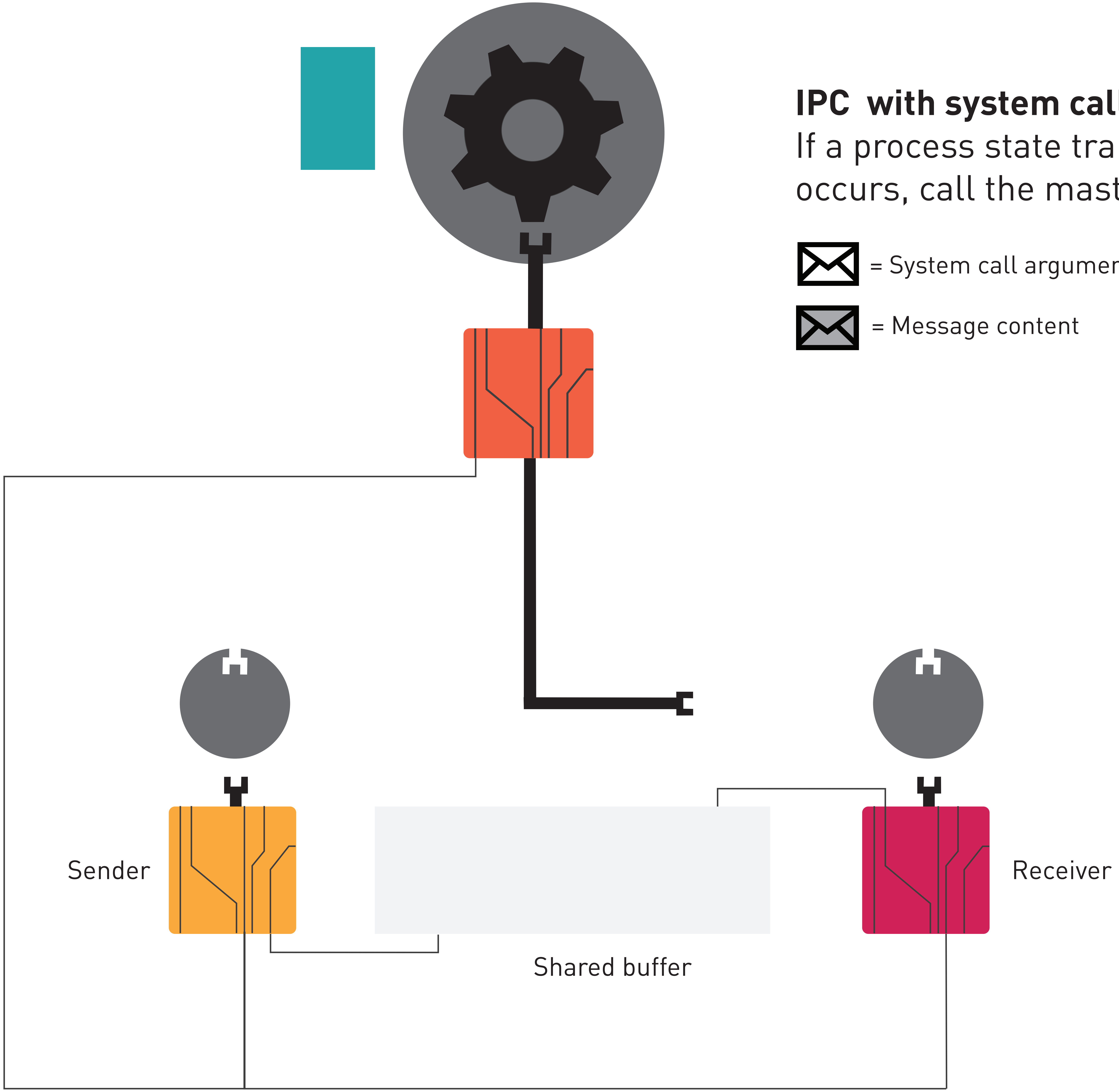


IPC with system calls

If a process state transition occurs, call the master

✉ = System call arguments

✉ = Message content

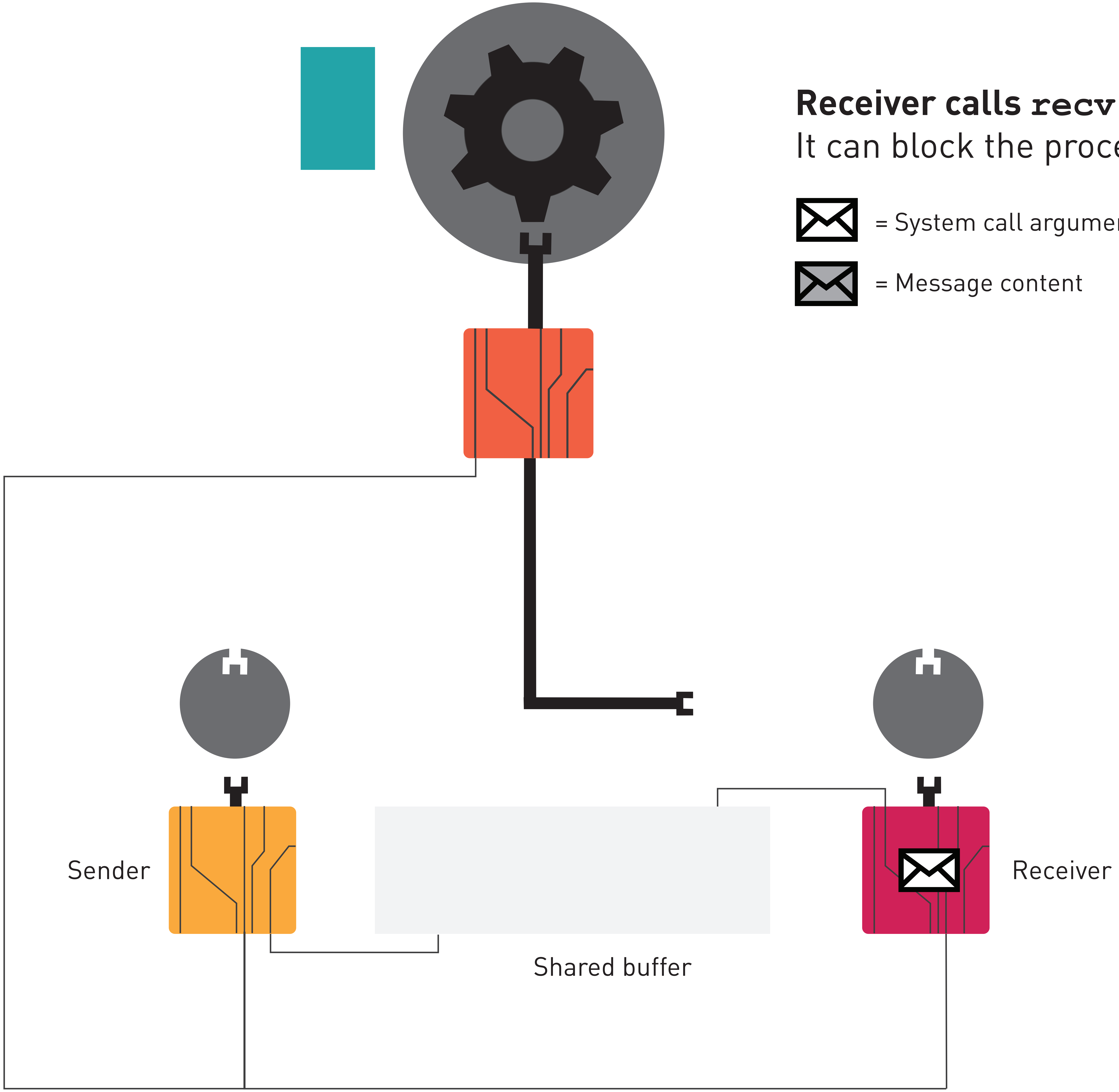


Receiver calls `recv()`

It can block the process

✉ = System call arguments

✉ = Message content



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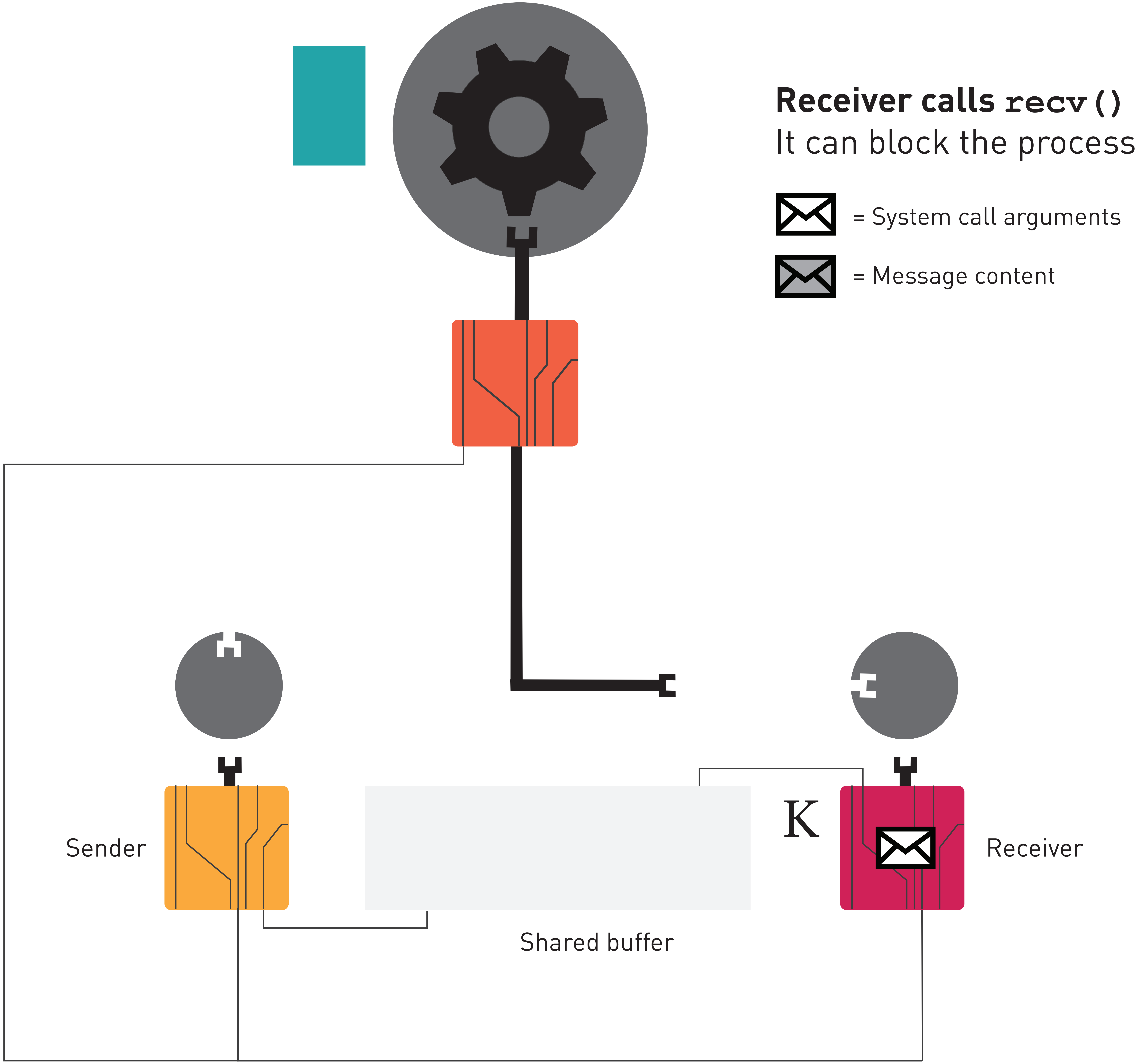
✉ = Message content



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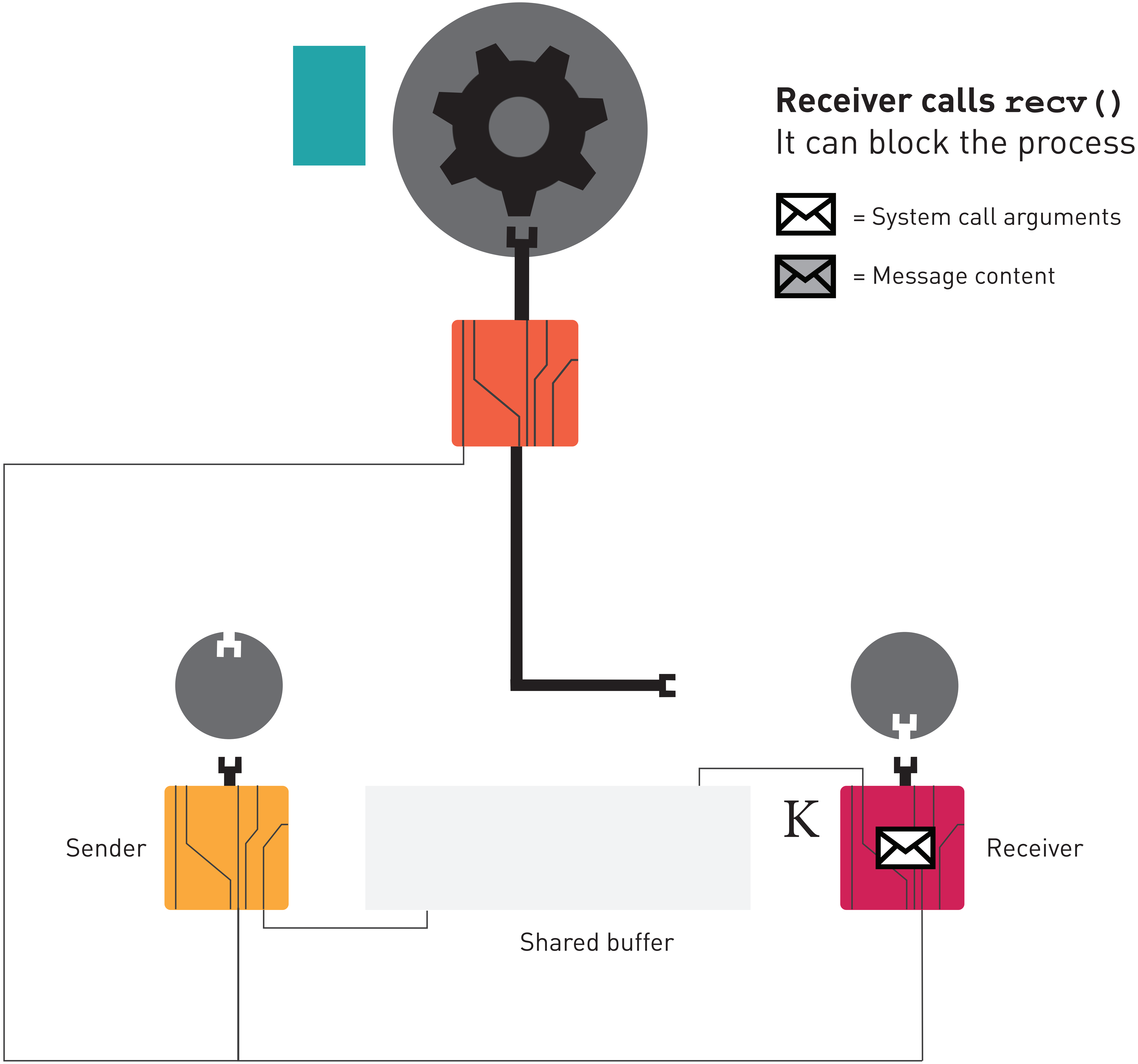

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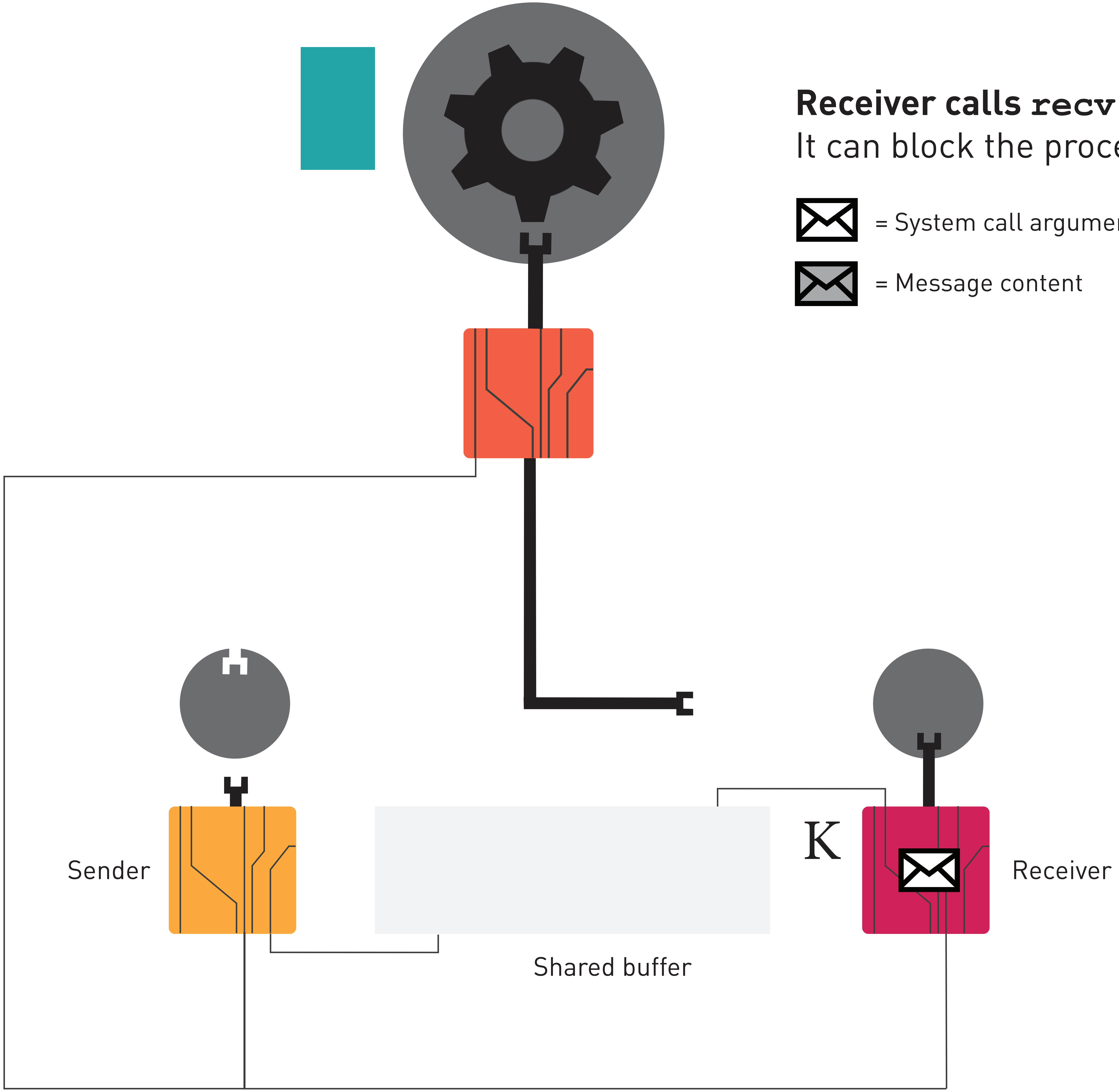

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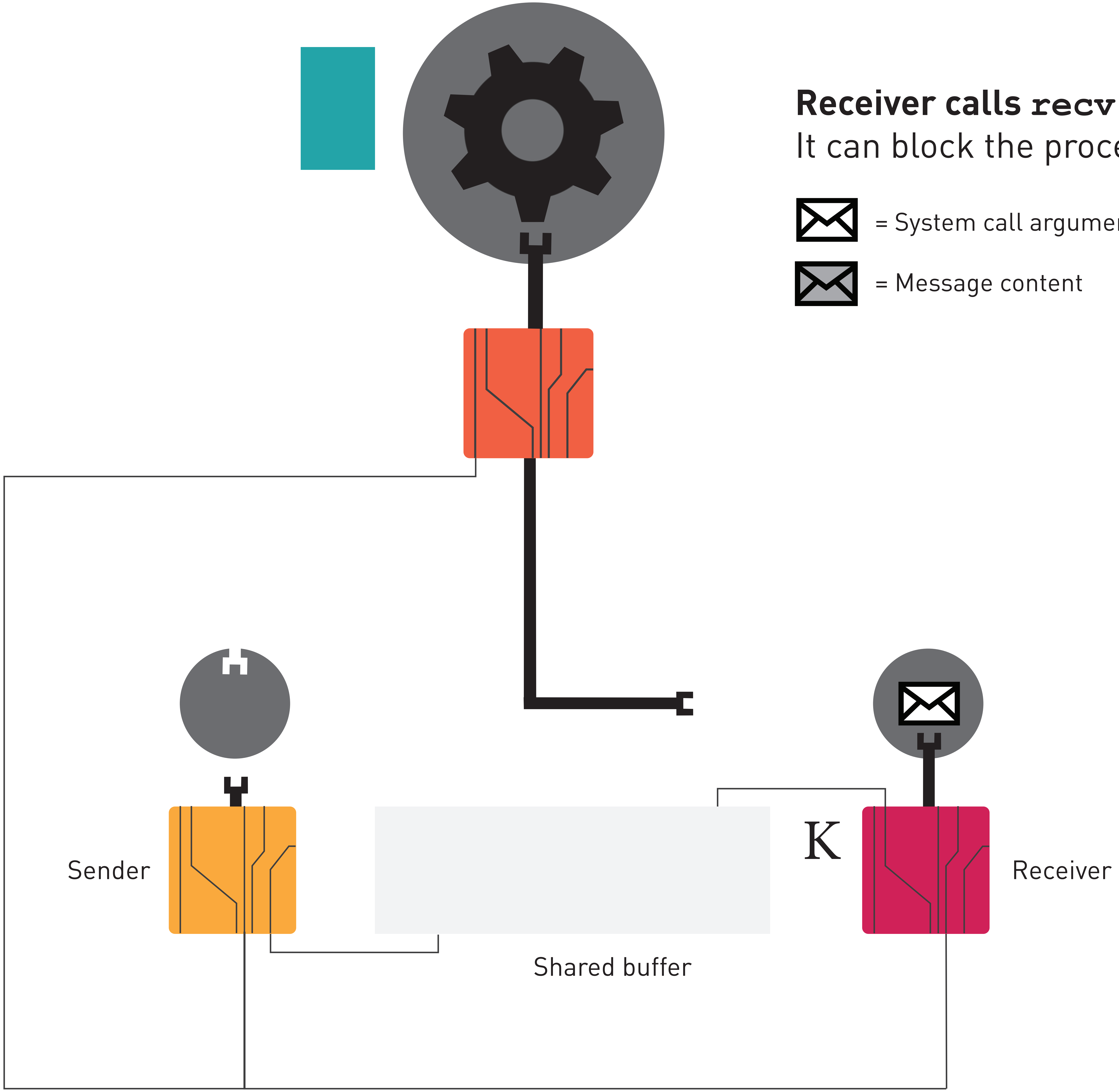

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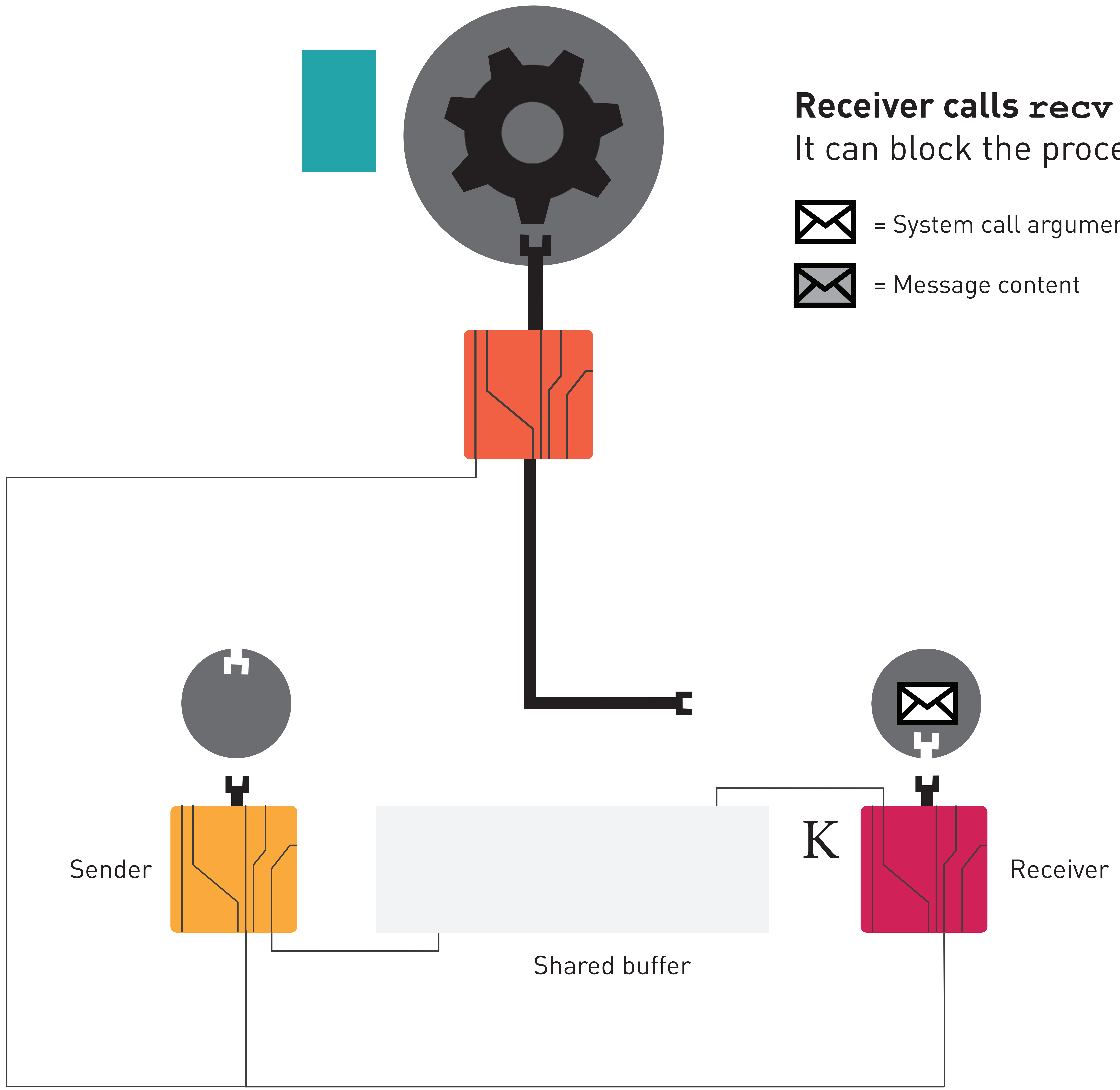

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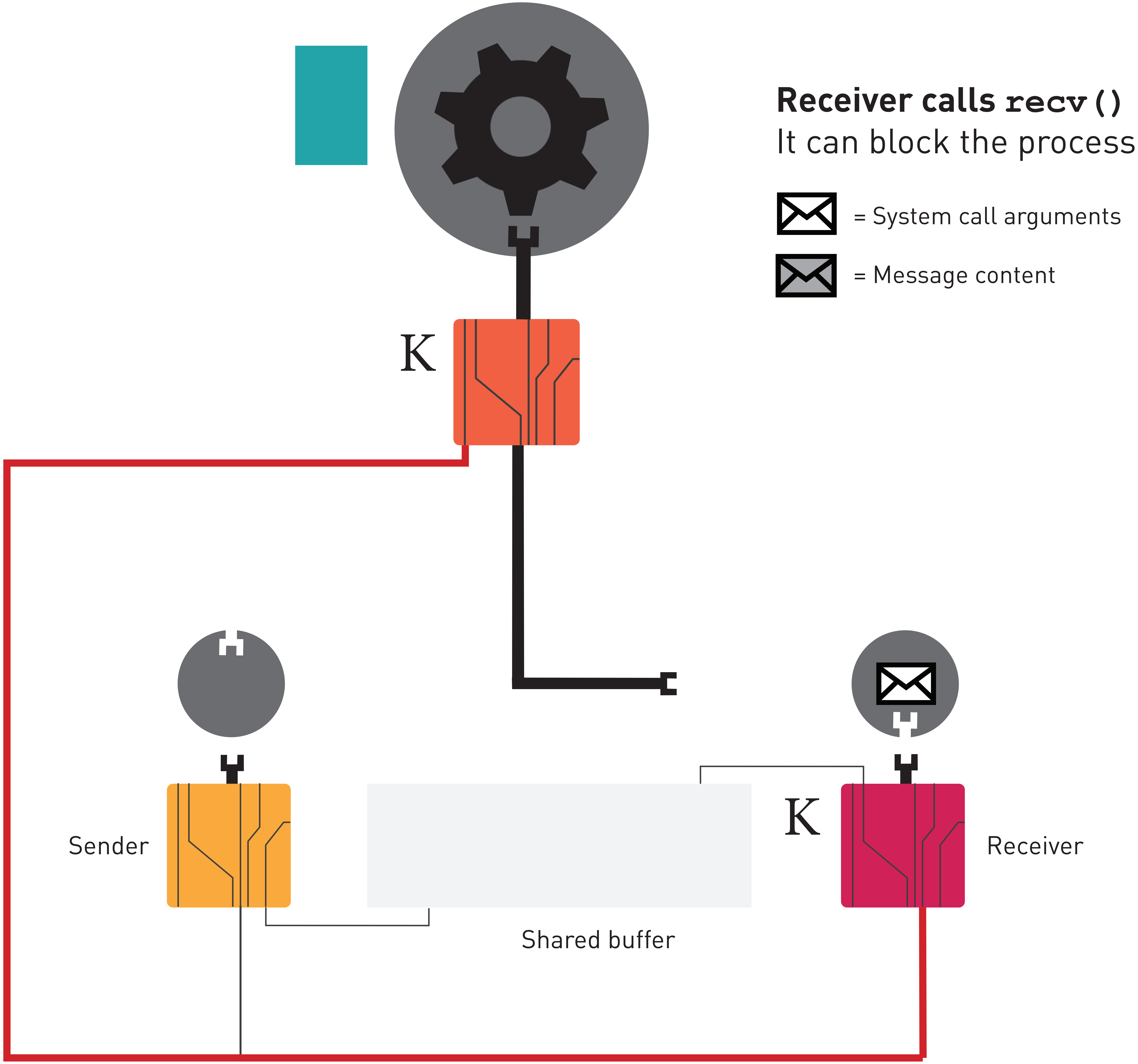

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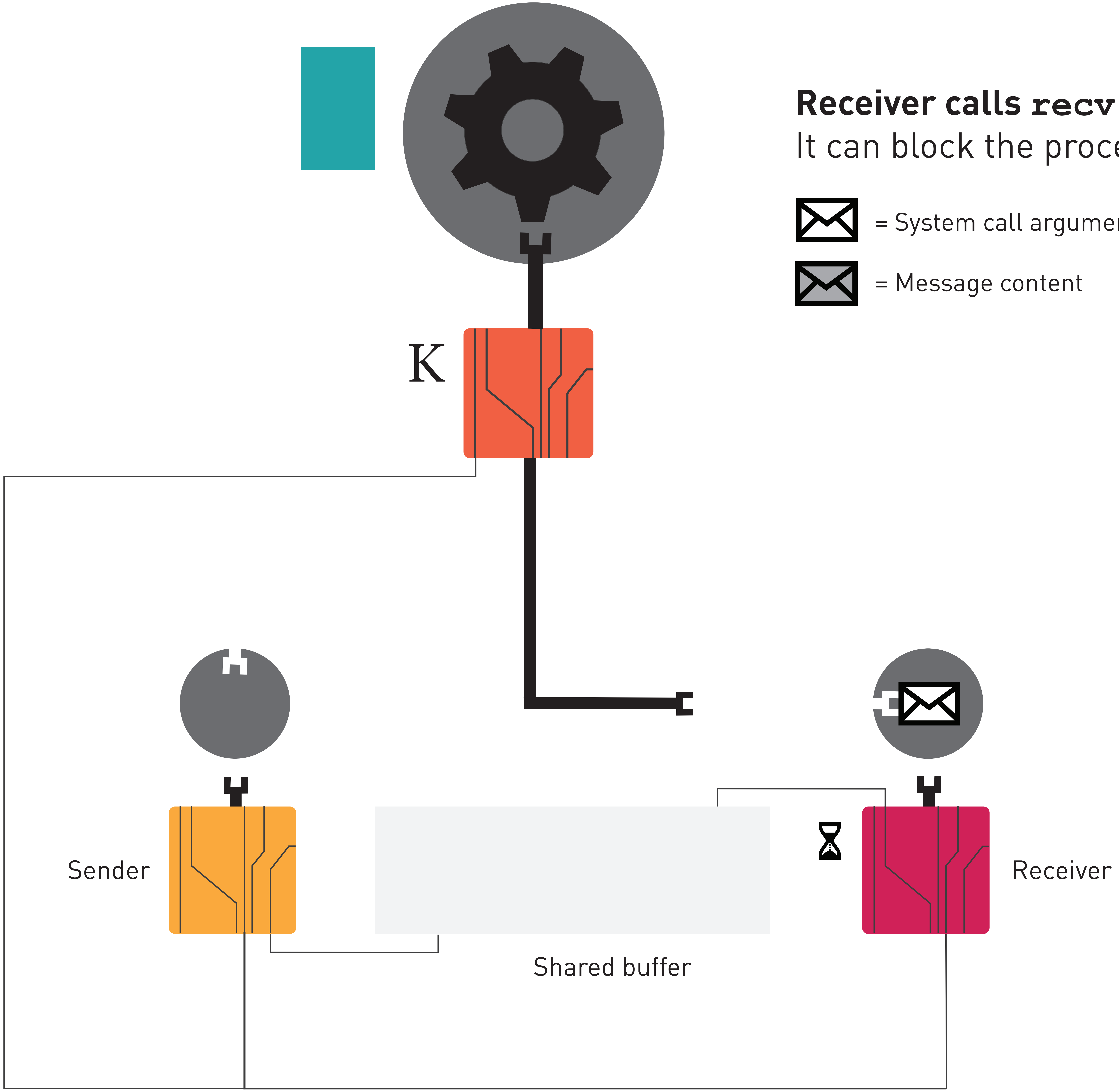

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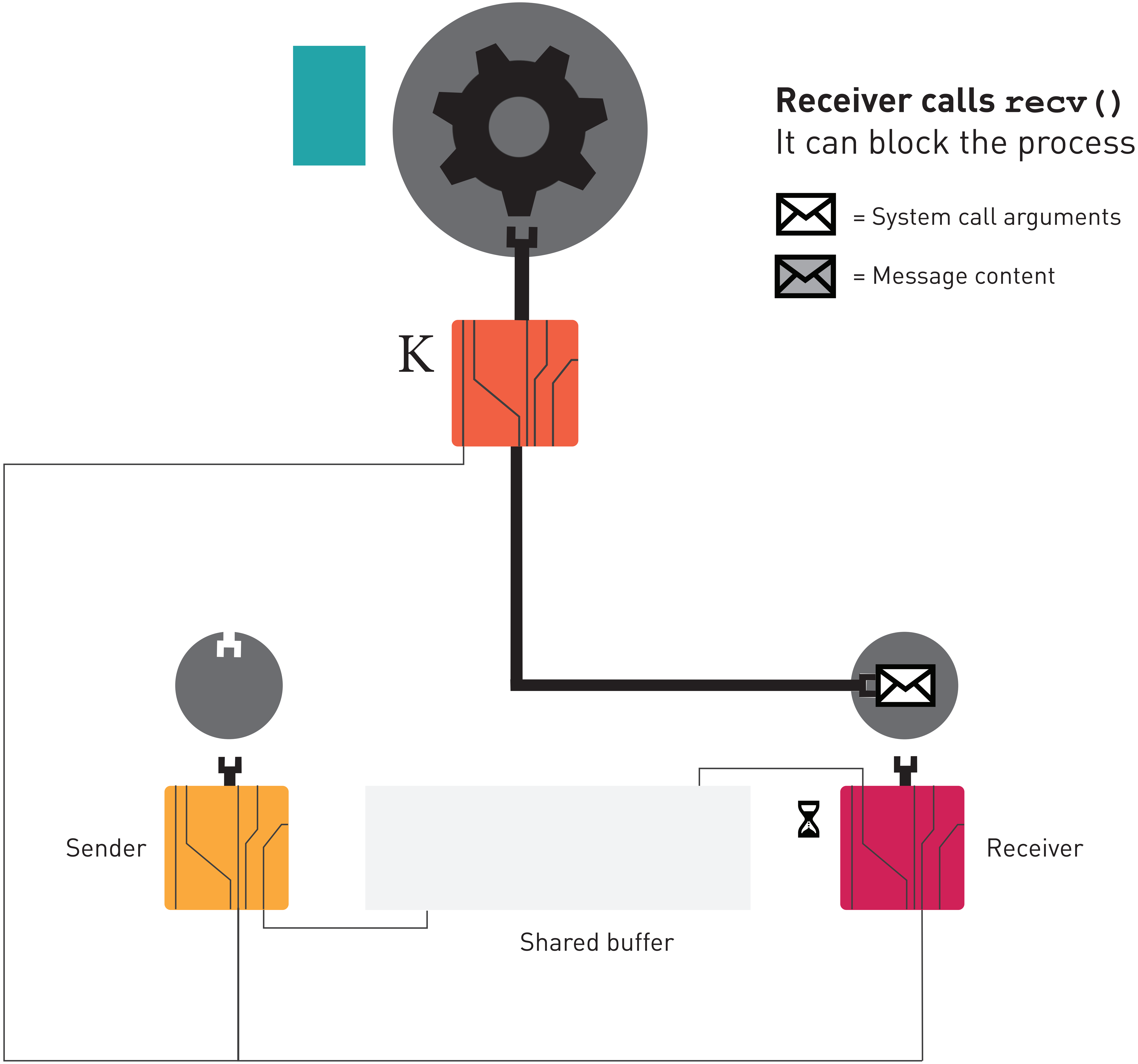

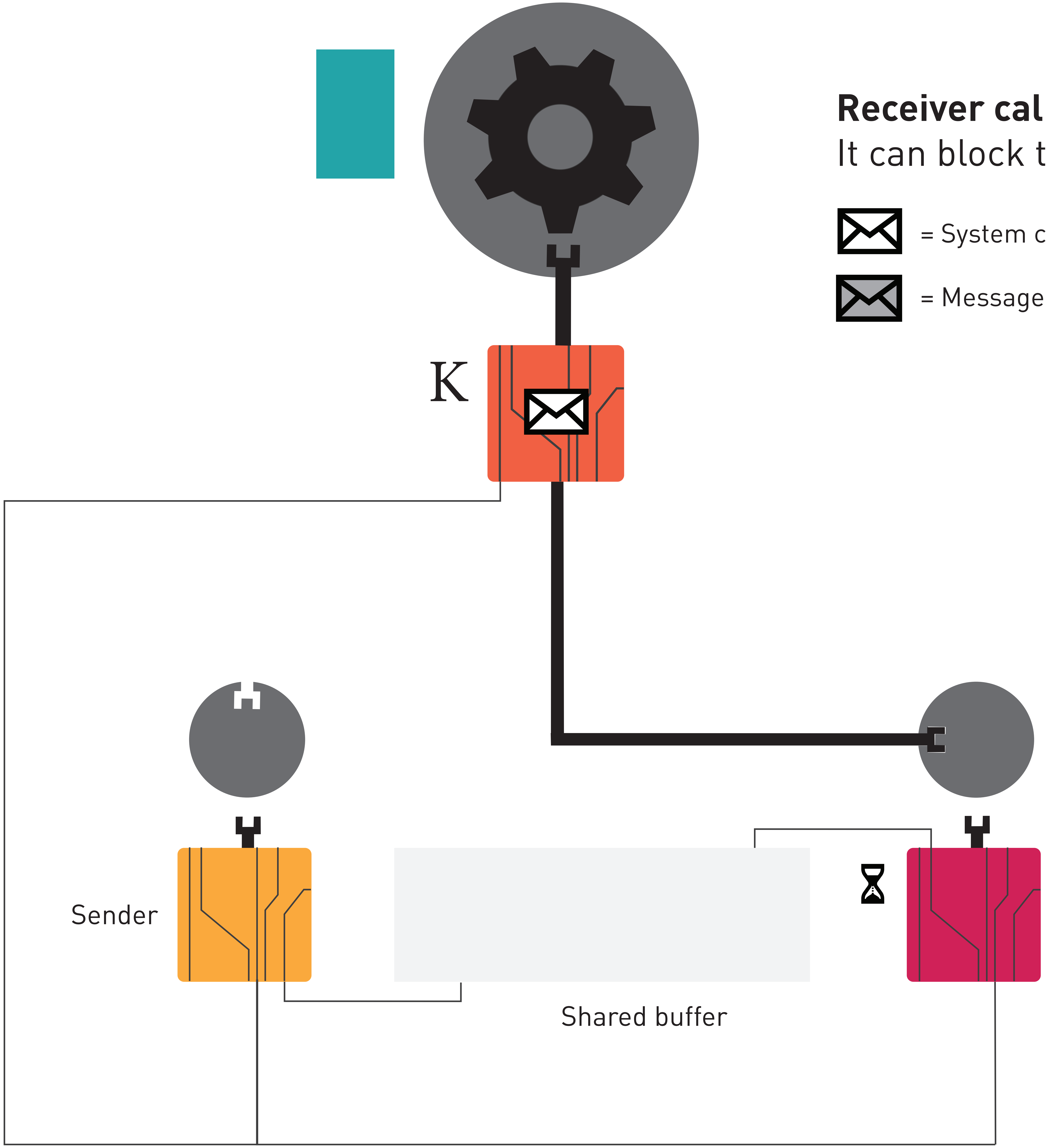

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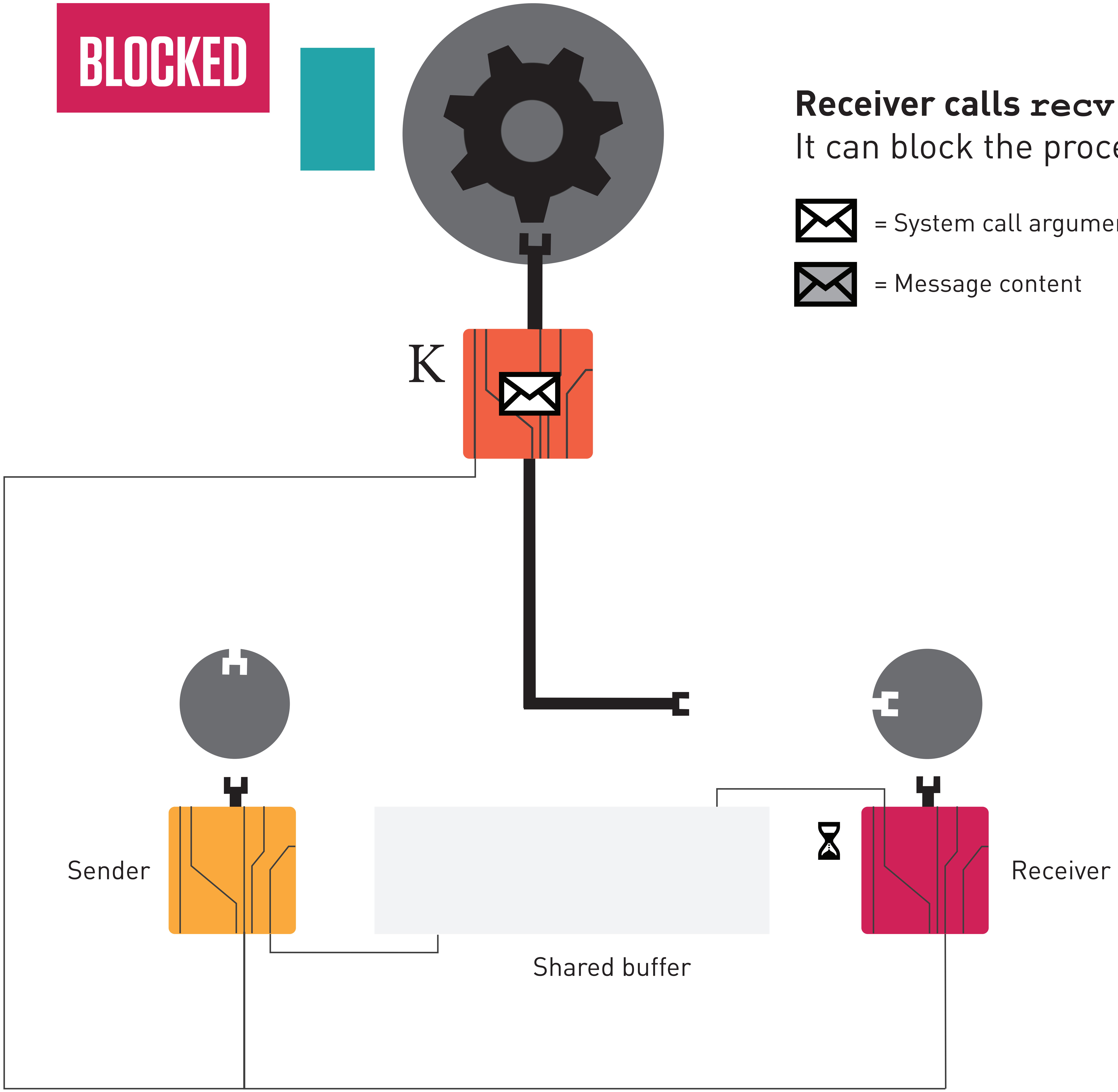

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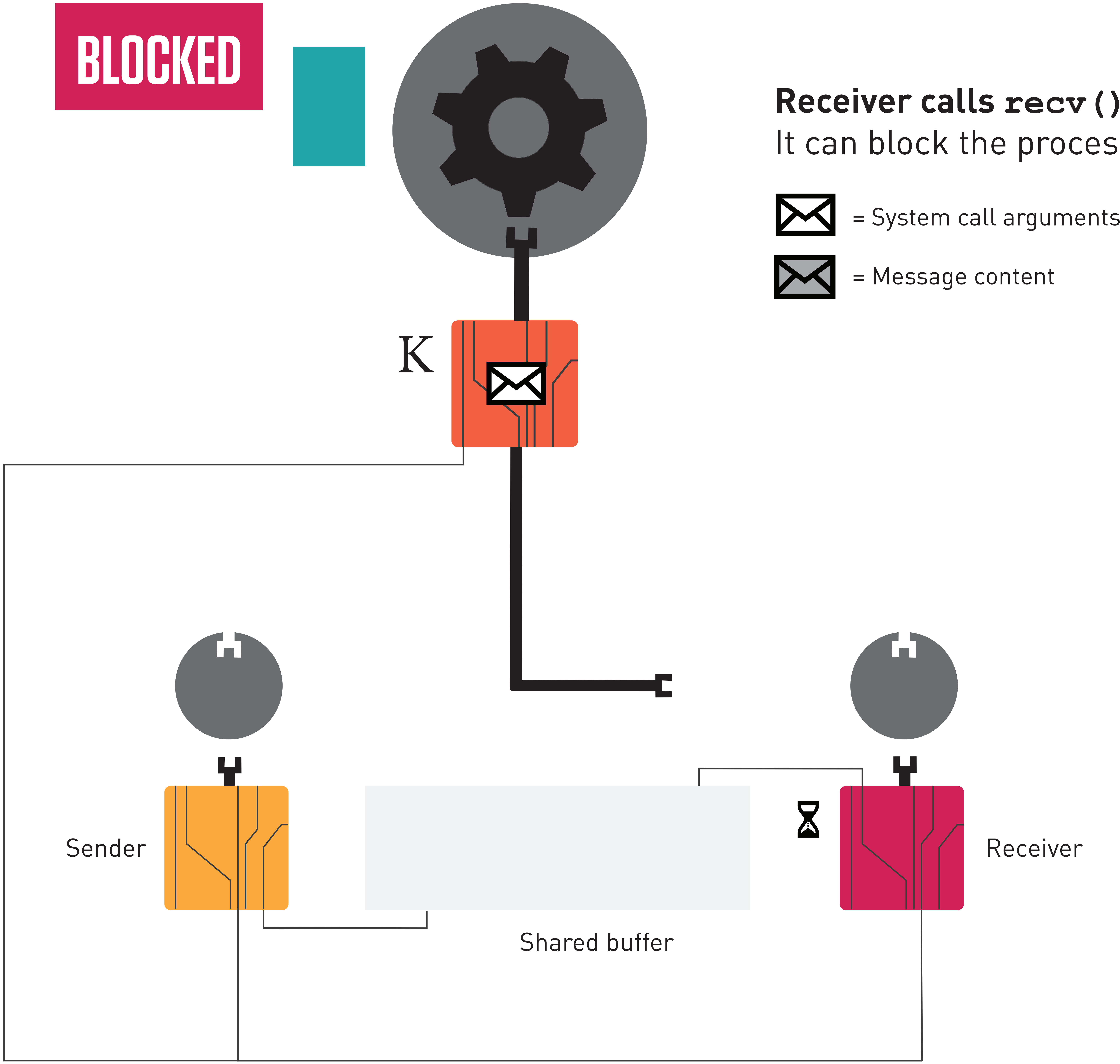


BLOCKED

K

Sender

Shared buffer

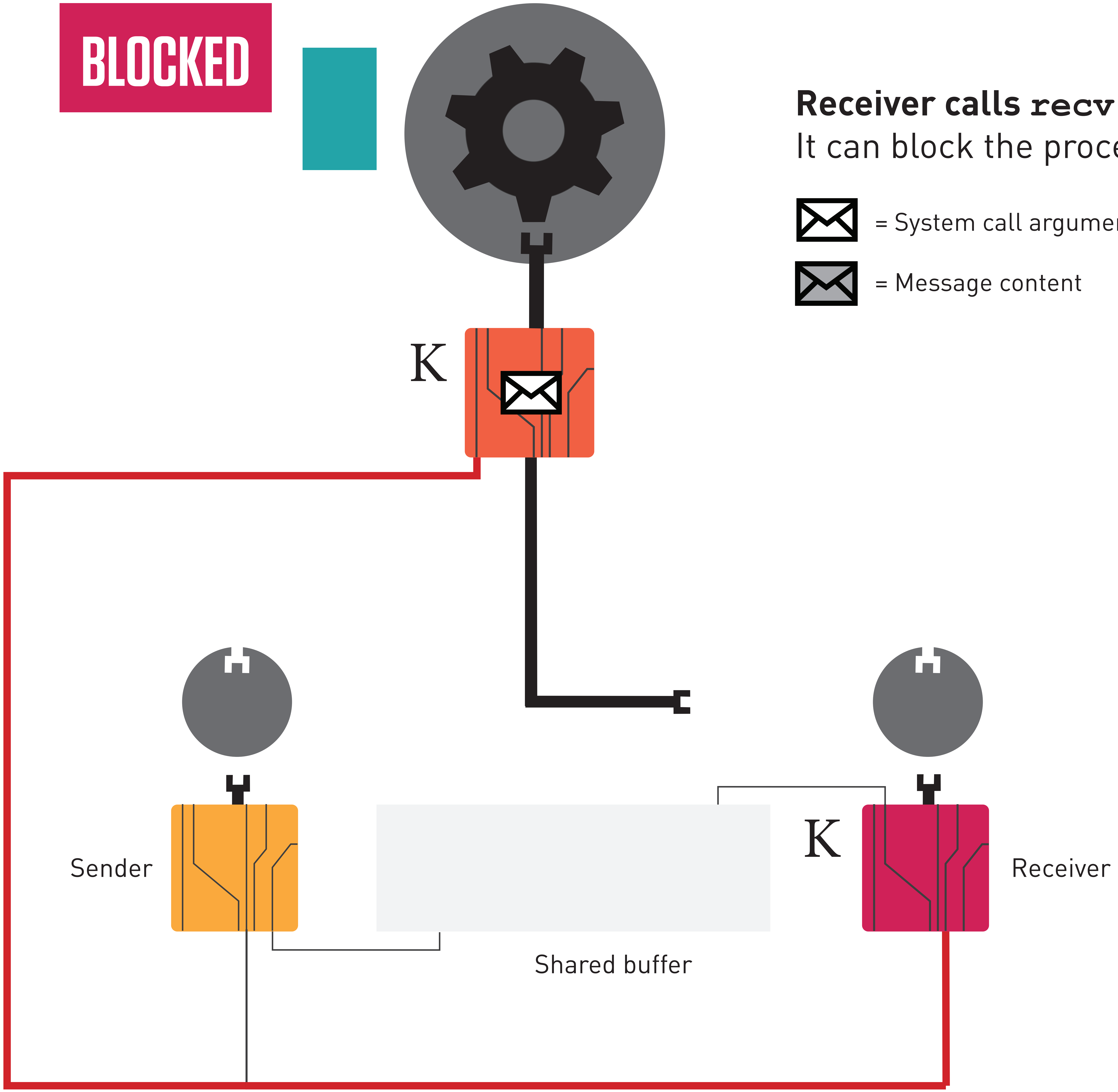
Receiver

Receiver calls `recv()`

It can block the process

✉ = System call arguments

✉ = Message content



Receiver calls `recv()`

It can block the process

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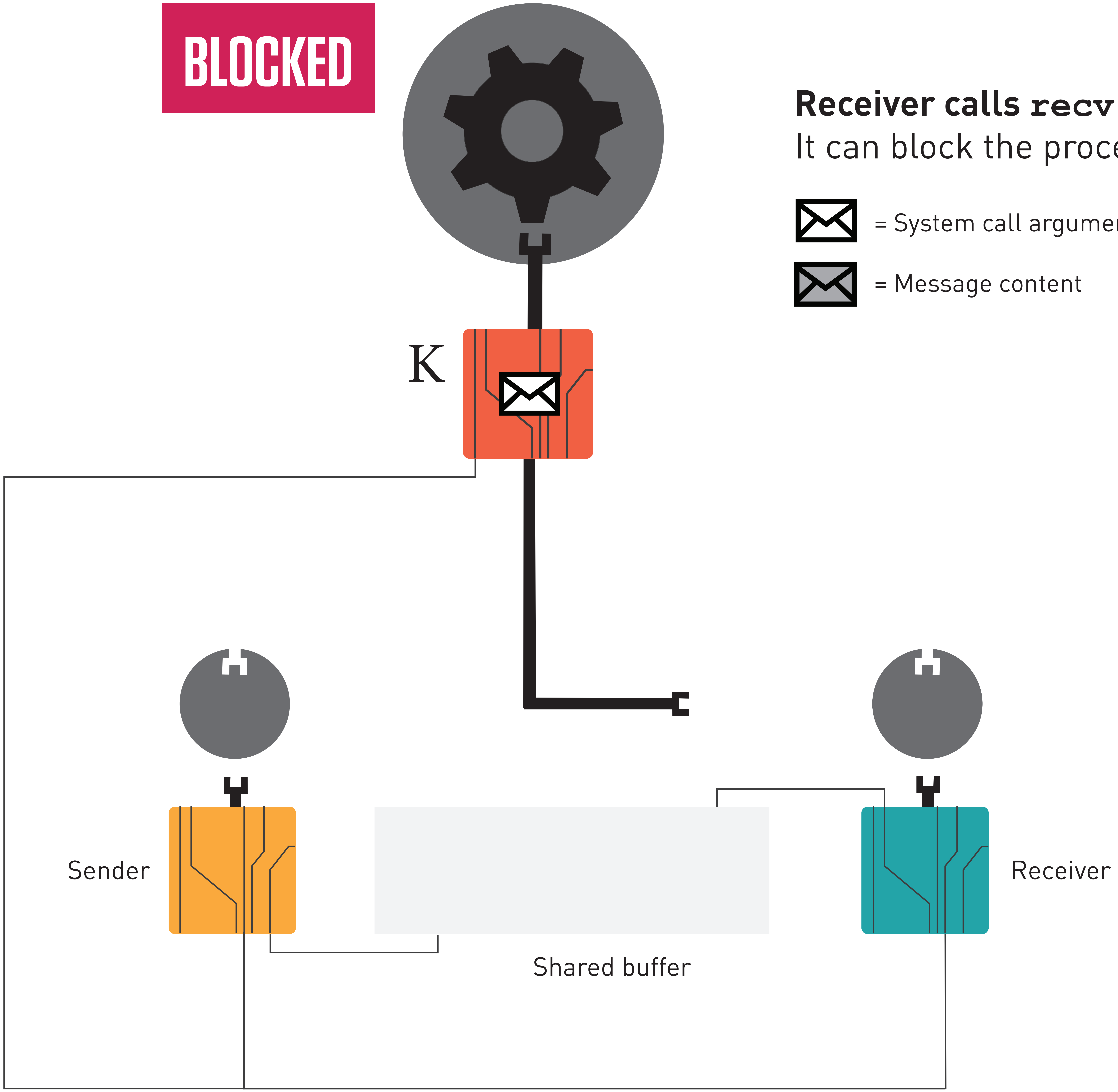

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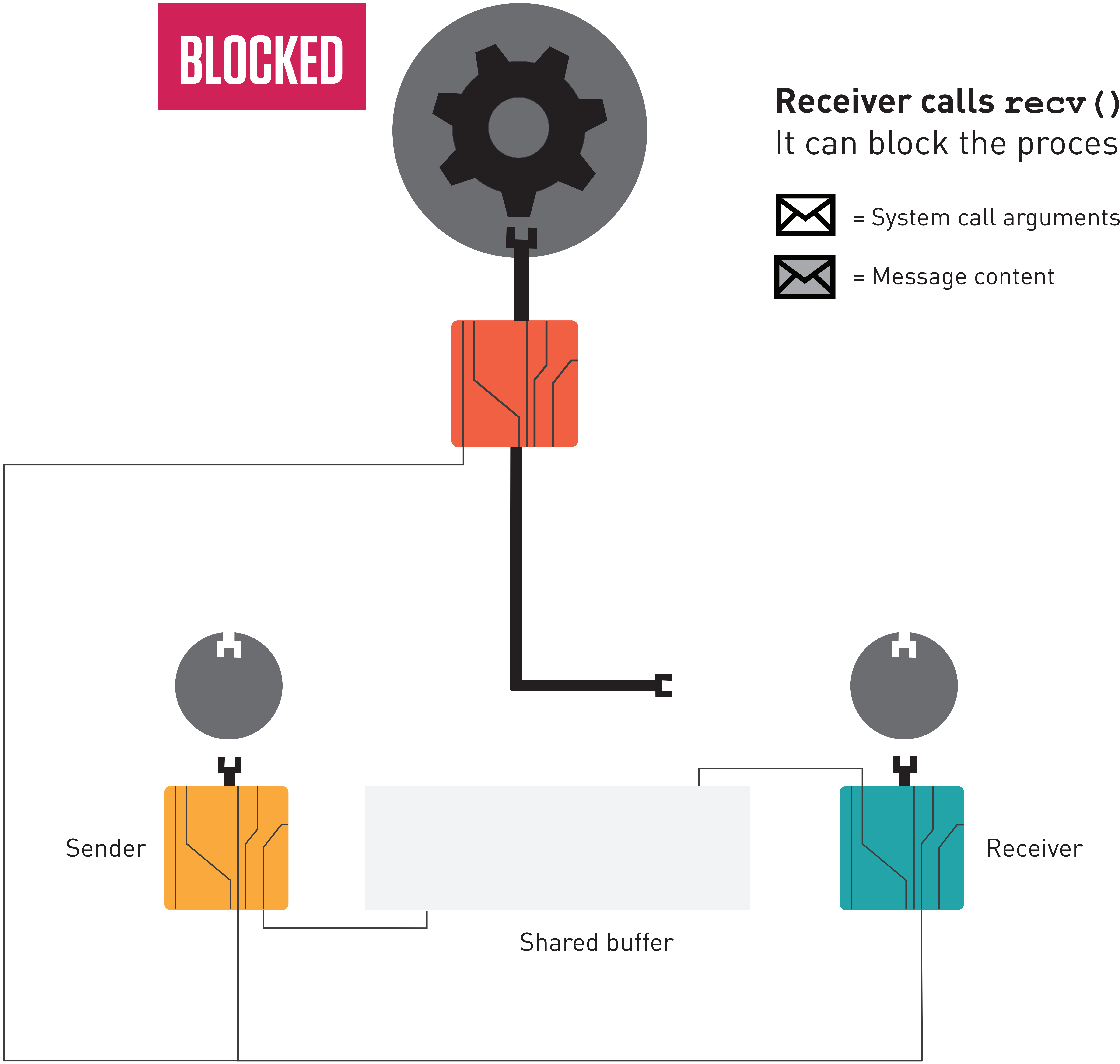
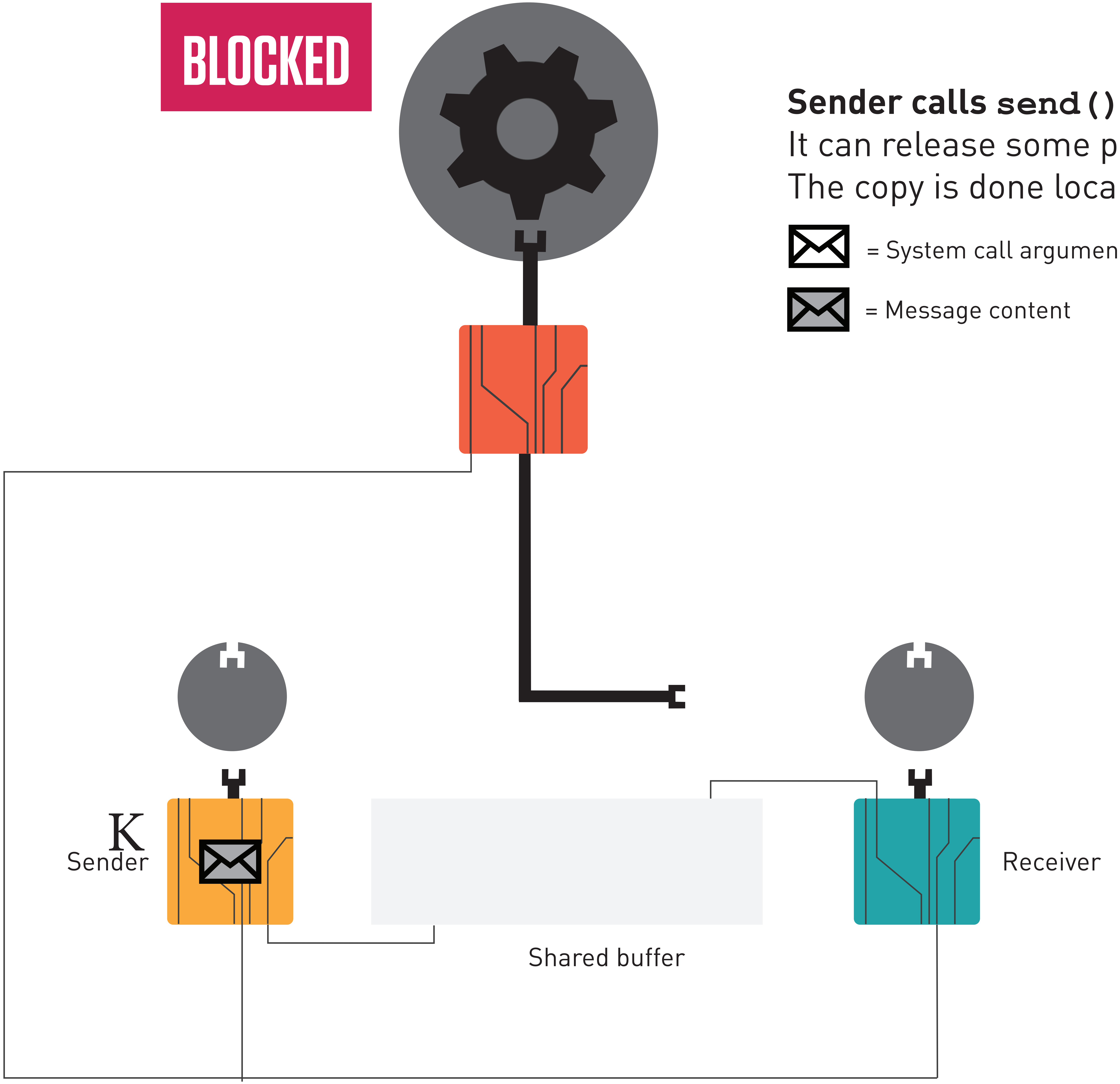


BLOCKED

Sender

Shared buffer

Receiver



Sender calls `send()`

It can release some processes

The copy is done locally

✉ = System call arguments

✉ = Message content

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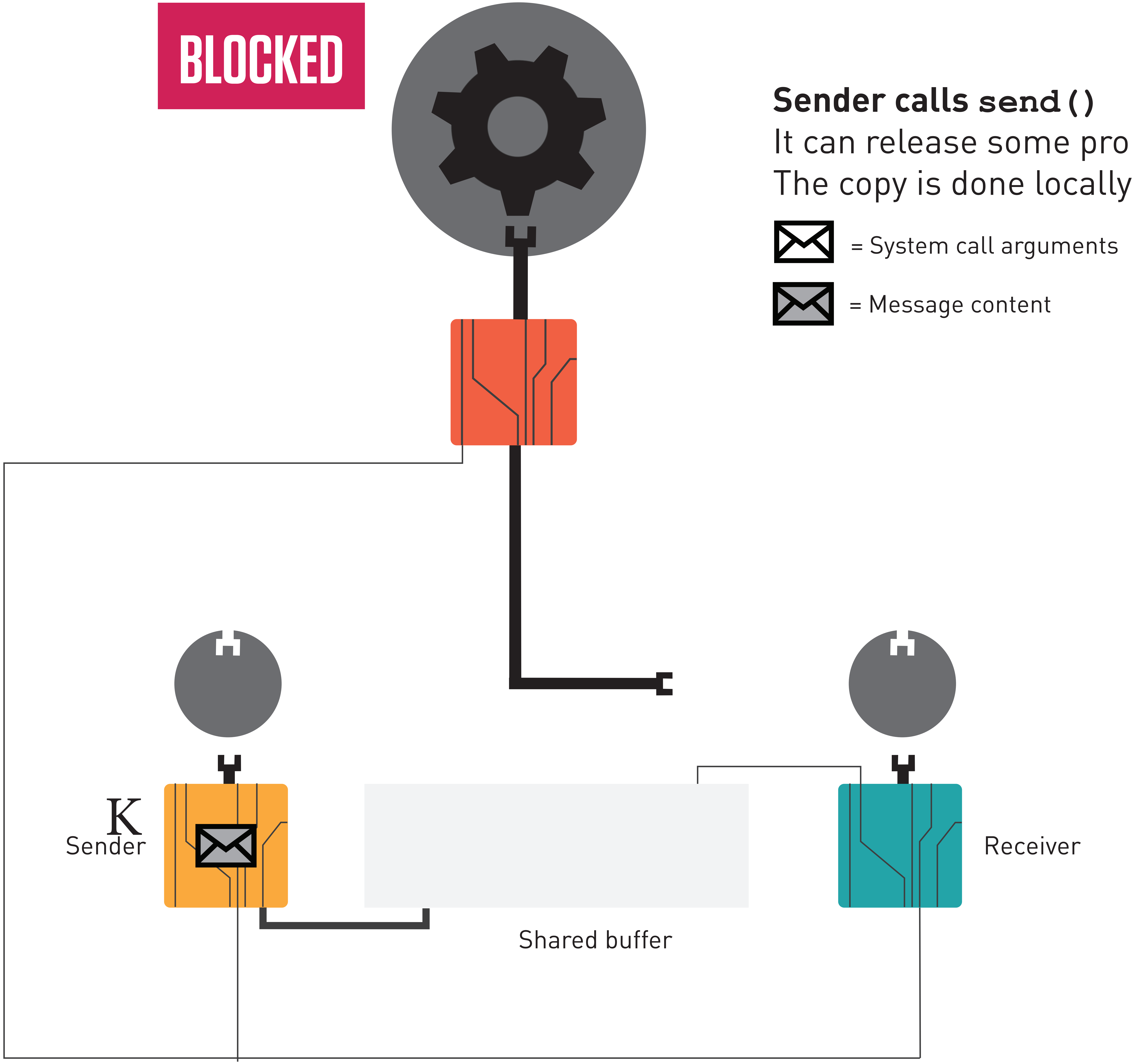

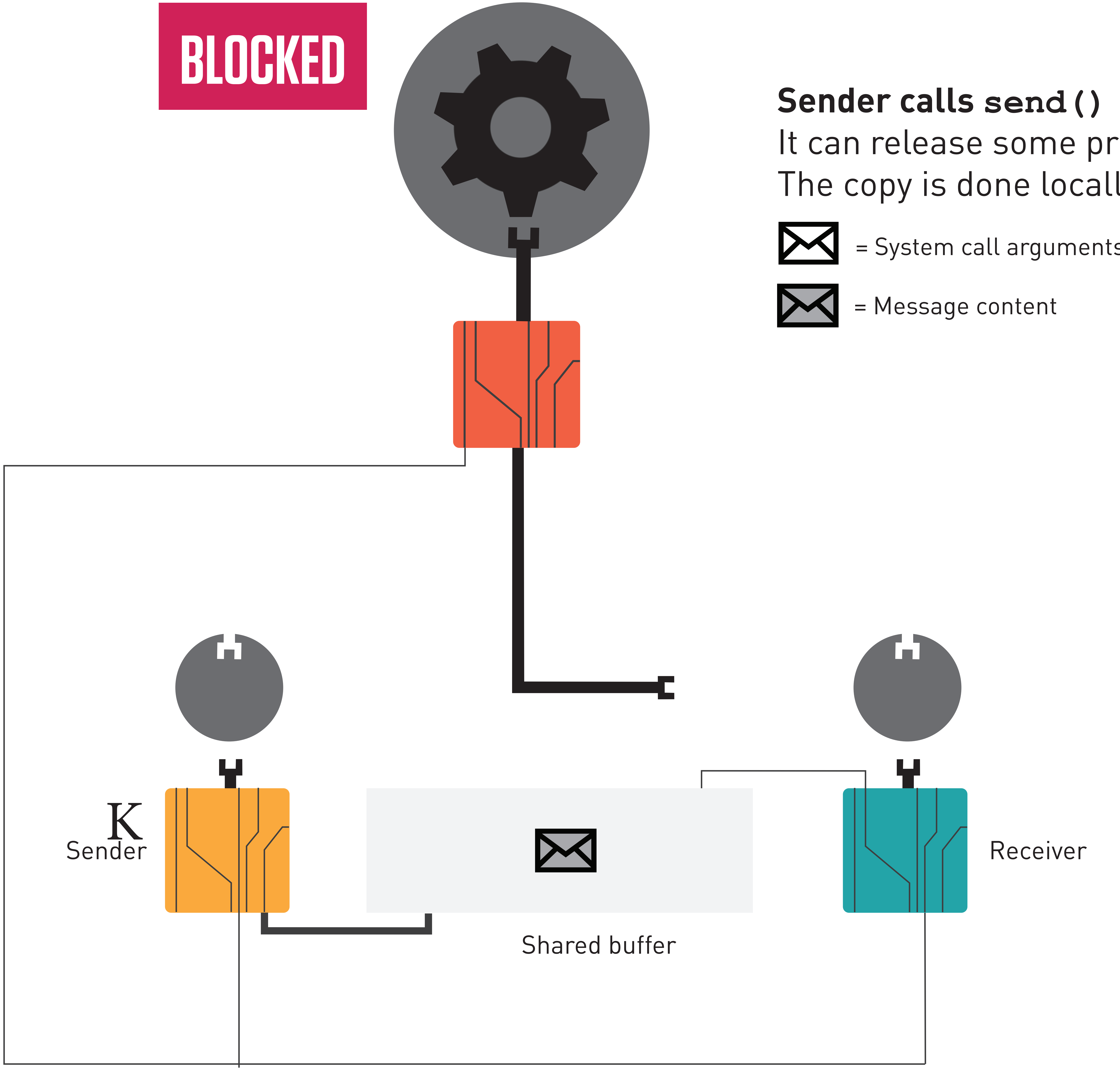

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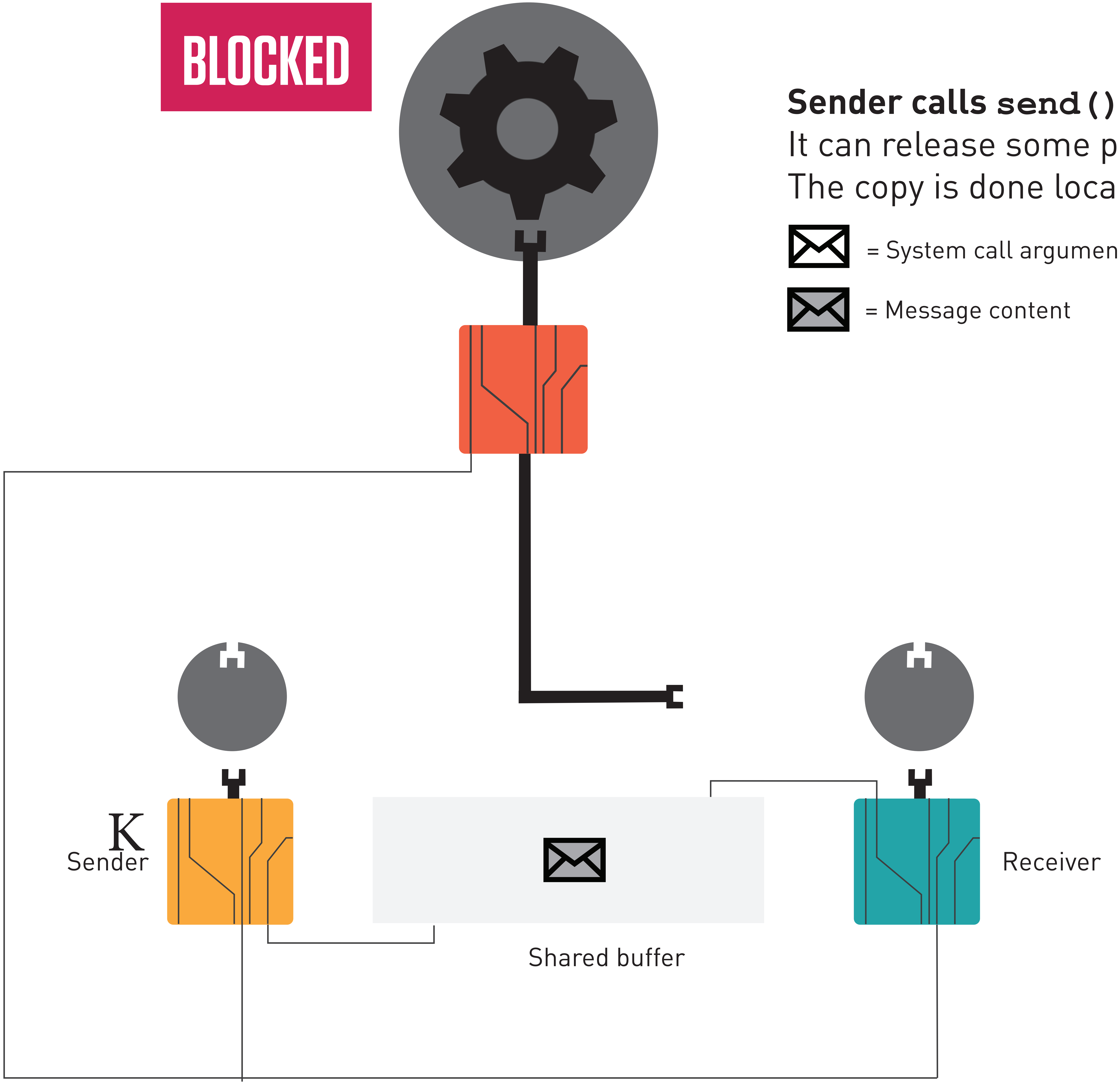

BLOCKED

K

Sender

Shared buffer

Receiver

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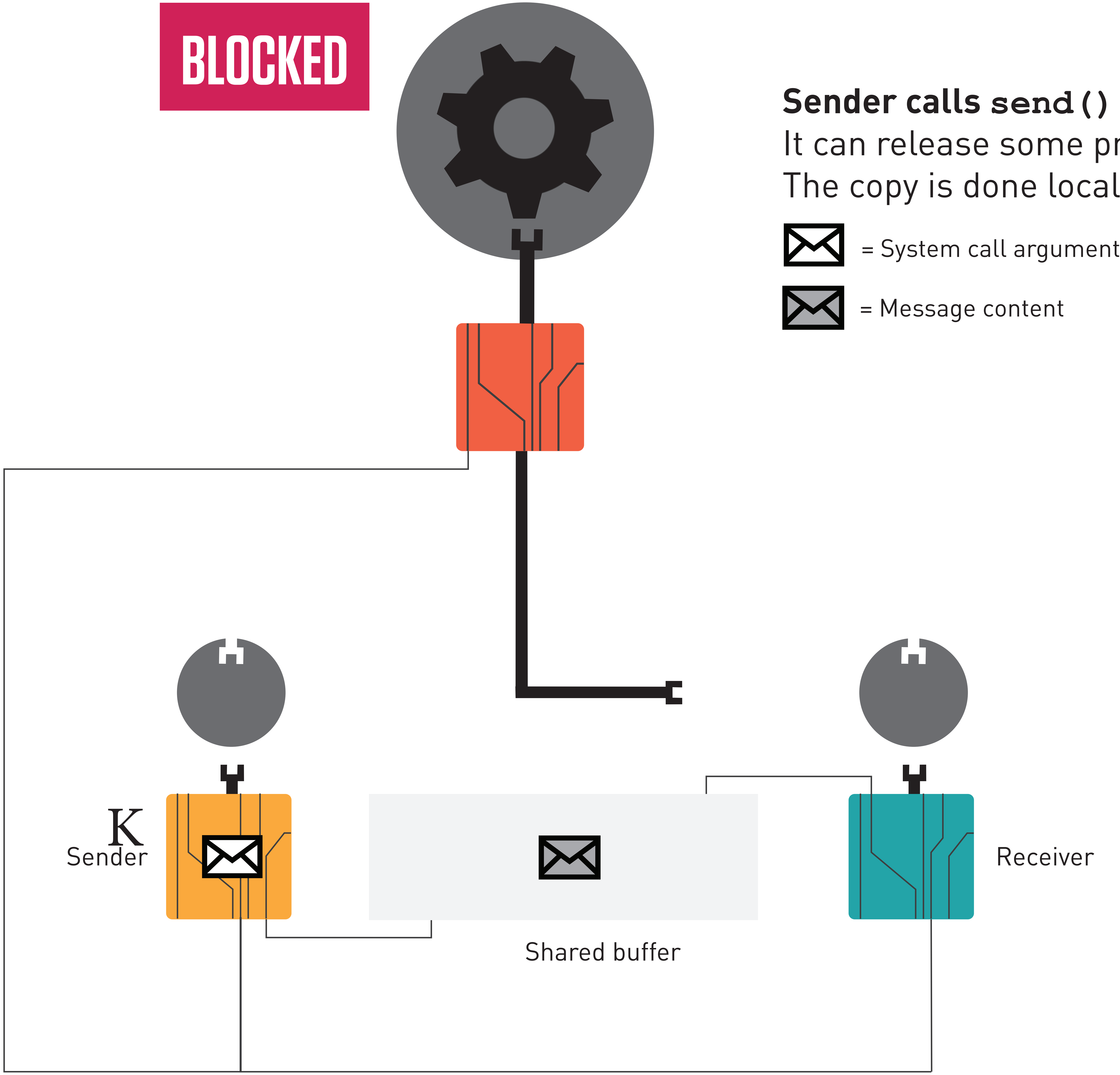

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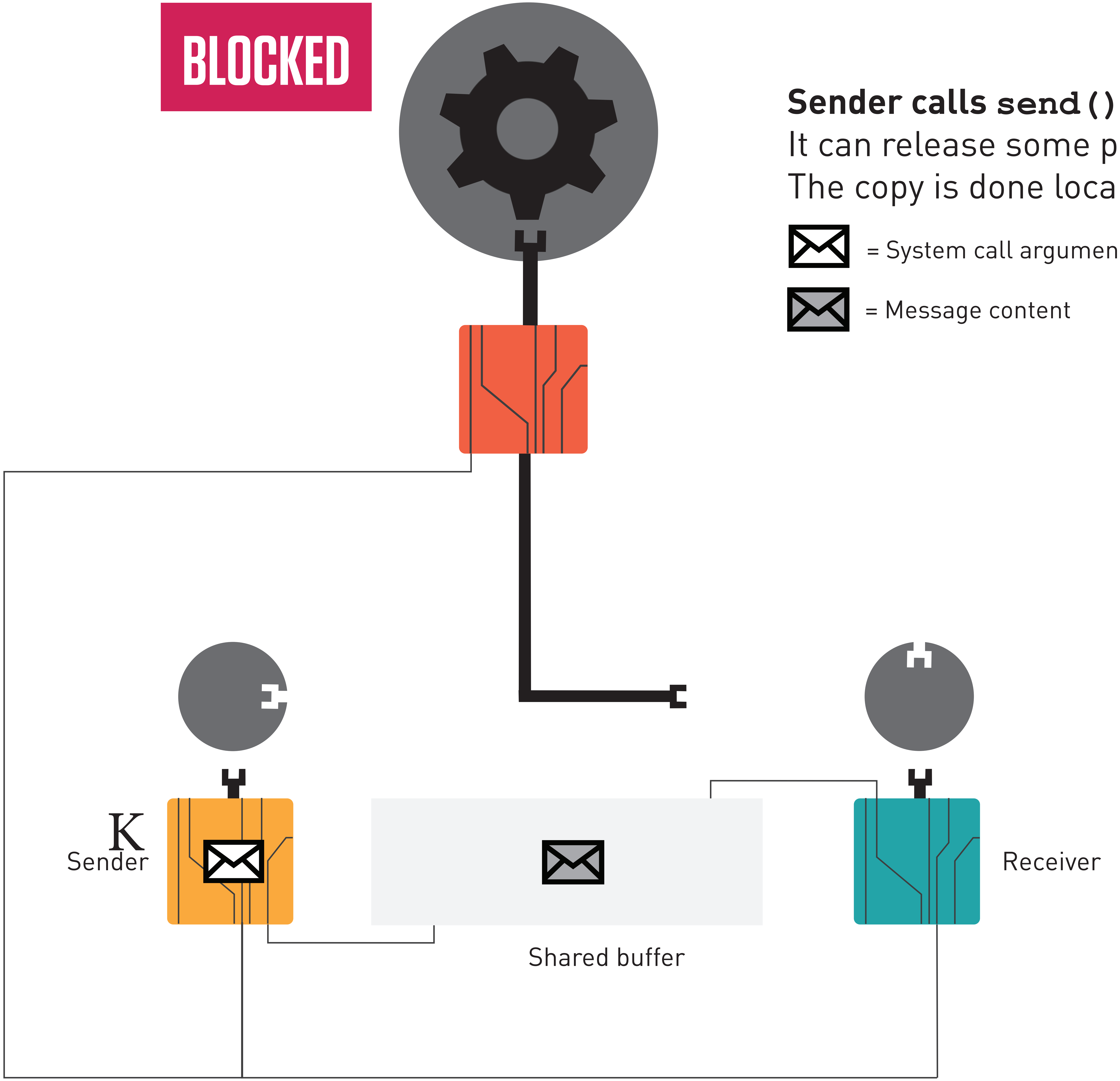

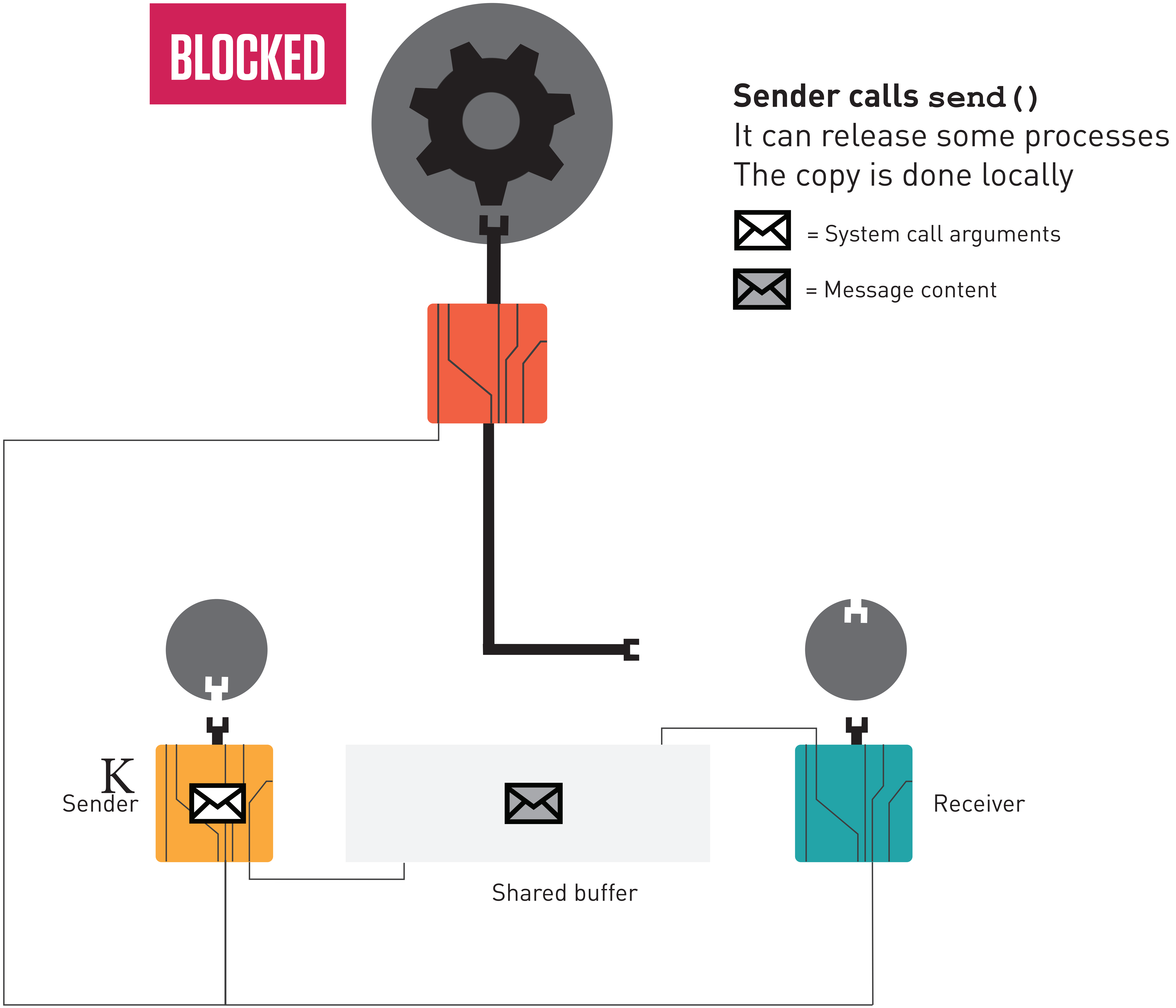

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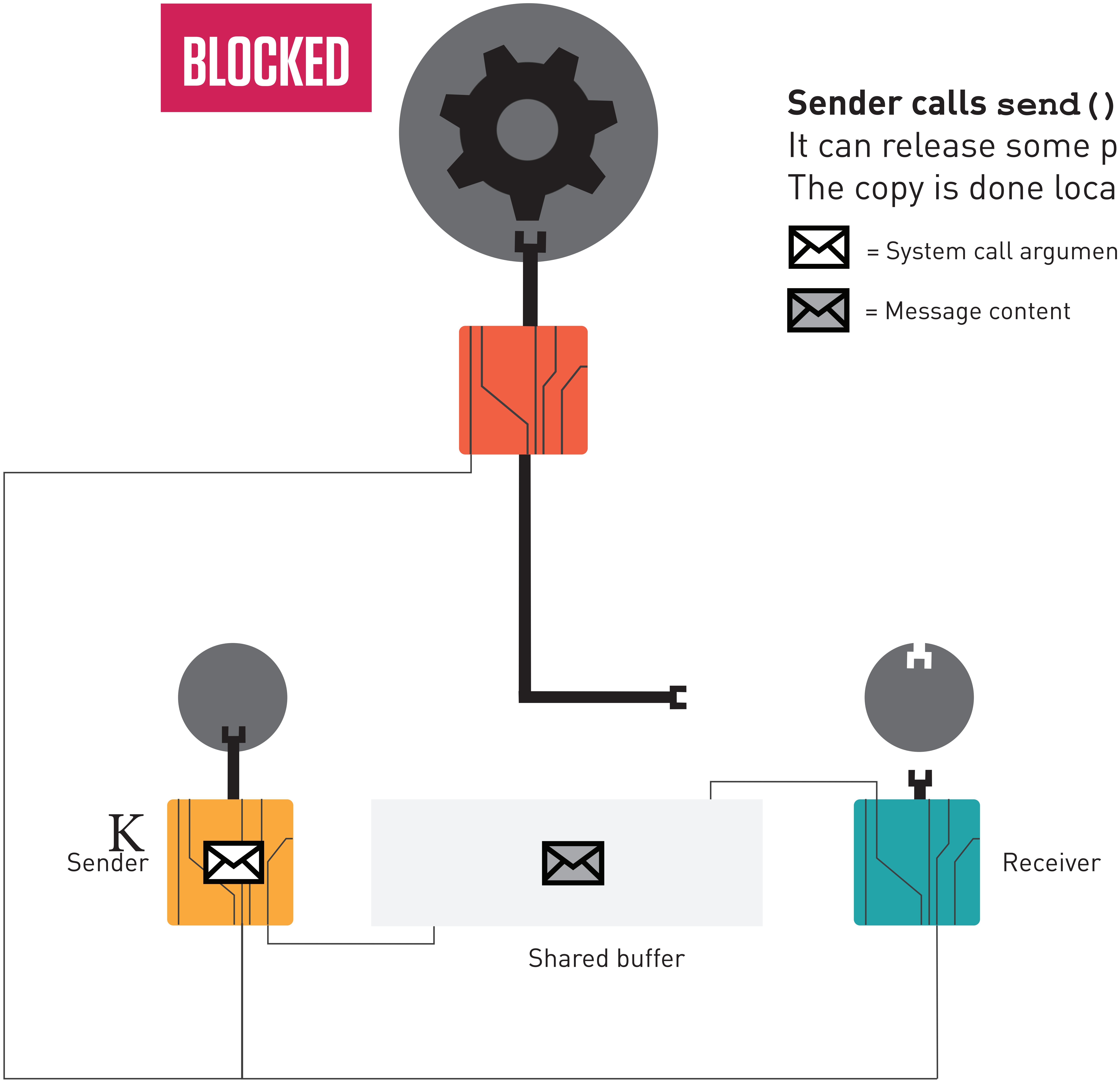

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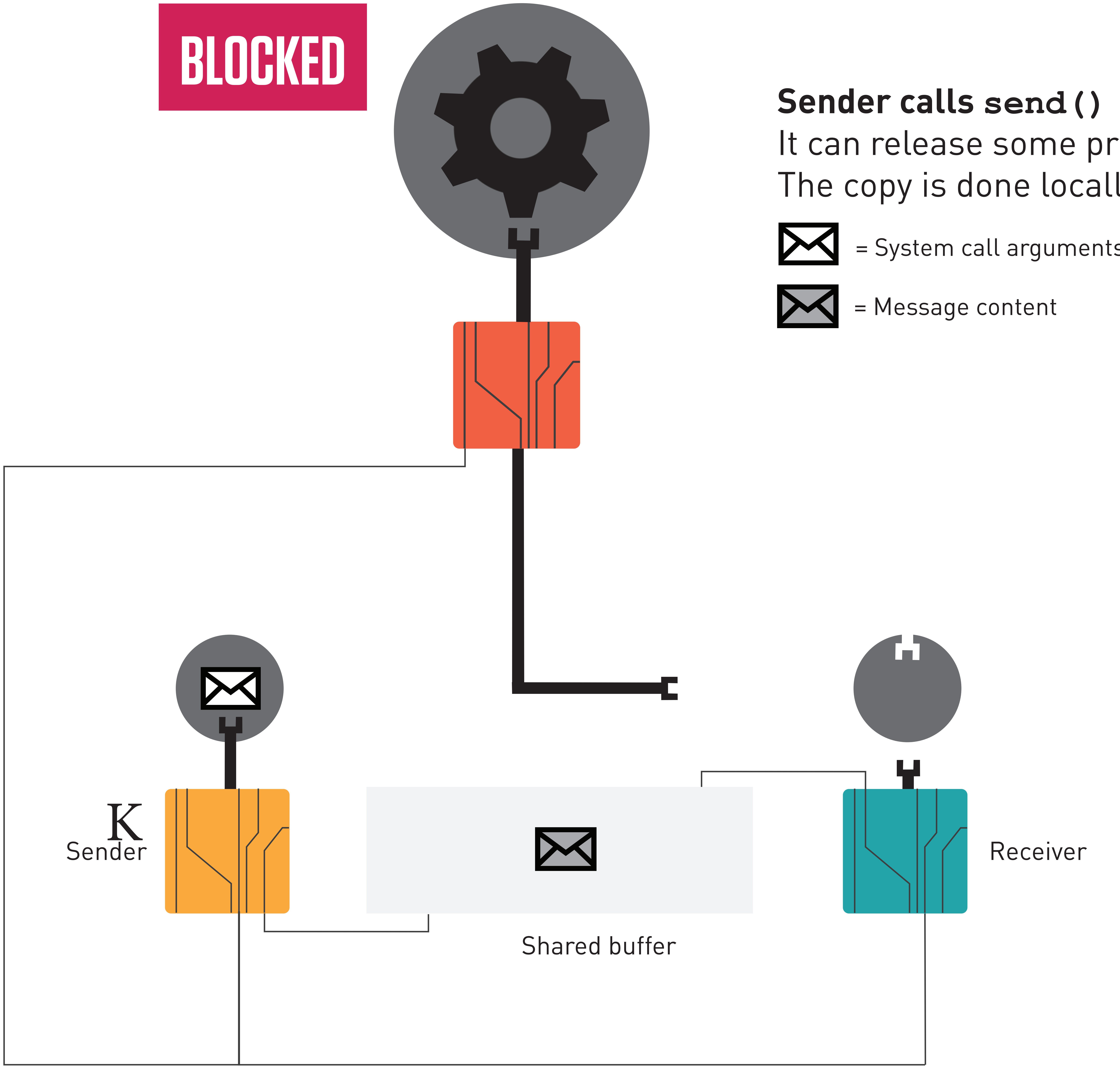

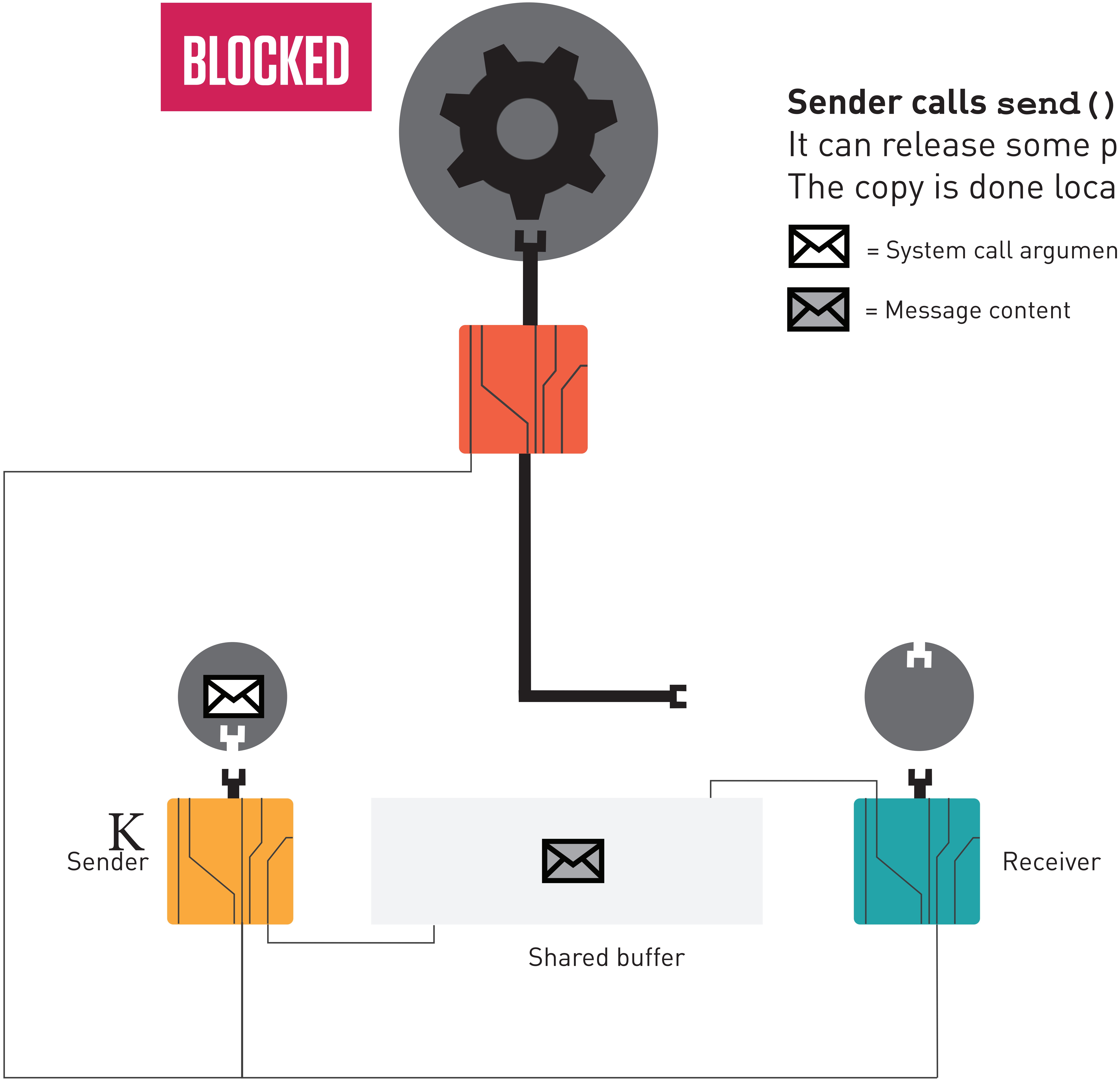

Sender calls `send()`

It can release some processes

The copy is done locally

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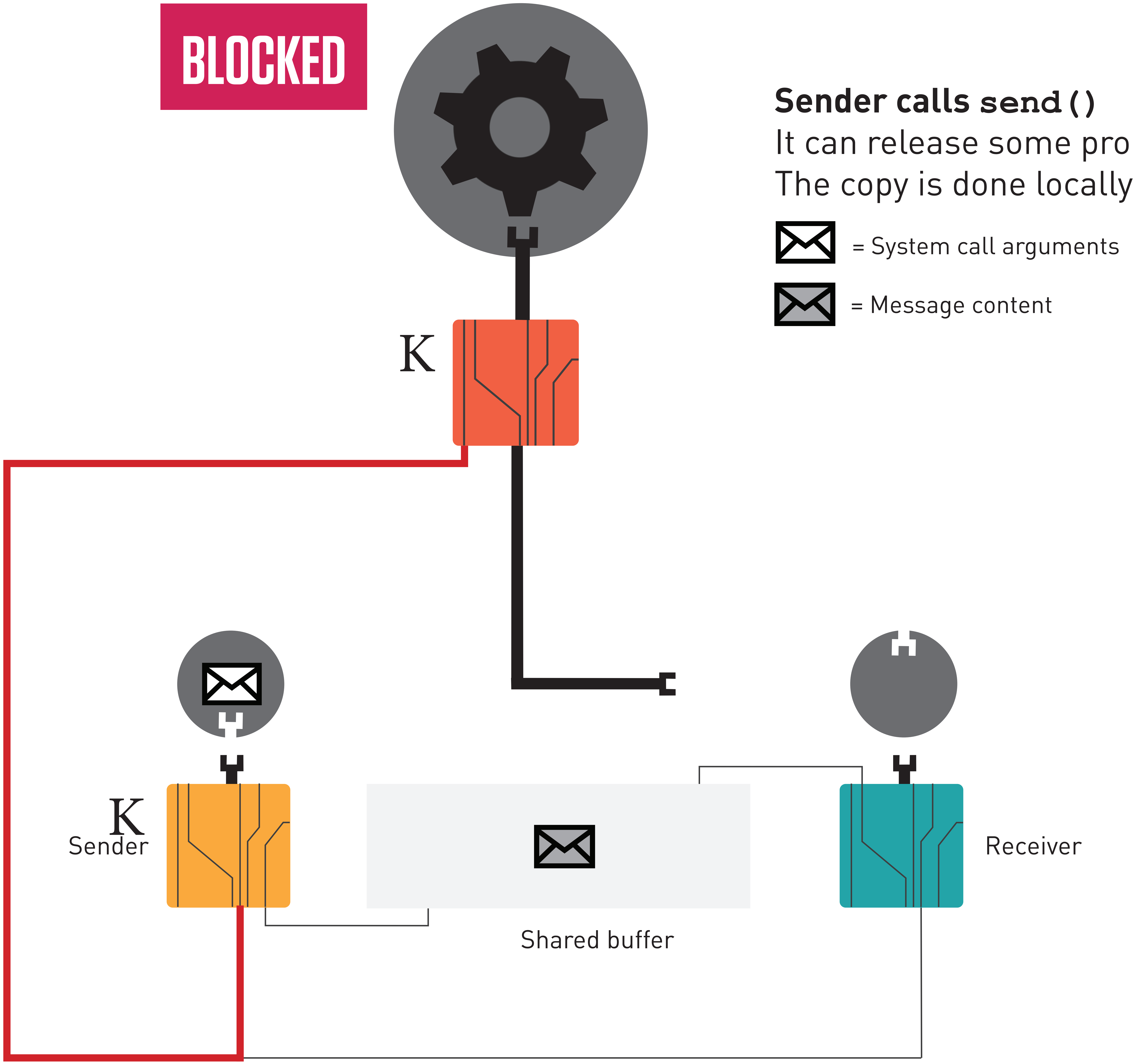
▨ = Message content



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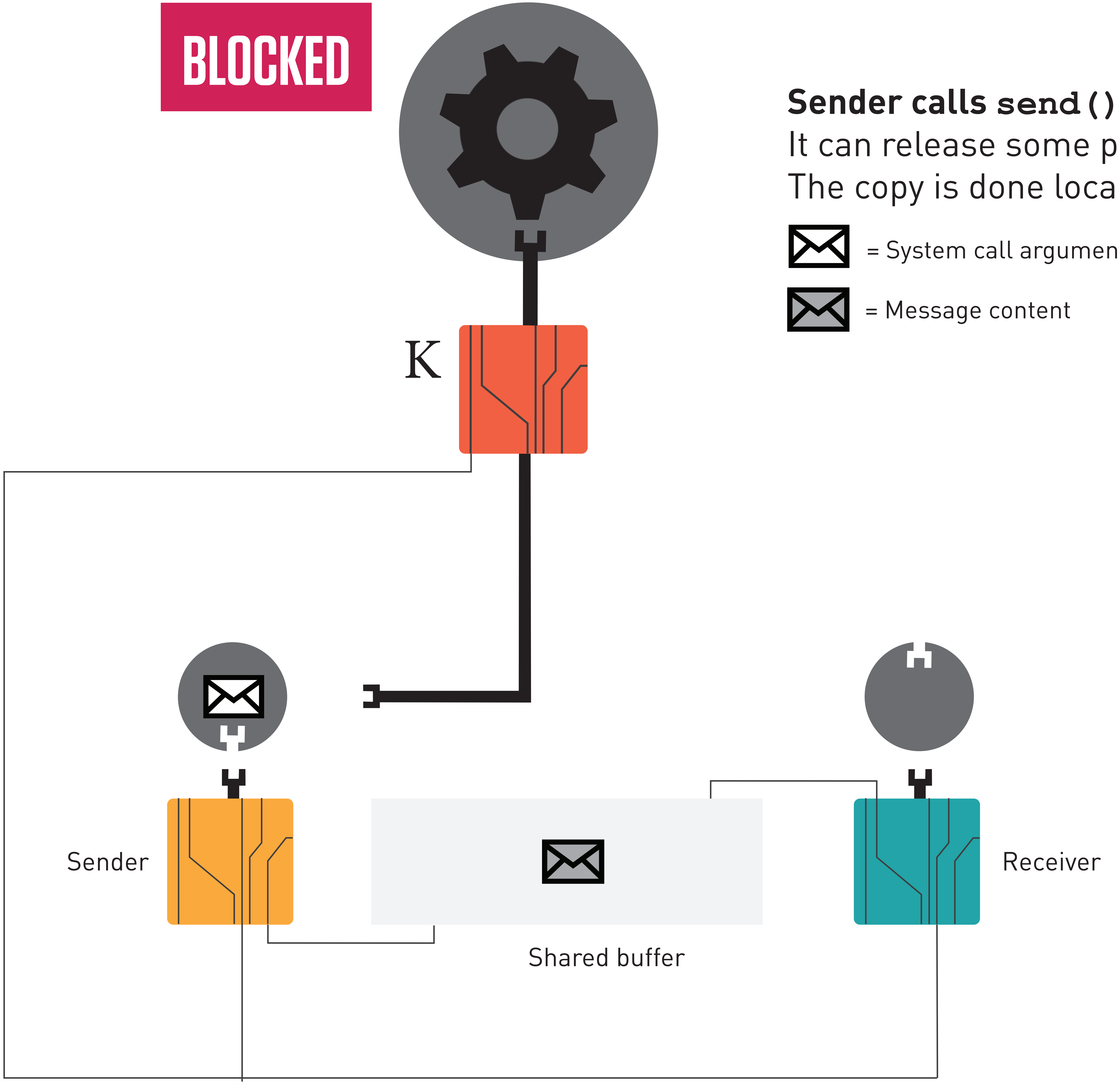

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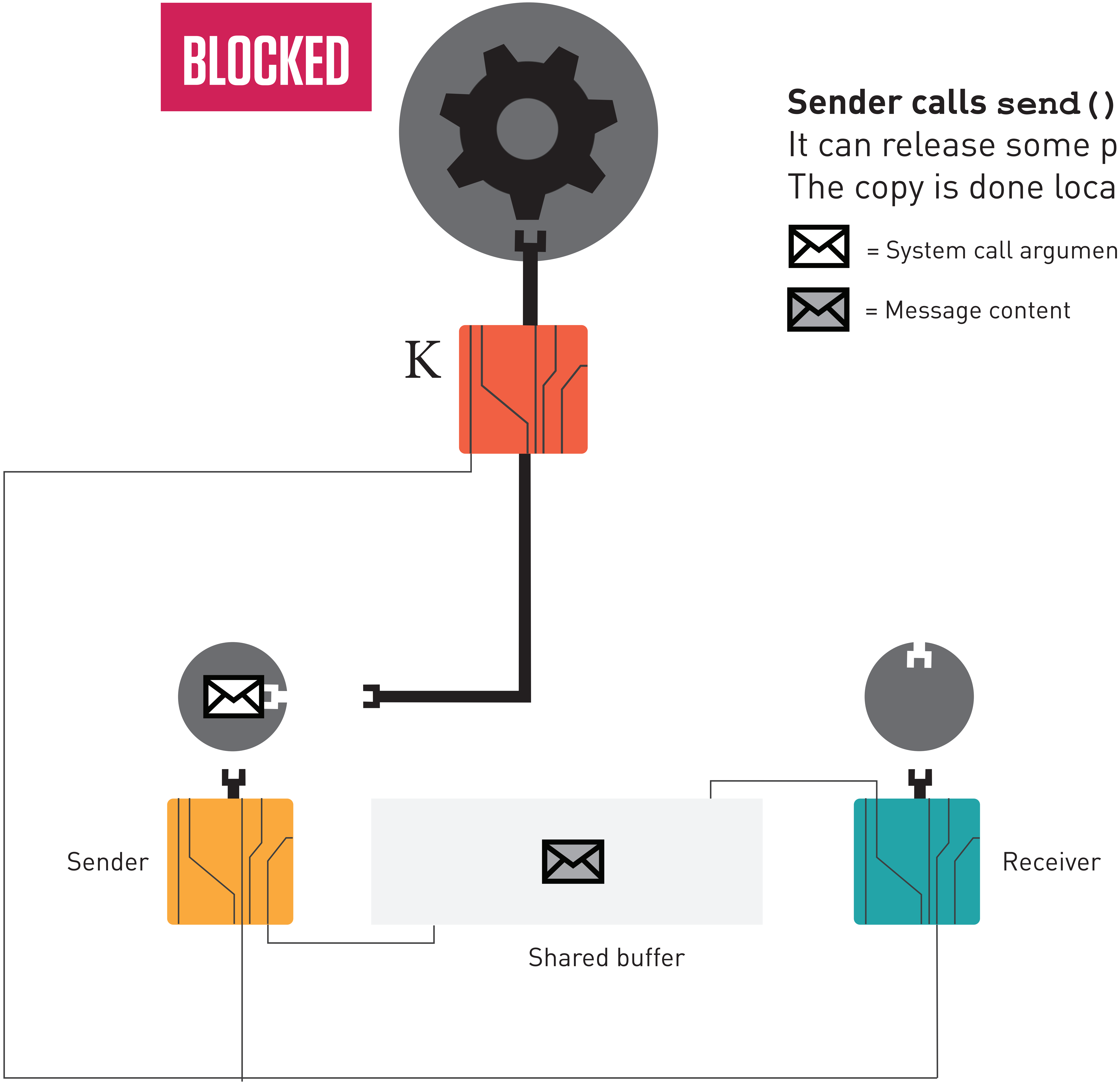

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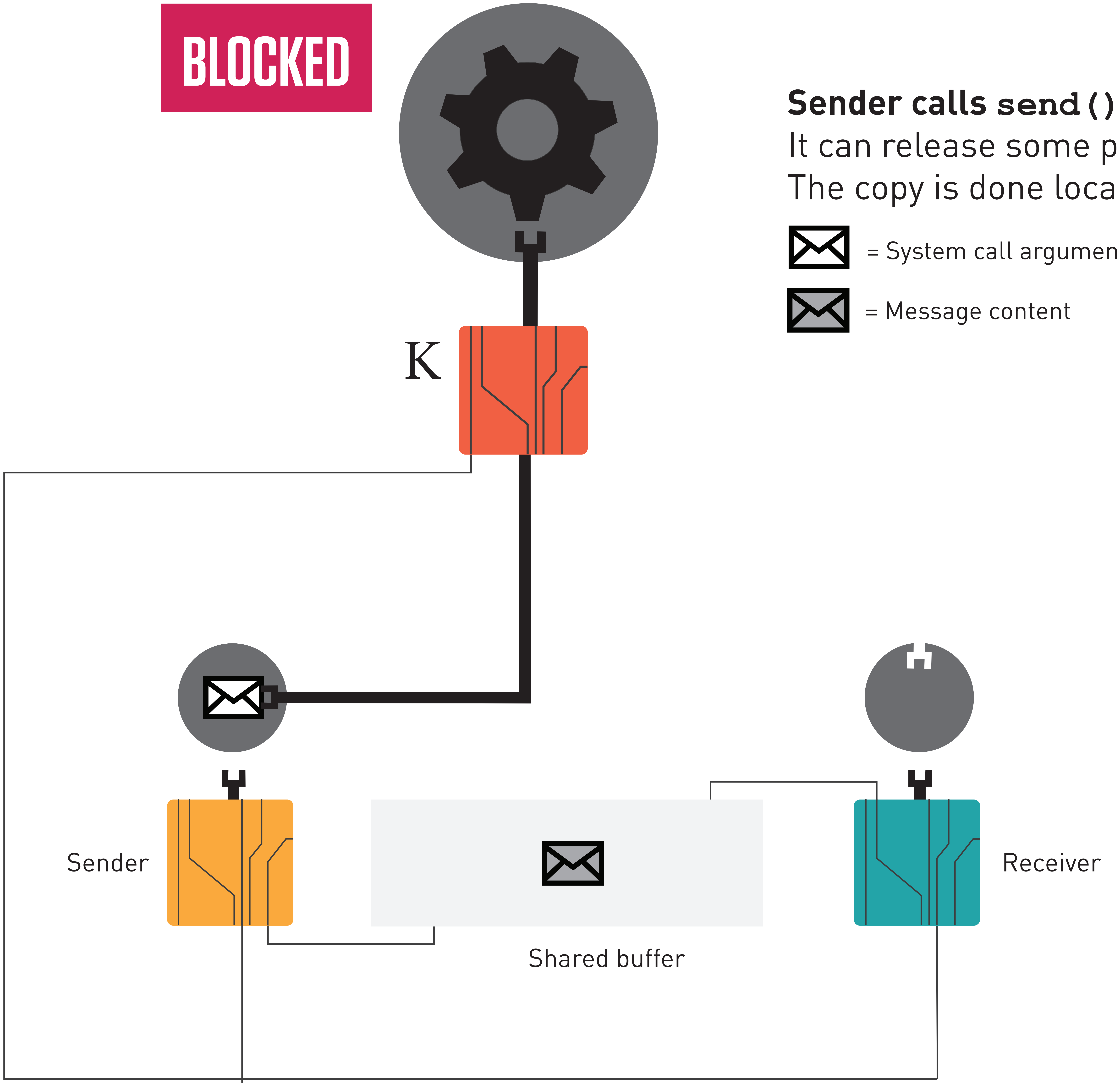

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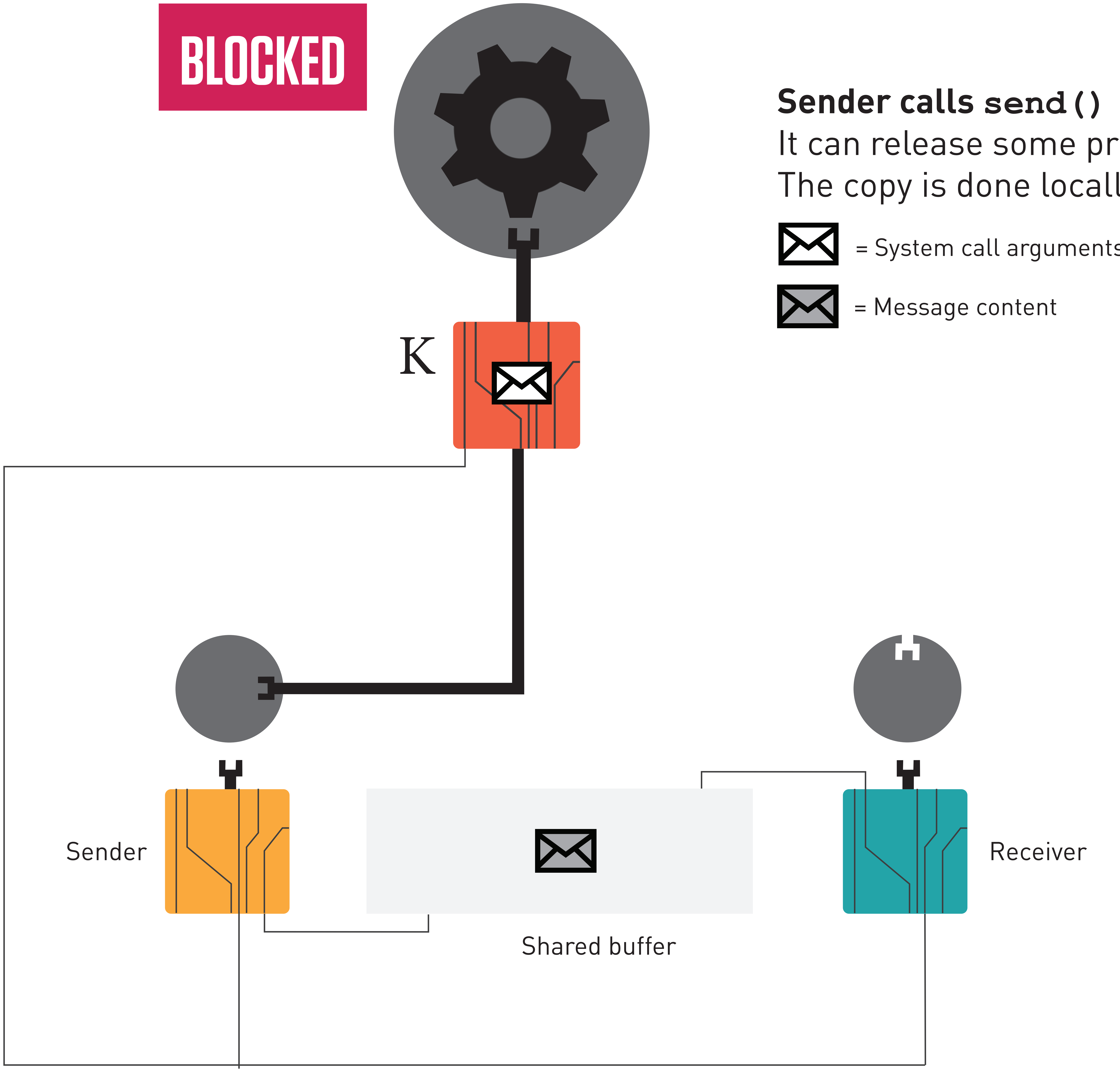

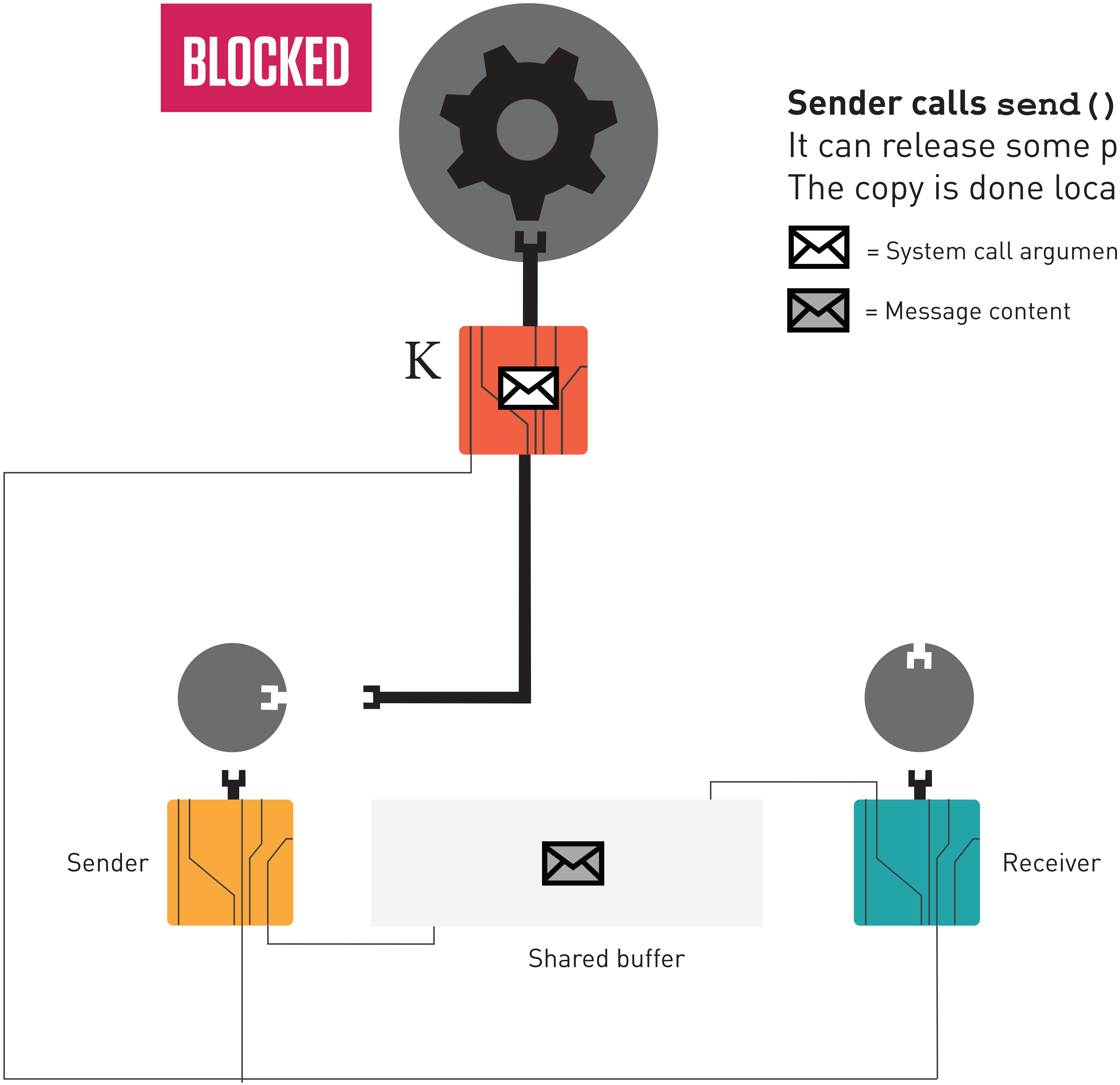

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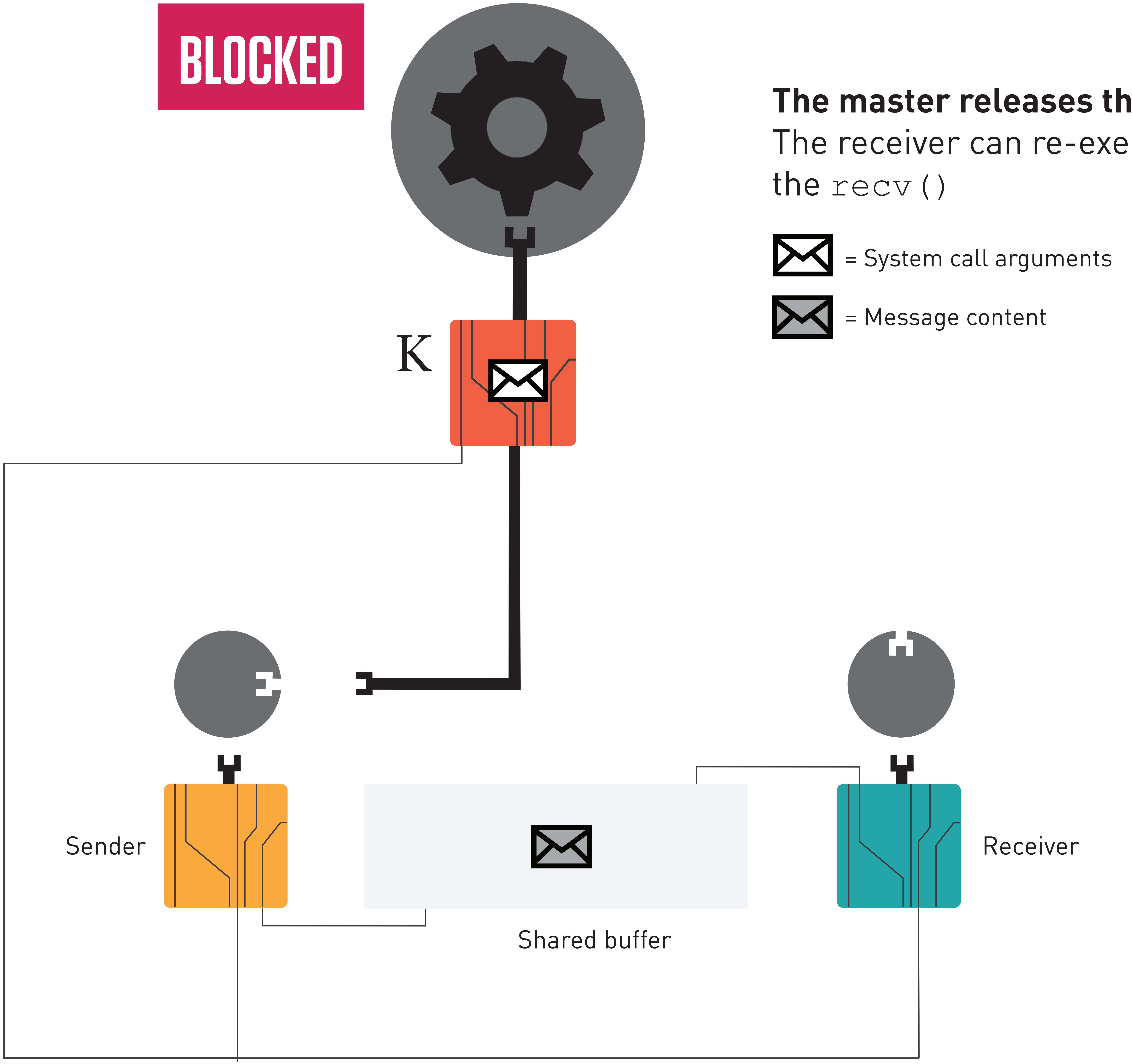
The master releases the receiver

The receiver can re-execute the `recv()`



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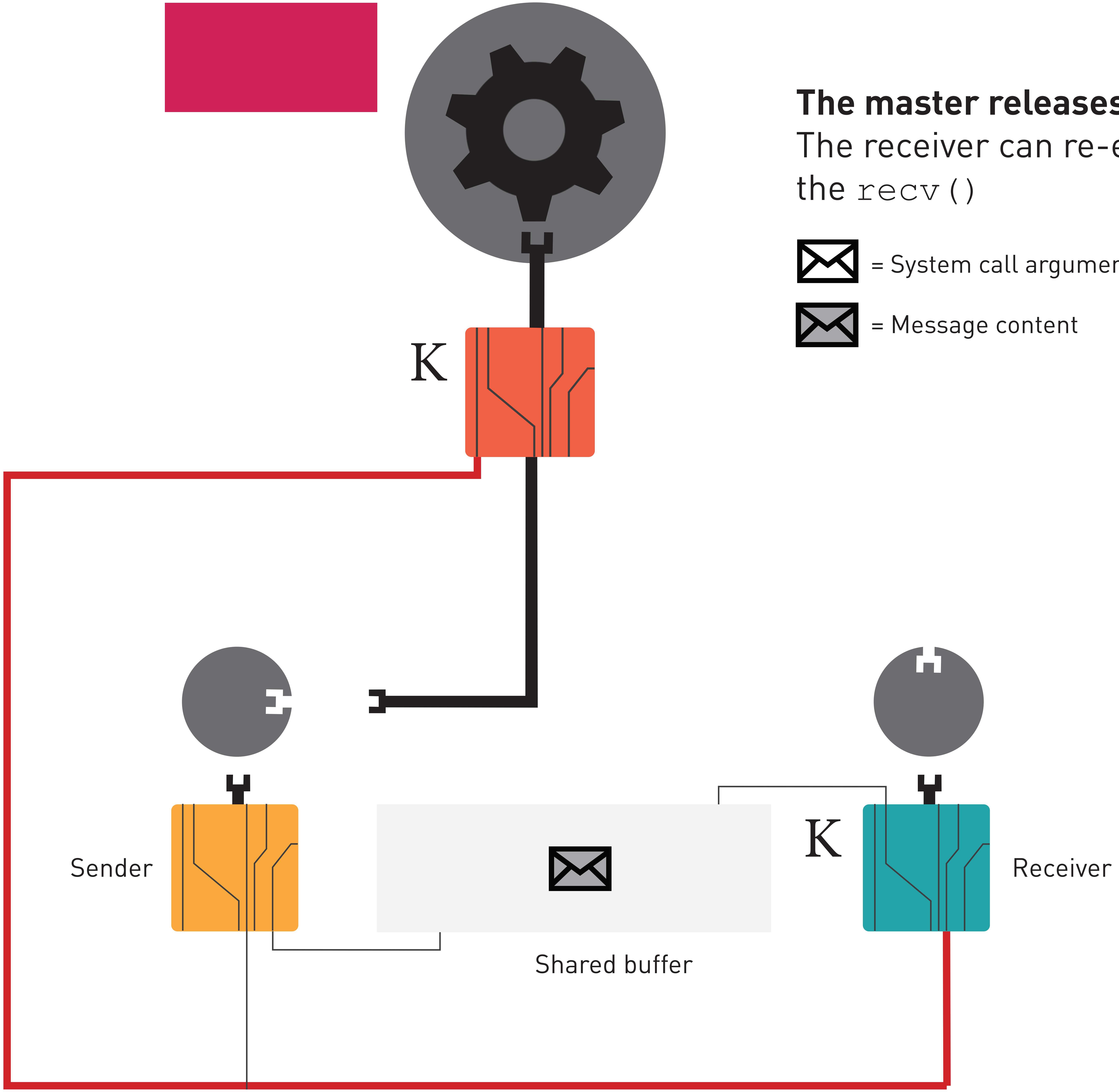

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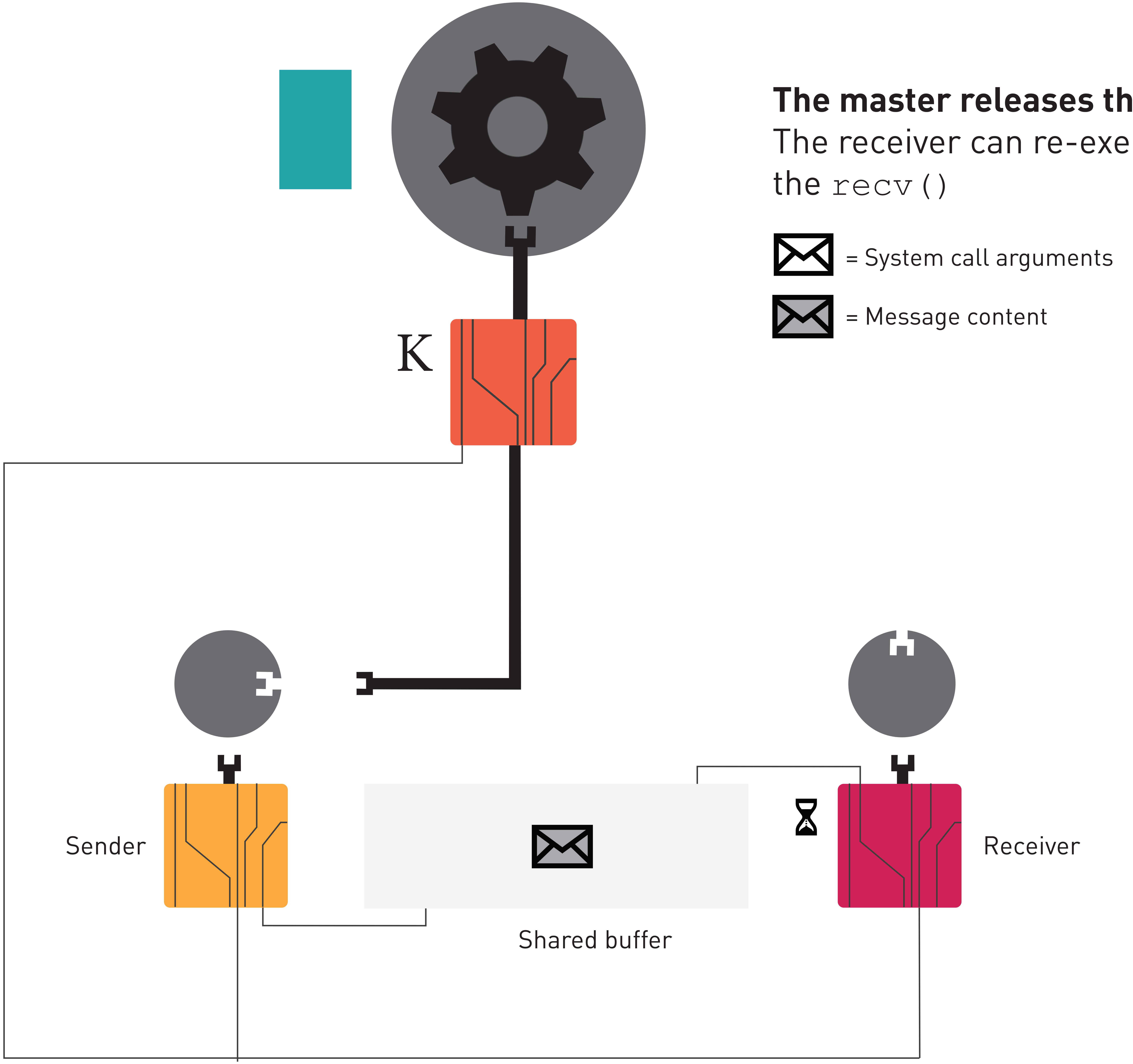

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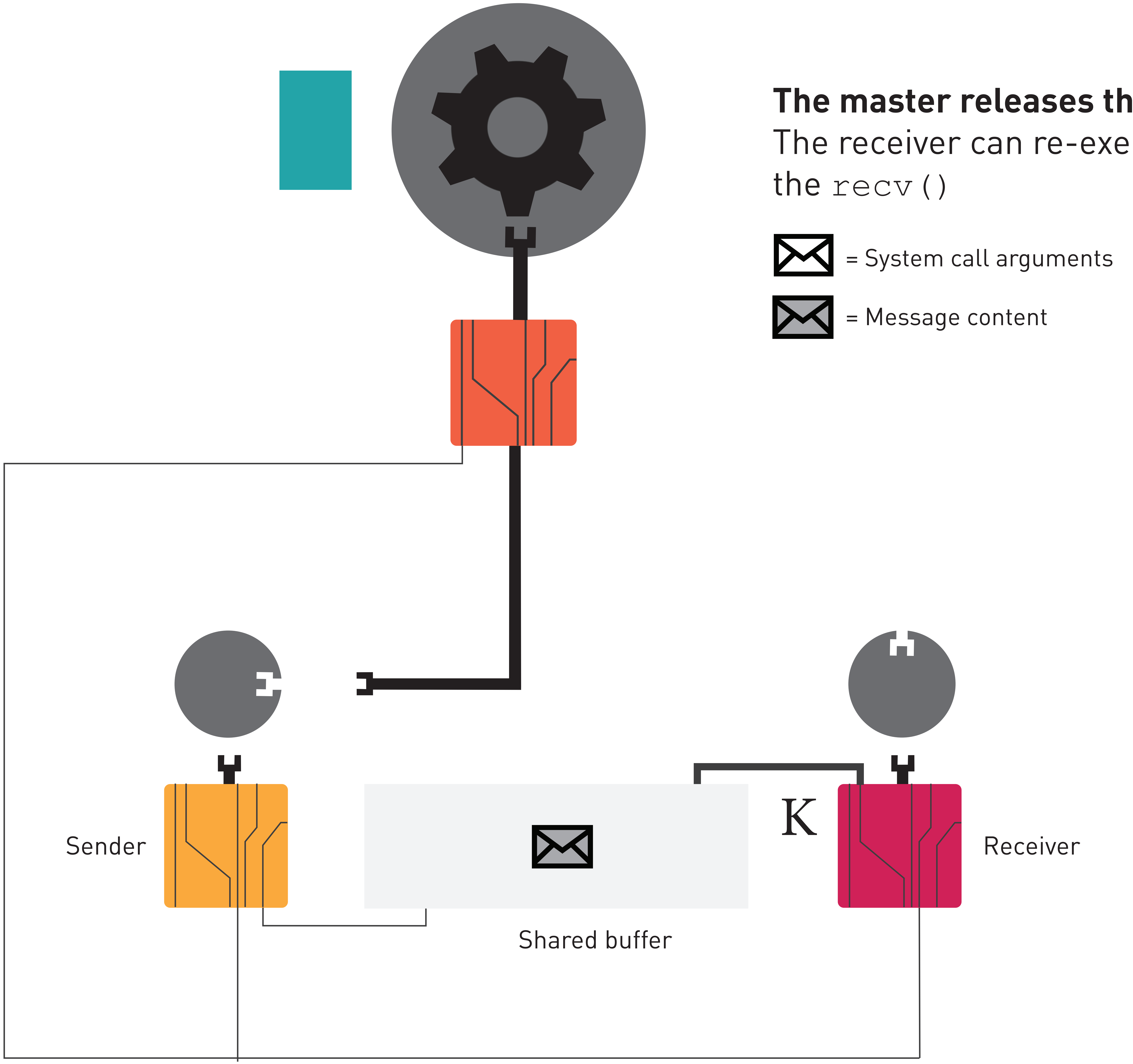

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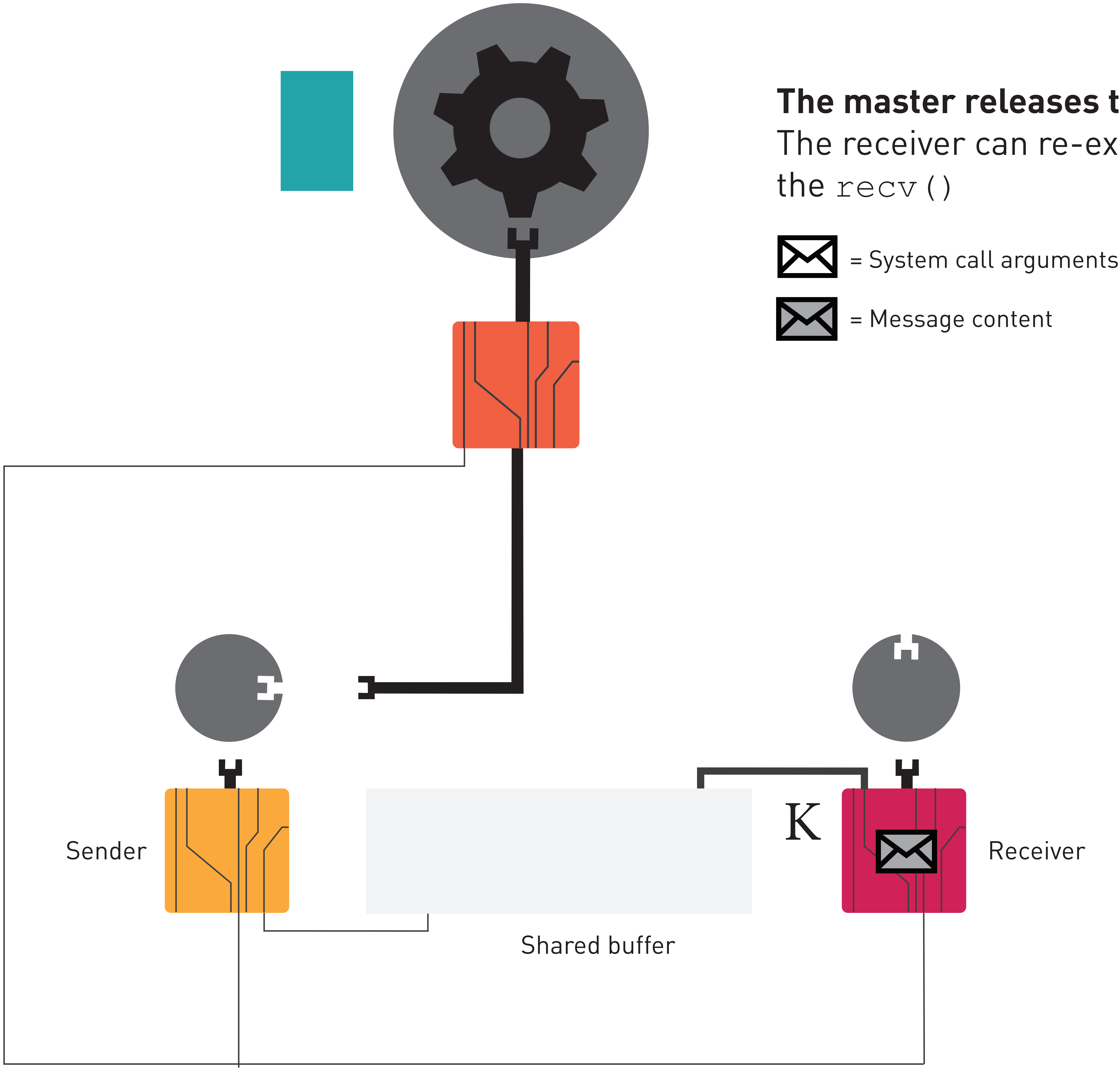

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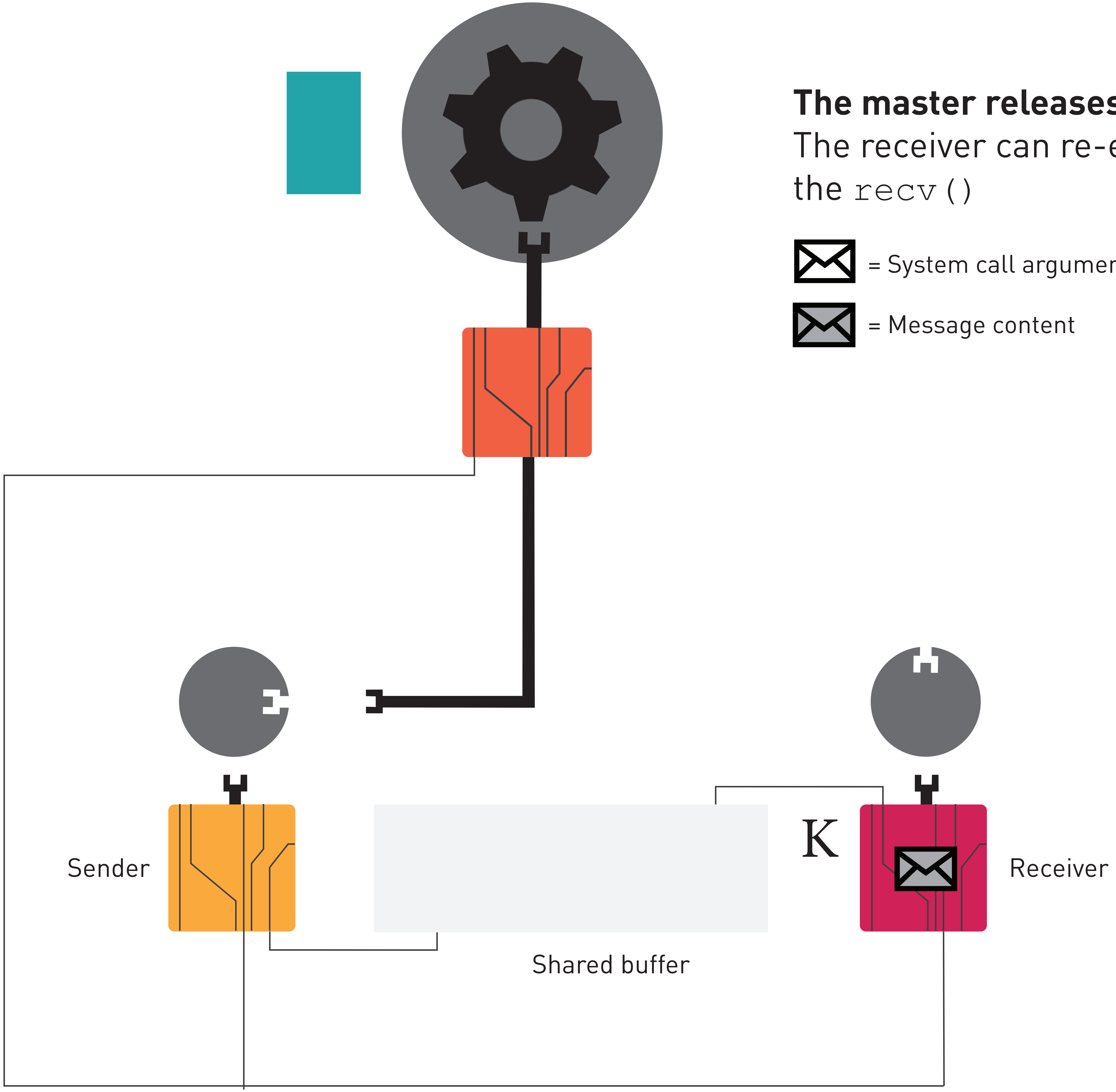

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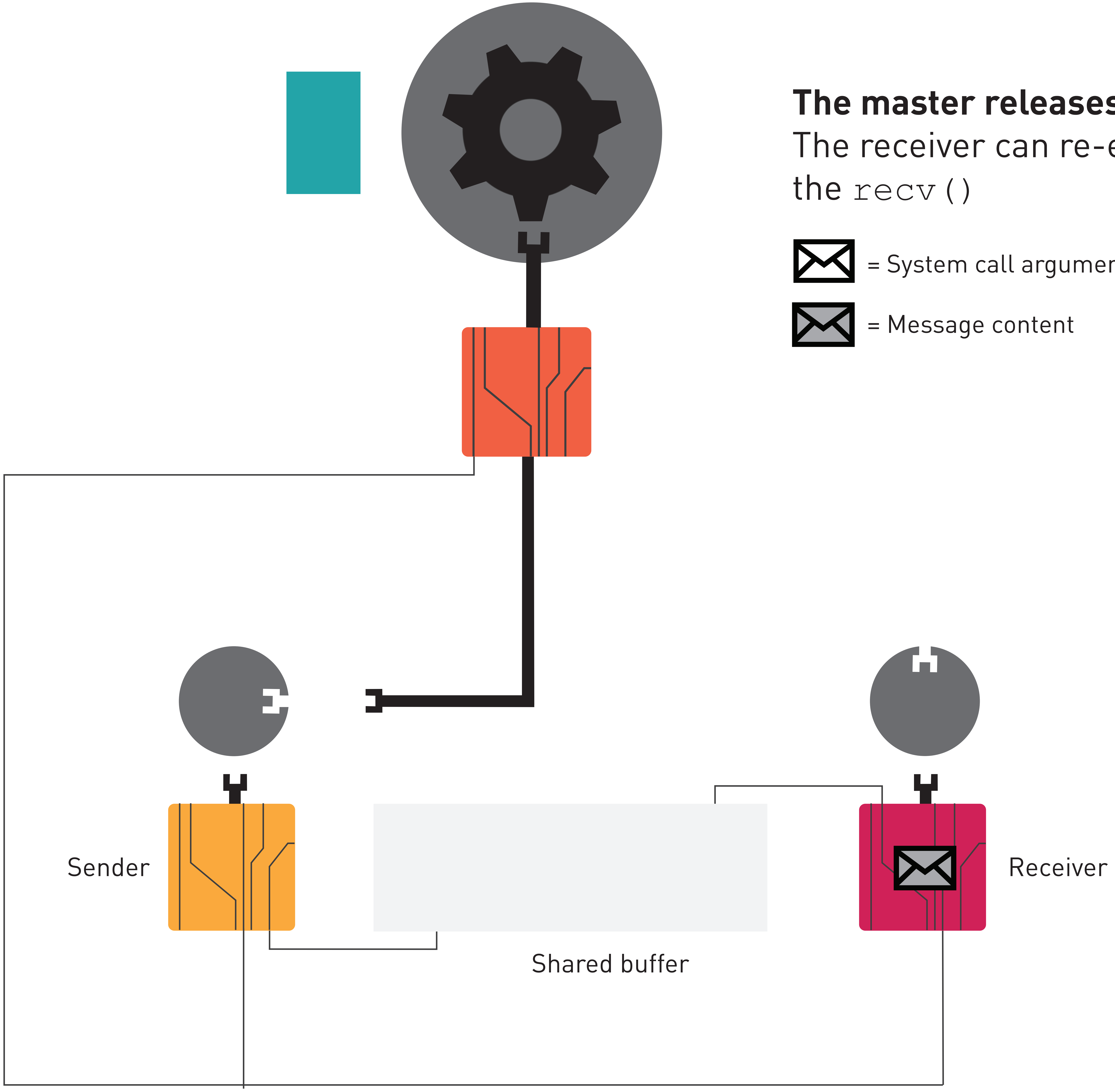

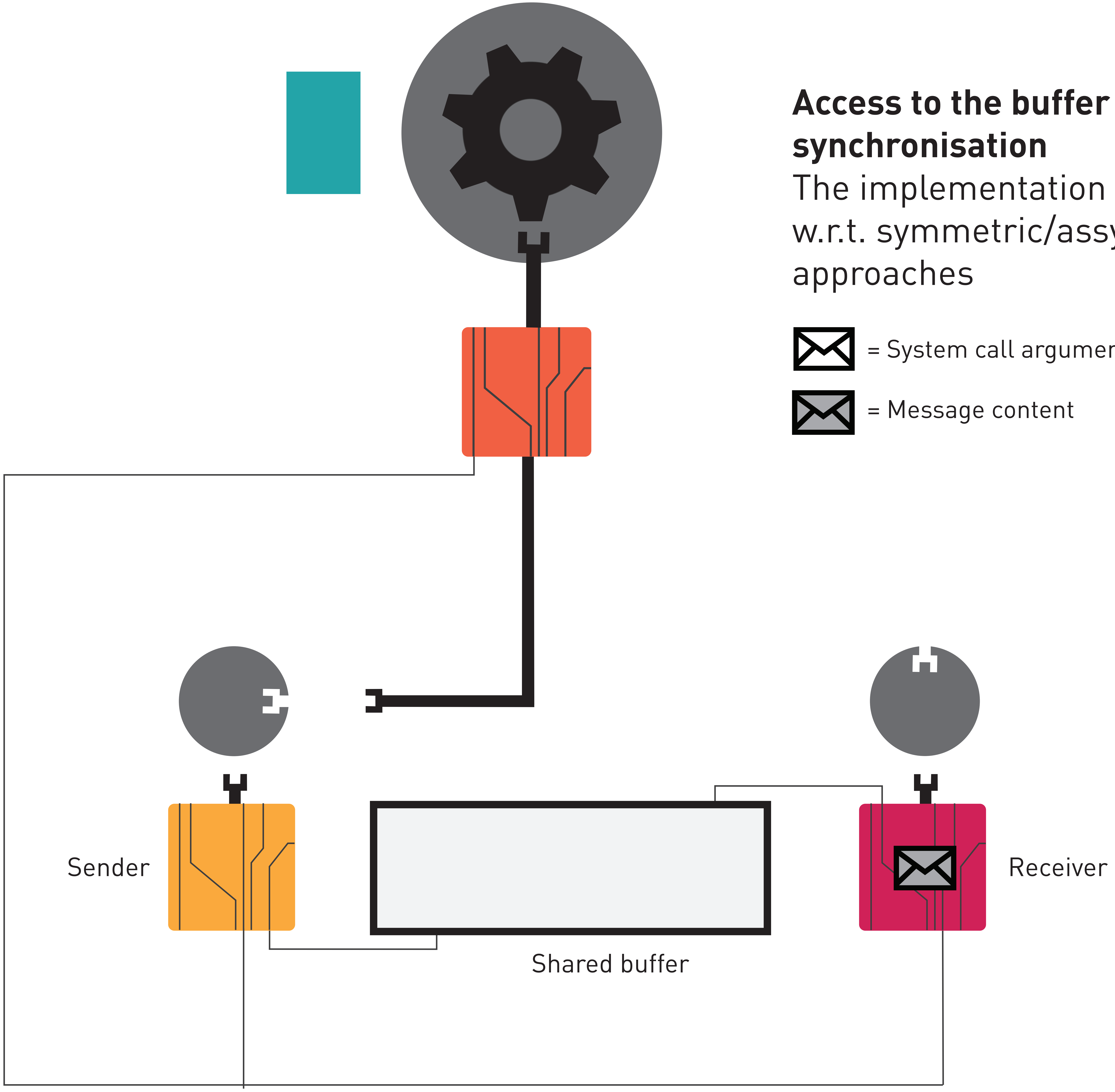

Access to the buffer requires synchronisation

The implementation is hybrid w.r.t. symmetric/assymmetric approaches

🖂 = System call arguments

✉ = Message content

FUTURE WORK

FUTURE WORK

Benchmark system calls and IPC scheme

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Analytically bound the protocol

FUTURE WORK

Benchmark system calls and IPC scheme

Analytically bound the protocol

Evaluate real-time schedulers

HIPPEROS = spin-off company of **ULB**
= family of RTOS

→ New kernel for Real Time Systems

Antonio Paolillo

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ULB

HIPPEROS

MangoGem