ICA - Interaction and Communication Assistant

AIDE SP3

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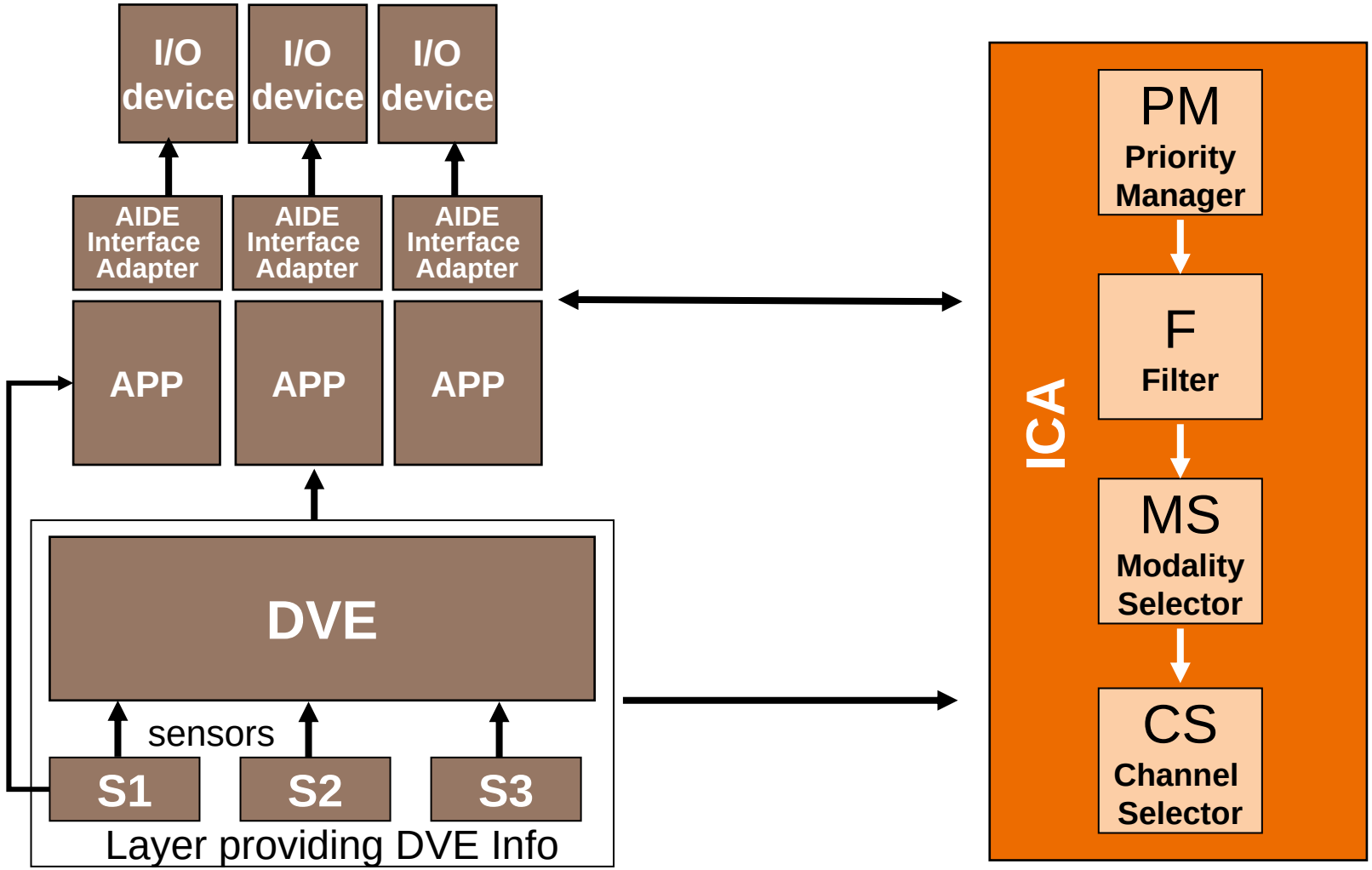
Interaction and Communication Assistant: the concept

- ICA is the **central intelligence** of the AIDE system: the core of the driver-vehicle interaction that defines the **communication and data exchange**

- ICA is responsible for **managing the interaction** and communication between the driver, the vehicle and the driver's personal nomadic devices in order to reduce or limit the driver's distraction and fatigue and to improve his/her safety especially whilst driving in demanding conditions.

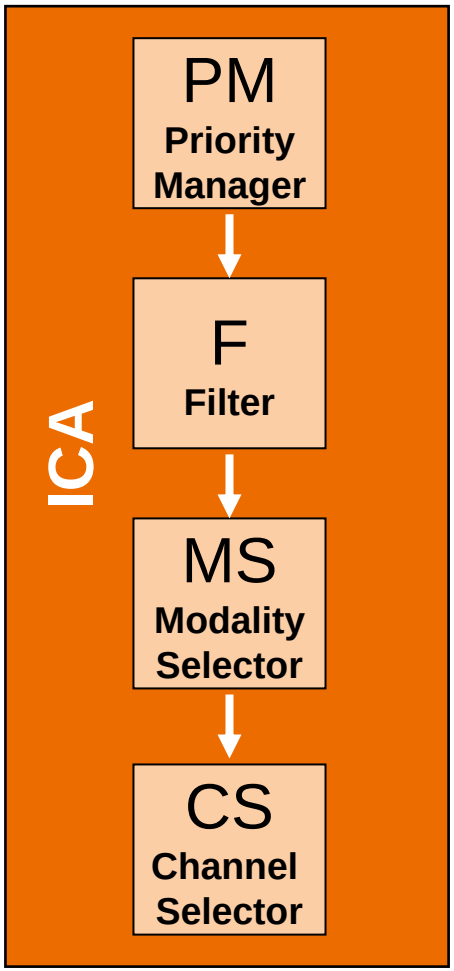
- Keeping into account the Driver-Vehicle-Environment (DVE) conditions ICA decides:
  - the information prioritisation and scheduling
  - the information display modality
  - the output channel to provide the information to the driver

Interaction and Communication Assistant: the logic architecture

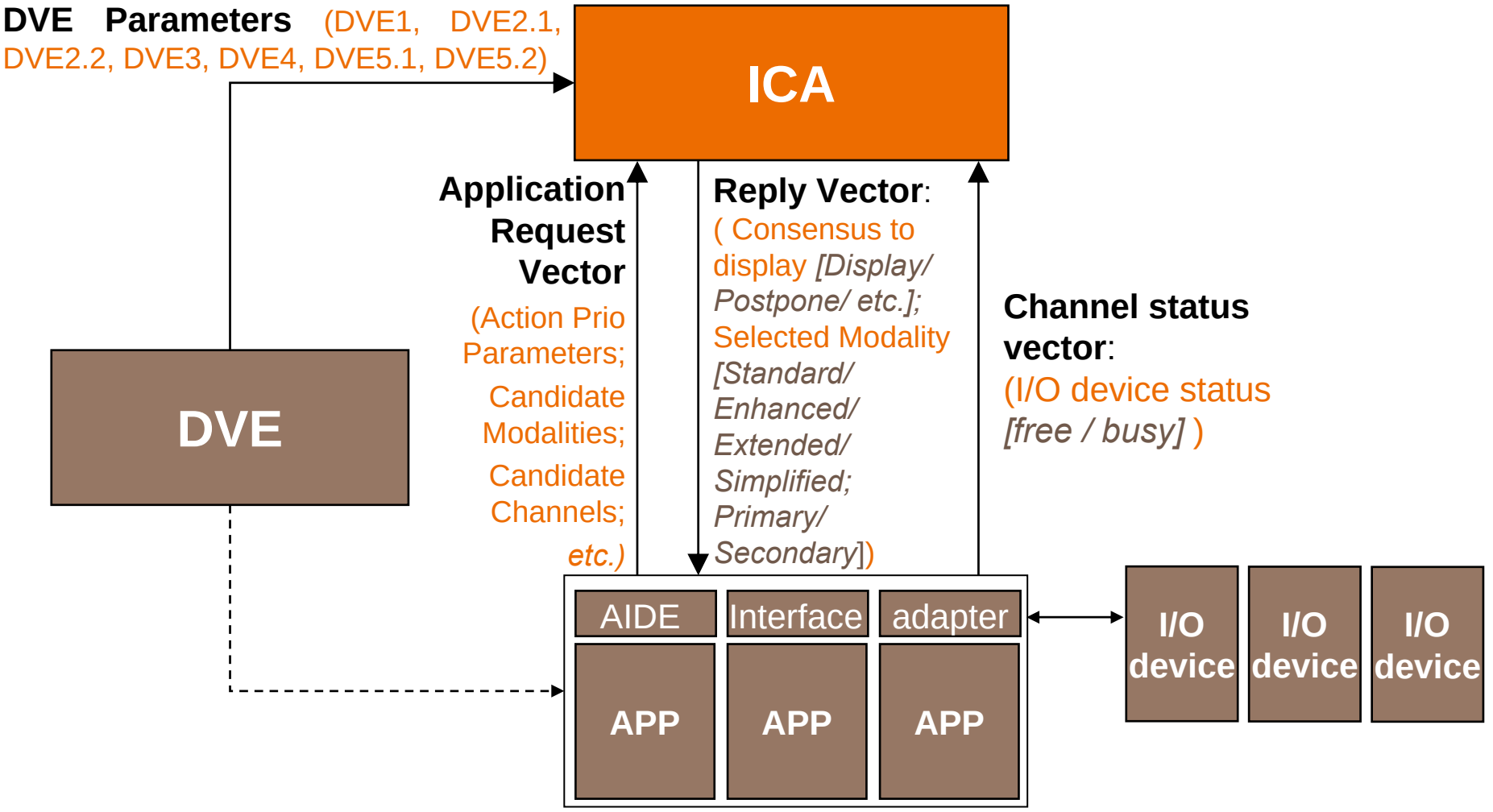


Interaction and Communication Assistant: ICA process

- **1st step.** the ***Priority manager*** assigns priorities on the basis of the actions' characteristics,
- **2nd step.** the ***Filter*** decides if an information can be given immediately or not according to the DVE conditions,
- **3rd step.** the ***Modality selector*** applies the adaptation strategy to decide if the information has to be displayed with its standard modality or if it has to be in some way highlighted, lengthened or simplified according to DVE conditions,
- **4th step.** the ***Channel selector*** checks if the candidate output channels (display, part of display, HUD, speech, loudspeakers, etc.) for that information are free, if not:
  - if a secondary channel is planned and available, the information is redirected
  - if a secondary channel is not available, the information is queued.



Communication among
ICA – Applications – DVE modules – I/O devices



DVE parameters taken into consideration by ICA logic

DVE parameter	DVE module	ID	DVE output values used by the ICA strategies
Driving demand	DAE	**DVE1**	0= available 1= intermediate 2= not available
Eyes off road	CAA	**DVE2.1**	0 = no 2 = yes
Visual time sharing	CAA	**DVE2.2**	0 = no 2 = yes
Cognitive distraction	CAA	**DVE2.3**	0 = no 2 = yes
Driver impairment	DSD	**DVE3**	0= alert 1= slightly drowsy 2= drowsy OR sleepy
Driver intent of manoeuvring	TERA/CAA	**DVE4**	0 = no 2 = yes
Traffic risk	TERA	**DVE5.1**	0= low 1= intermediate 2= high
Environmental risk	TERA	**DVE5.2**	0= low 2= high
Driver Characteristic	DC	**DC_TIME**	0= fast driver 2= slow driver

ICA strategies

Specific strategies are devoted to the **Filtering** task, the **Modality selection** and the **Channel selection**.

Three sets of rules have been defined:

- **Filter strategies**: define if an action can be displayed or postponed according to the current driving conditions described by the DVE output parameters.
- **Modality selection strategies**: for the modality adaptation on the basis of the DVE conditions.
- **Channel selection strategies**: to manage the output of concurrent actions according to the status of occupation of the I/O channels and of the amount of information already presented to the driver.

Actions priority

- Eleven classes of priorities have been defined divided in **Warnings** (W), **Dialogues** (D) and **Outputs** (OP).

Priority Class	Definition	Examples
W1	Reliable primary task info requiring immediate action by the driver ($<t_1$) to prevent an accident or a situation of high potential danger	ACC-take over request, collision warning
W2	Reliable primary task info to prevent an accident or a situation of high potential danger – not requiring immediate action by the driver, because the system reacts automatically	ABS, ESP-info
D1	Dialog (with Human being – real time) via communication system	Phone conversation
D2	Dialog with the system	Each interaction with the system

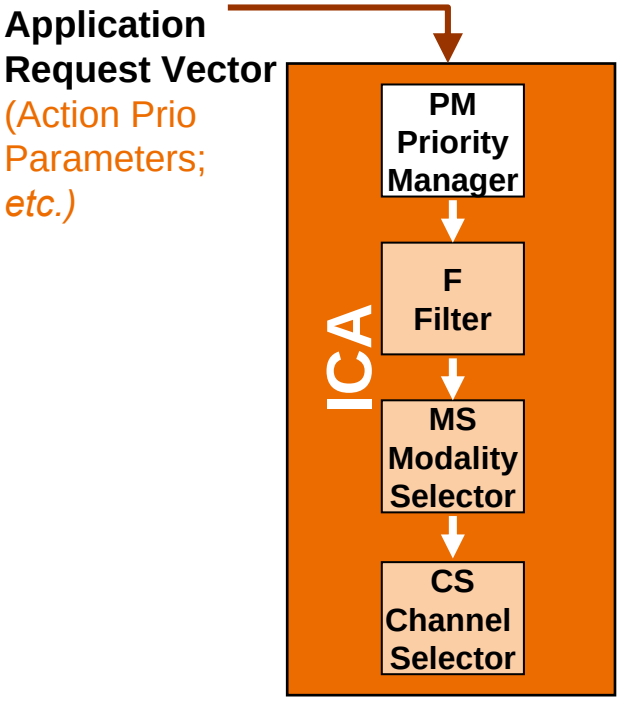
Actions priority

OP1	Primary task info requiring immediate action or decision by the driver ($<t_1$) – low potential danger for the driver or worse driving performance if the action is not executed	Navi «turn left immediately», Info on approaching accident, Information regarding driver status
OP2	Primary task info requiring action in the near future or decision by the driver ($>t_1$) to avoid malfunction of the car or possible damage of the car	High engine temperature, low oil pressure
OP3	Primary task info requiring action in the near future by the driver ($>t_1$) to avoid potential risky situations or increase driving performance	Speed alert (only informative), Navi «turn left in 500m», «filtered» traffic announcement
OP4	Primary task info requiring no action	Traffic announcement («not filtered»)
OP5	Secondary task info with “real time” indication ($t_{min}<t< t_{Max}$)	Phone Call signaling
OP6	Secondary task info initiating an action by the driver in the near future (but no fast action required)	Info about incoming email or SMS; Forthcoming date info
OP7	Secondary task info – no action required	Travel info, info about point of interest

Priority Manager

- Assigns the proper level of priority to each action according to the set of parameters describing the action and sent by the application together with the request for consensus (**ARV – Application request Vector**).

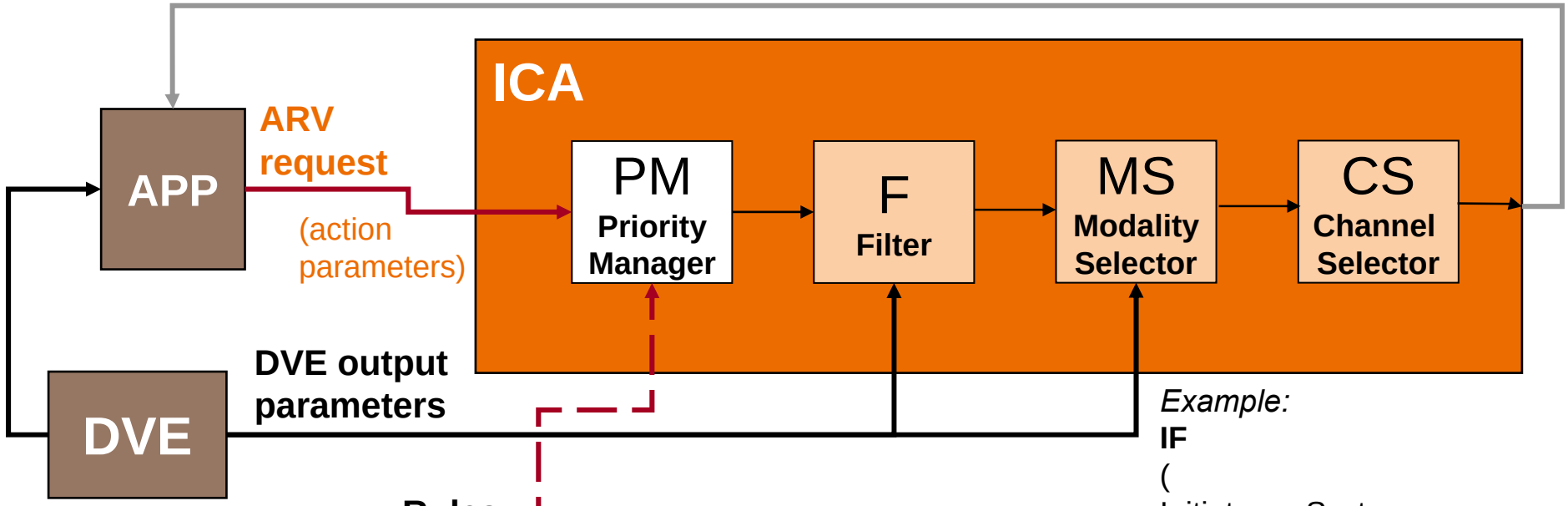
- These parameters are:
  - Initiator (System / User),
  - Duration (Transient / Defined) ,
  - Safety criticality (None / Low / High),
  - Time criticality (None / Low / High),
  - Real time (Yes / No),
  - Mandatory (Yes / No),
  - Driving relevance (Yes / No),
  - Driver's Preference (Yes / No).



- The ***Priority management rules*** are:

IF(param. combination) = (p1;p2;p3;…; pn) **THEN** Priority =OPn

Priority Manager



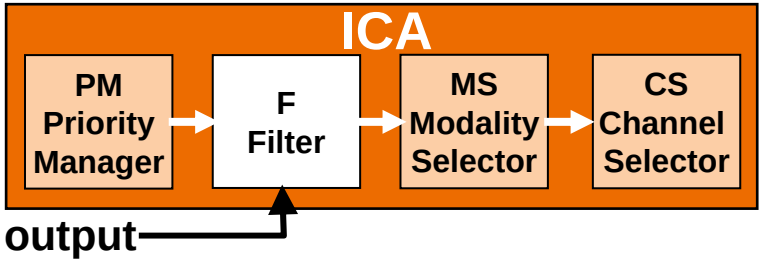
Rules

Parameters	Priority
IF(param. combination) = (p_1;p_2;p_3;…; p_n) →	Wi
IF(param. combination) = (p_1;p_2;p_3;…; p_n) →	Di
IF(param. combination) = (p_1;p_2;p_3;…; p_n) →	OPi

Example:
IF
(
Initiator = System,
Duration = Transient,
Safety criticality = None,
Time criticality = Low,
Real time = No,
Mandatory = No,
Driving relevance = Yes,
Driver's Preference = No
)
THEN Action Priority = OP2

Filter

- The **Filter** decides if an information can be given immediately to the driver or not according to its **priority** and the **DVE conditions**.
- A **Filter decision table** summarizes all the decision taken by the Filter according to the defined strategies applying the ***Action Postponing Rules***.



- A rule is a clause like this:

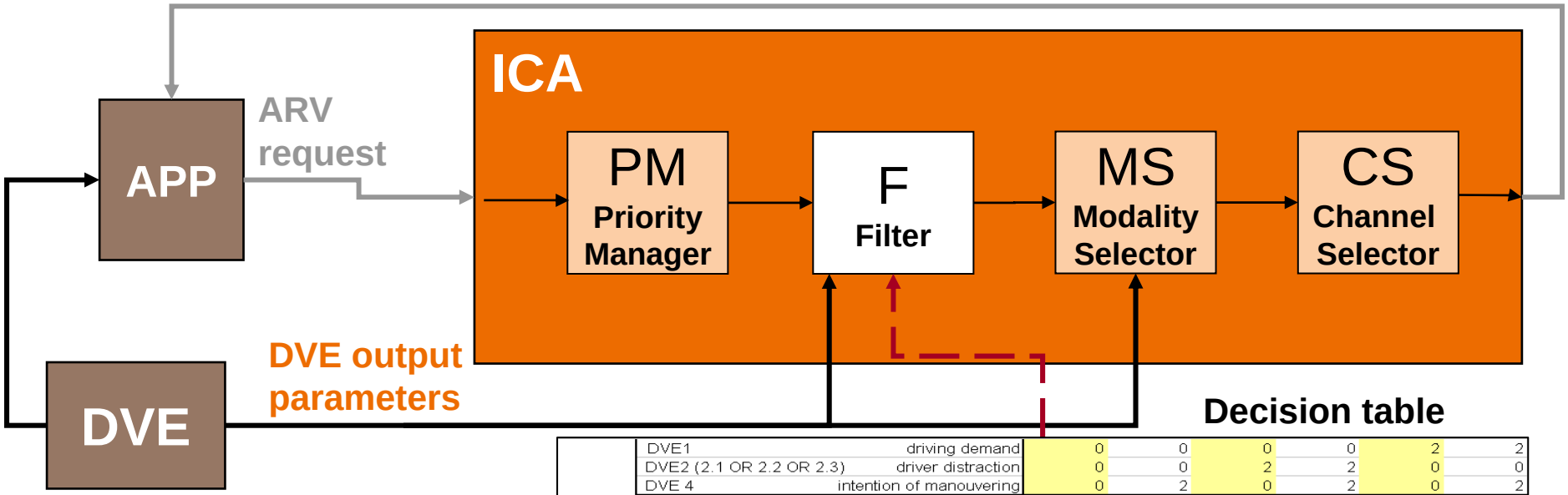
  IF *(High Traffic Risk [TERA])* ***AND*** *OPi ≥ 2*, ***OR ... ... THEN*** *Action postponing*

- In the Filter decision table:
  - **NO** means that the information has to be postponed.
  - **EMPTY CELL** means the consensus of ICA to the application to send the action to the I/O devices:

    the modality adaptation is defined by the subsequent module (Modality Selector).

Incoming Action Priority								
	DVE1	driving demand	0	0	0	0	2	2
	DVE2 (2.1 OR 2.2 OR 2.3)	driver distraction	0	0	2	2	0	0
	DVE 4	intention of manouvering	0	2	0	2	0	2
	DVE3	driver ability	0	0	0	0	0	0
	DVE5.2	environment risk	0	0	0	0	0	0
	DVE5.1	high traffic risk	0	0	0	0	0	0
	DC_TIME	time of warning	0	0	0	0	0	0
W1								
W2								
D1								
D2								
OP1								
OP2								
OP3							no	no
OP4							no	no
OP5							no	no
OP6				no	no	no	no	no
OP7				no	no	no	no	no

Filter



Decision table

	DVE1	driving demand	0	0	0	0	2	2
	DVE2 (2.1 OR 2.2 OR 2.3)	driver distraction	0	0	2	2	0	0
	DVE 4	intention of manouvering	0	2	0	2	0	2
	DVE3	driver ability	0	0	0	0	0	0
Incoming	DVE5.2	environment risk	0	0	0	0	0	0
Action	DVE5.1	high traffic risk	0	0	0	0	0	0
Priority	DC_TIME	time of warning	0	0	0	0	0	0
W1								
W2								
D1								
D2								
OP1								
OP2								
OP3							no	no
OP4							no	no
OP5							no	no
OP6				no	no	no	no	no
OP7				no	no	no	no	no

Modality and Channels

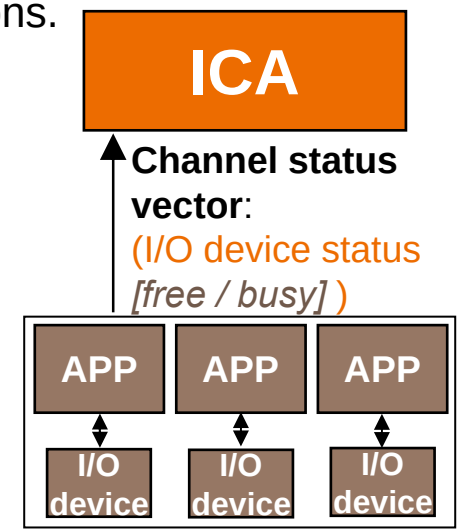
Modality

- describes in which way an information is given to the driver :
  - Acoustic *(possible formats: Voice / Alarm tone / Sound / etc..)*
  - Visual *(possible formats: Pictogram / Text / Map / Icon / etc..)*
  - Haptic *(possible formats: Steering wheel vibration, seat vibration, pedal force, etc.)*

The **Modality** of presentation of each action is defined by the Applications.

Channel

- corresponds to an I/O device or a portion of it (i.e.portion of a display)**:**
  - Display
  - Portion of display
  - Led
  - Telltale
  - etc…
  - Buzzer
  - Loudspeaker
  - TTS
  - Haptic Seat



- The **Channels** for each modality and for each action are defined by Applications and must be communicated to ICA in order to check if they are free or not to display information.
- Each Application is connected to the I/O device corresponding to the channels assigned to its own actions.

Modality adaptation

For each action the application defines a number of possible **modality adaptations** to be selected by ICA according to its strategies based on the DVE conditions:

- **Normal modality:** default modality
  example: Acoustic (alarm tone) + Visual (Icon)
- **Simplified modality:** to be used if the DVE outputs require a **modality simplification** (i.e. telephone ringing, but no visualisation in the instrument cluster).
  example: Acoustic only (Alarm tone)
- **Enhanced modality:** to be used if the DVE outputs require a **modality enhancement** (i.e. bigger dimension, brighter color, higher volume, etc.)
  example: Acoustic (Louder alarm tone) + Visual (Bigger Icon)
- **Extended modality**: to be used if the DVE outputs require a **duration adaptation** (i.e. displayed for a longer time) *example: Acoustic (Alarm tone) + Visual (Icon displayed for a longer time)*

For each of these modalities the applications define the corresponding I/O **channels**.

Primary and Secondary Modality

For each action the application can define a **secondary** set of modalities to be used if the candidate I/O Channels are already occupied by other actions and if this is compatible with the AIDE strategies.

- **Primary modalities** (Normal, Enhanced, Extended, Simplified): to be used as a first option

  example A: Visual text message occupying the whole display
  example B: Visual icon + speech message

- **Secondary modalities** (Normal, Enhanced, Extended, Simplified): to be used if the primary channels are found busy by the ICA check.

  example A: Short text message occupying only a small portion of display
  if the display is already busy
  example B: Visual icon + acoustic tone
  if another speech output is running

- Not necessarily all the actions must have more than one possible modality, it is up to the application to define them and up to ICA to decide if they have to be used.

Modality Selector strategies

The **Modality Selector** works with these three sets of rules depending on **DVE** and **priority** :

Intensity and/or duration increase or repetition (the modality will be ***Extended*** [1])
Intensity increase (the modality will be ***Enhanced*** [2])
Intensity scale down (the modality will be ***Simplified*** [3])

In all the other cases, not considered by these rules sets, the modality will be ***Normal*** [4].

The way to manage the possible conflicts between the Filter and Modality Selector rules is:

Action postponing rules sets **overcomes**
Intensity increase and repetition rules sets, which **overcomes**
Intensity increase rules sets, which **overcomes**
Intensity scale down rules sets

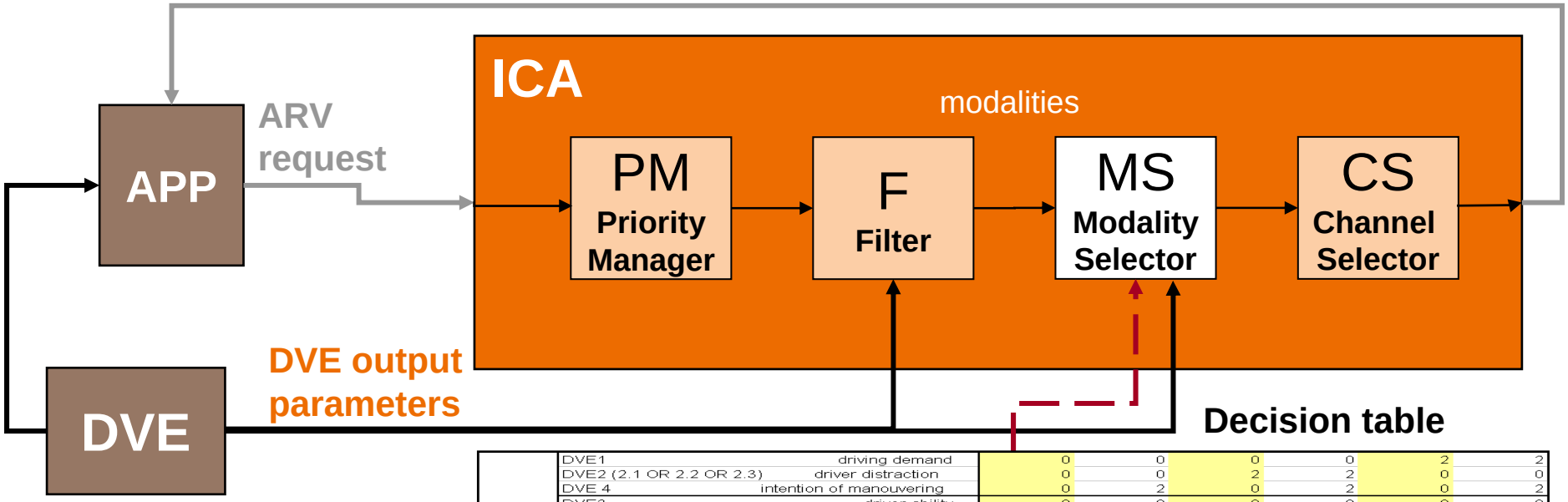
[1] To be used if the DVE outputs require a duration adaptation: i.e. icon displayed for a longer time

[2] To be used if the DVE outputs require an intensity increase of the modality: i.e. bigger icon, change colour, higher volume

[3] To be used if the DVE outputs require a simplification of the modality – in principle it could be either a subset of the primary modality (i.e. acoustic only/visual only) or a different one (i.e. haptic): i.e. telephone ringing, but no visualisation in the instrument cluster)

[4] To be used if the DVE outputs require a default modality

Modality Selector



Decision table

Incoming Action Priority								
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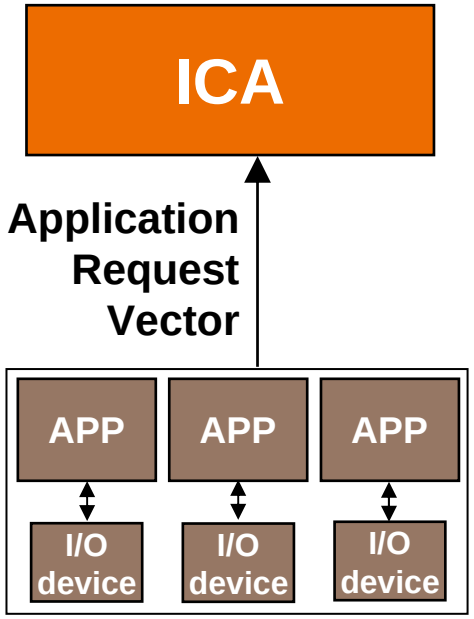
	DVE 4	intention of manouvering	0	2	0	2	0	2
	DVE3	driver ability	0	0	0	0	0	0
	DVE5.2	environment risk	0	0	0	0	0	0
	DVE5.1	high traffic risk	0	0	0	0	0	0
	DC_TIME	time of warning	0	0	0	0	0	0
W1			normal	simplified	enhanced	enhanced	simplified	simplified
W2			normal	simplified	enhanced	enhanced	simplified	simplified
D1			normal	simplified	enhanced	enhanced	simplified	simplified
D2			normal	simplified	enhanced	enhanced	simplified	simplified
OP1			normal	simplified	enhanced	enhanced	simplified	simplified
OP2			normal	simplified	enhanced	enhanced	simplified	simplified
OP3			normal	simplified	enhanced	enhanced		
OP4			normal	normal	normal	normal		
OP5			normal	normal	normal	normal		
OP6			normal					
OP7			normal					

Application request vector

ICA receives from applications, together with the **parameters describing each action**, information about the **channels** (I/O device or part of device) associated to each **modality** assigned to an action.

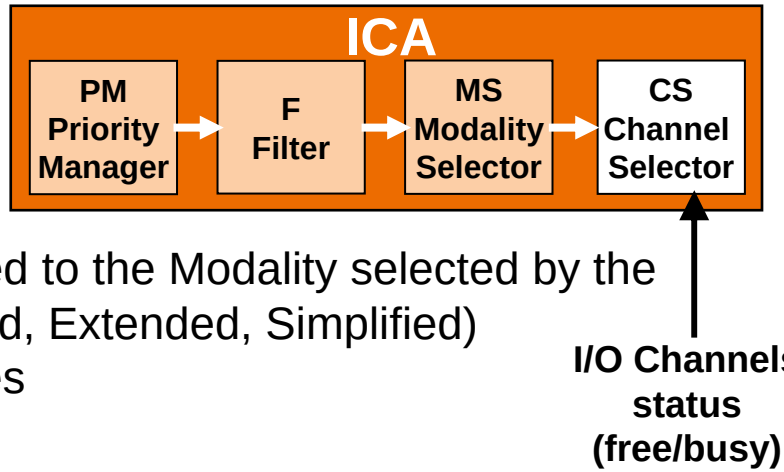
The **Application Request Vector** contains, for each action :

- Message Type (ARV)
- Application ID (identifying the application)
- Action unique ID (characterizing the specific action)
- Parameters (Initiator, Duration, Safety criticality, Time criticality, Real time, Mandatory, Driving relevance, Driver's Preference)
- Channels for Primary Modalities:
  - Channel where to display the action in Normal modality
  - Channel where to display the action in Enhanced modality
  - Channel where to display the action in Extended modality
  - Channel where to display the action in Simplified modality
- Channels for Secondary Modalities:
  - Channel where to display the action in Normal modality
  - Channel where to display the action in Enhanced modality
  - Channel where to display the action in Extended modality
  - Channel where to display the action in Simplified modality



Channel selector

- The main task of the **Channel Selector** is to manage the available output channels **solving conflicts** and **avoiding driver information overload** caused by the visualization of too many actions.



- It works considering:
  - Action priority (Wi, Di, OPi)
  - Status of availability of the channels devoted to the Modality selected by the Modality Selector (Normal, Enhanced, Extended, Simplified)
  - Amount (and weight) of displayed messages

- The **Channel Selector** module**:**
  - checks the occupation status of the candidate channels
  - considers the number (weight) and priority of the already running actions

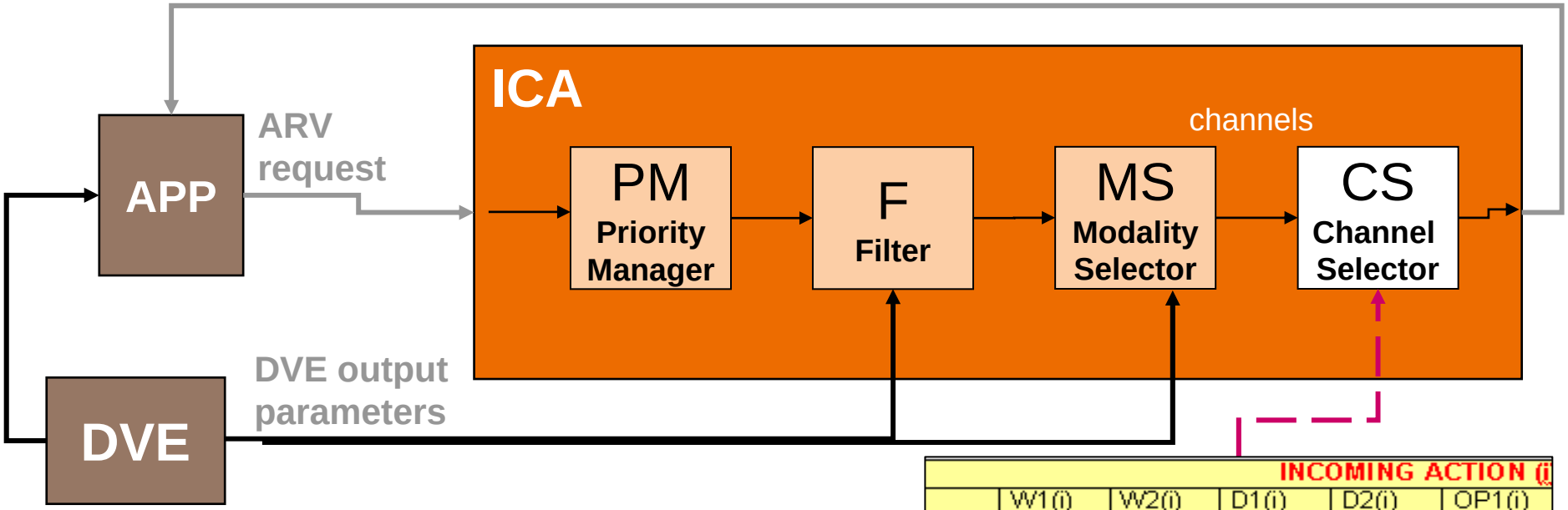
and sends to applications the following information:

- Consensus to display / queue the action with the Primary / Secondary modality
- Indication to interrupt / suspend other already displayed actions.

Channel Selector: actions' weight

- It has been introduced as well the possibility to **limit the total number of the displayed actions** to not overload the human cognitive capabilities.
- The purpose of this limit is to present only a restricted number of contemporary information to the driver.
- Every action belonging to one of the defined priority classes has an associated **"weight".**
- After having assigned to every priority class the most suitable weight, the actions visualisation will be defined by an algebraic sum of the weights of all information until the achievement of the established limit (for example 100).

Channel Selector



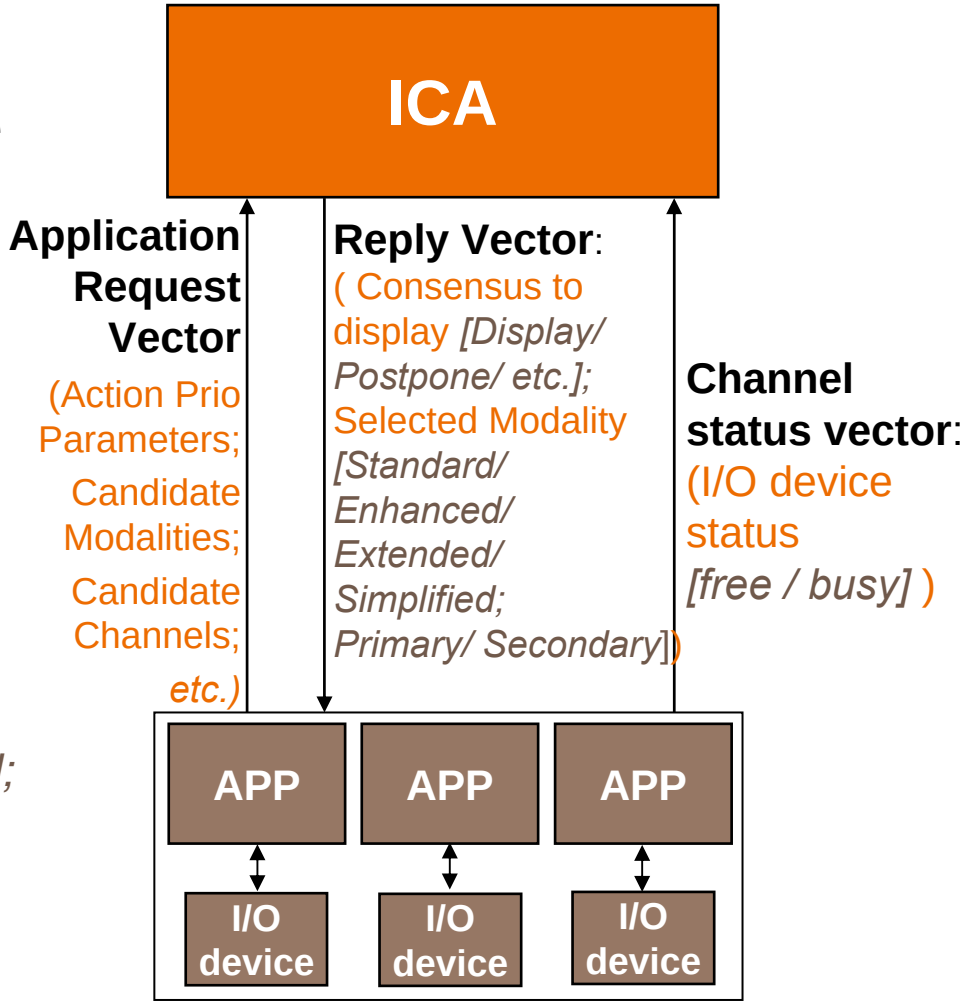
	INCOMING ACTION (i				
	W1(i)	W2(i)	D1(i)	D2(i)	OP1(i)
W1 (c)	Cycle W1(i)/ W1(c)	W1(c) = displ.	W1(c) = displ.	W1(c) = displ.	W1(c) = displ.
W2 (c)	W2(c) = susp. W1(i) = displ.	Cycle W2(i)/ W2(c)	W2(c) = displ.	W2(c) = displ.	W2(c) = displ.
D1 (c)	D1(c) = susp. W1(i) = displ.	D1(c) = susp. W2(i) = displ.	Cycle D1(i)/ D1(c)	D1(c) = displ.	D1(c) = displ.
D2 (c)	D2(c) = susp. W1(i) = displ.	D2(c) = susp. W2(i) = displ.	D2(c) = susp. D1(i) = displ.	Cycle D2(i)/ D2 (c)	D2(c) = displ.

Reply Vector

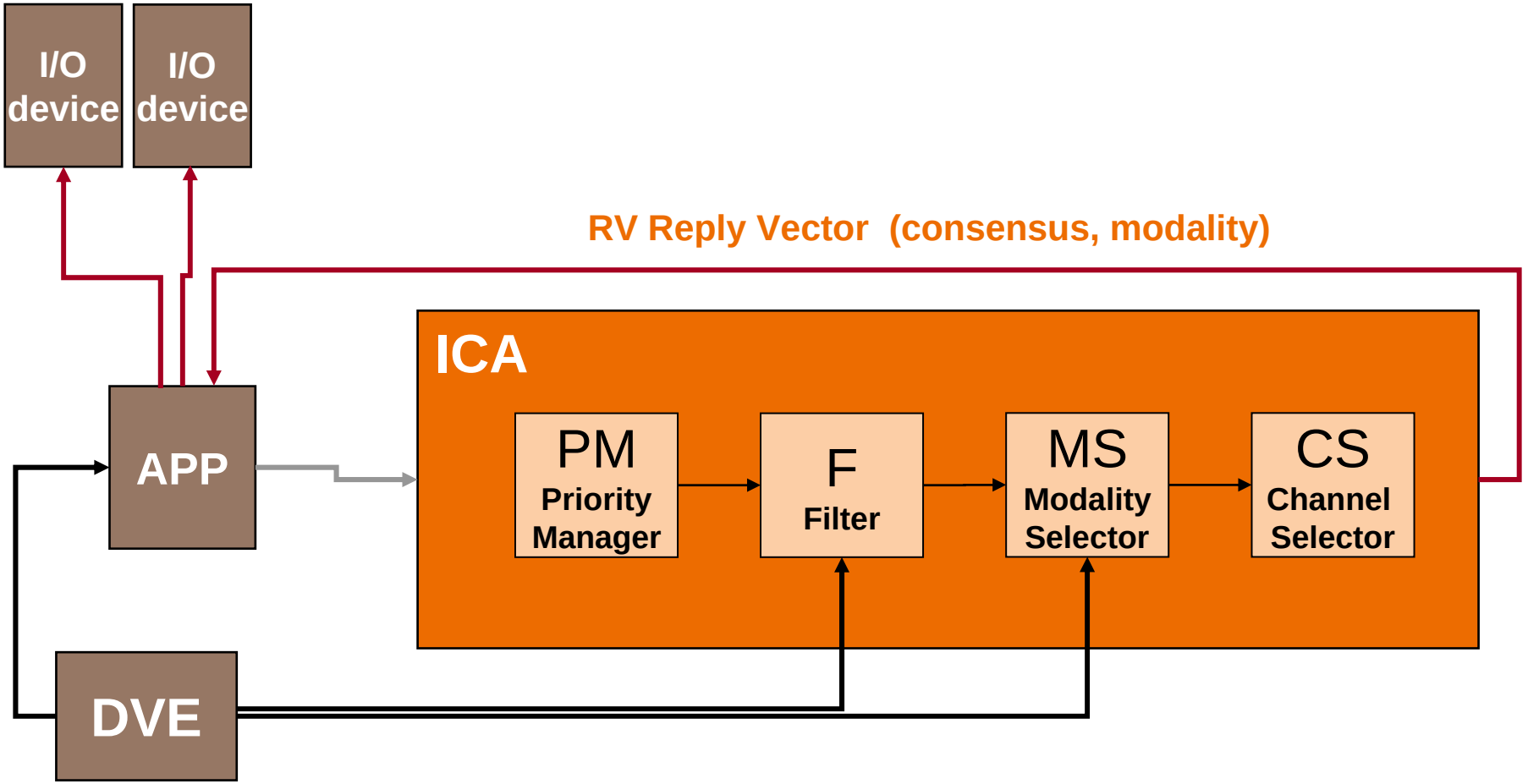
At the end of the process ICA answers to applications with a **Reply Vector** containing the **consensus** to display the action and the **selected modality**

Reply Vector:

- Message Type (RV)
- Application ID (identifying the application)
- Action unique ID (characterizing the specific action)
- Consensus to display *[Display now / Postpone];*
- Selected Modality *[Standard/ Enhanced/ Extended/ Simplified; Primary/ Secondary]*



Reply Vector from ICA to Applications



Time to Calm and Hysteresis

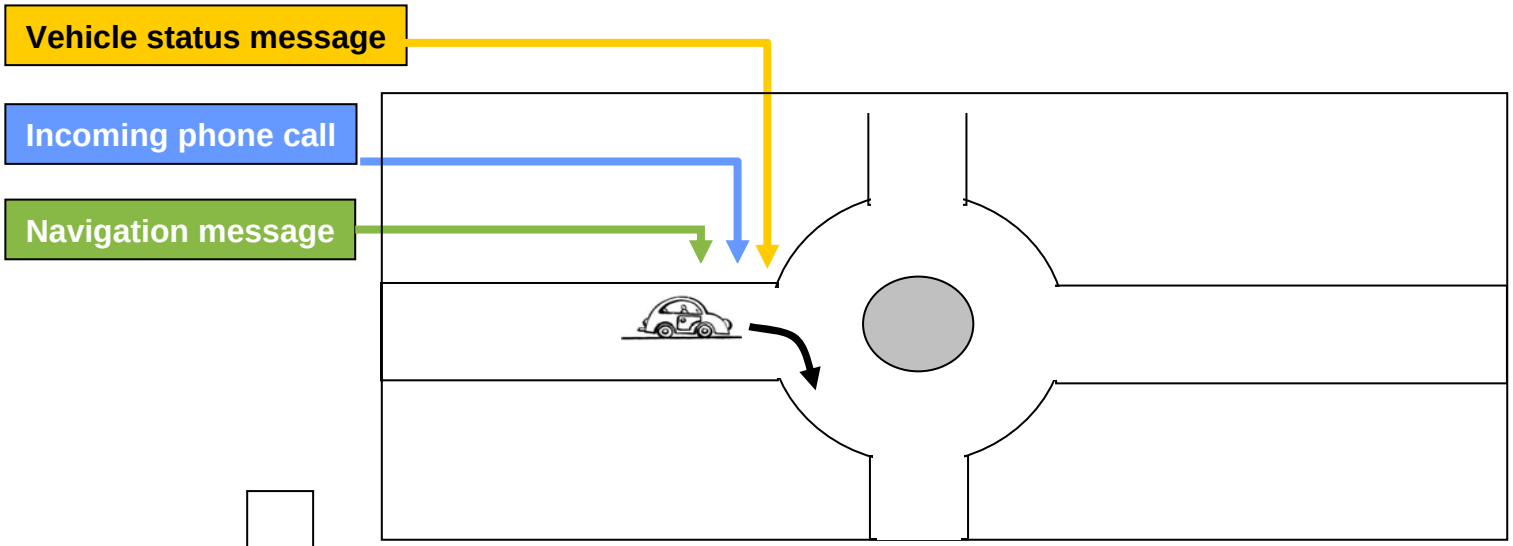
- **To avoid driver's overload due to the simultaneous presentation of the delayed actions just after the decrease of the DVE parameters**, when the driver is passing from a demanding scenario to a non critical one without the necessary period of time to adapt to the new situation (i.e. two or more postponed actions displayed at the same time immediately after the car has left a critical roundabout), two virtual functions have been introduced:

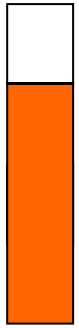
- ***Hysteresis*** introduces a time frame between the turning of the DVE from a critical to a non critical status and the visualisation of the delayed actions (because of the critical DVE status).
  - It determines the time interval after which a lower (than the previous one) DVE value is considered inside the logic of the ICA in order and to allow the driver to have the time to recover from a difficult driving condition (signalled by the high value of the DVE).
  - It is useful as well to avoid DVE signal spikes.

- ***Time to calm*** is a time frame introduced among messages to avoid that subsequent information could be given in rapid sequence startling the driver with a continuous sequence of messages.

Time to Calm and Hysteresis

Without ICA

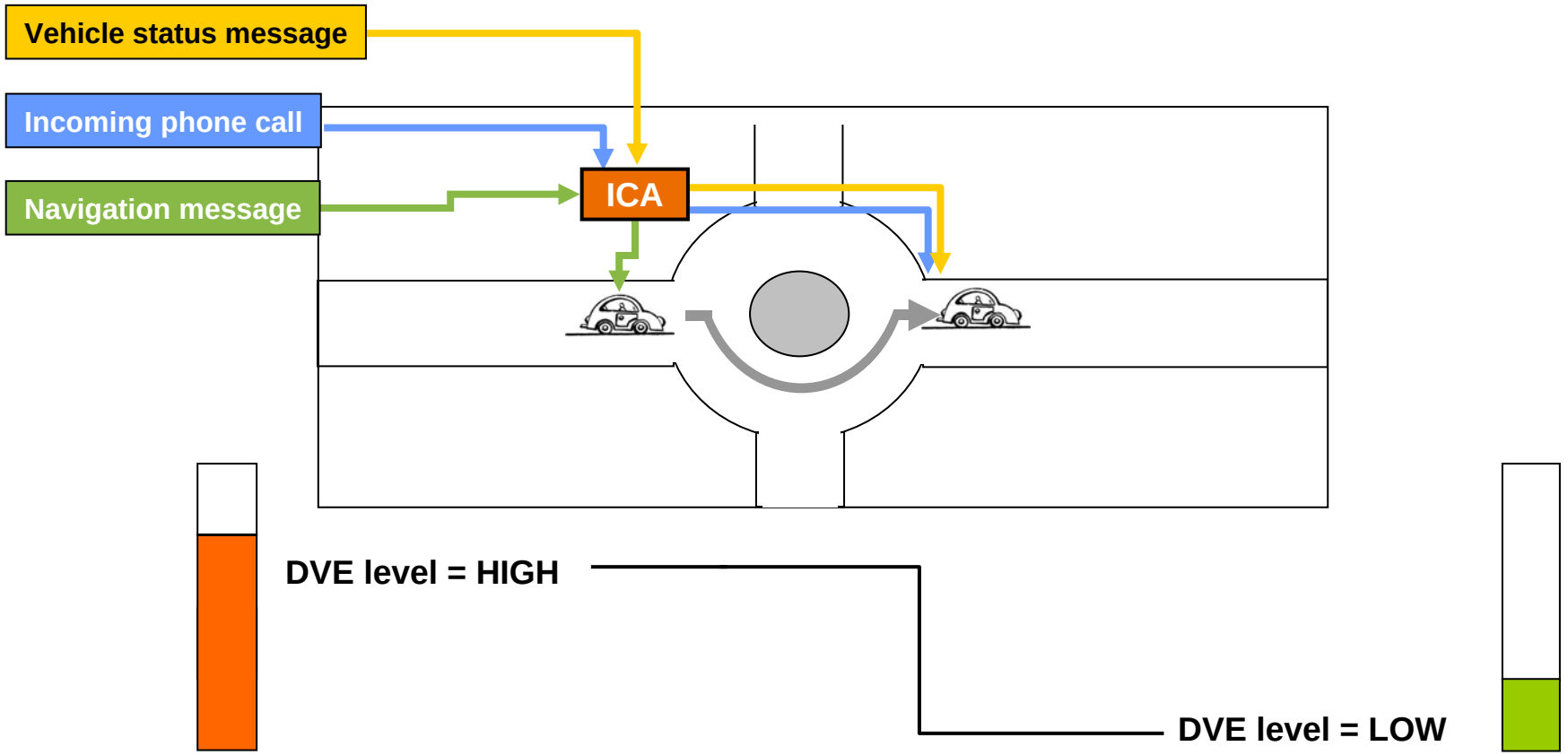




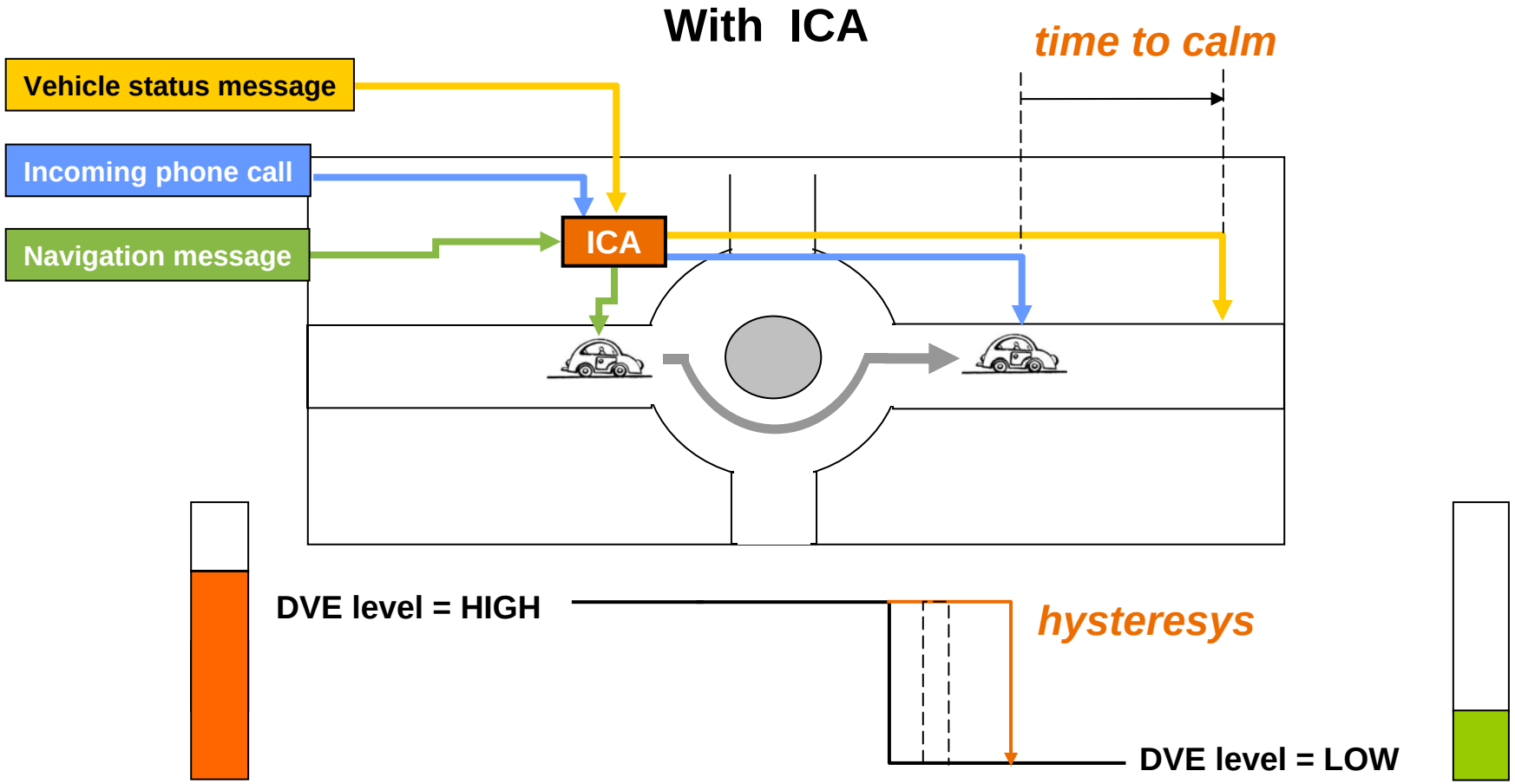
DVE level = HIGH

Time to Calm and Hysteresis

ICA without Time to calm and Hysteresis



Time to Calm and Hysteresis



Main effects of ICA on AIDE HMI

- Information messages are **prioritized** and **scheduled** according to the demand of the current Driver – Vehicle – Environment condition:
  - **Overlapping** of information is **avoided**
  - **Only the most safety critical information** or warnings are given **during demanding driving condition**
    (no phone calls, SMS, low priority info arrive to the driver during demanding manoeuvre)
  - **Only the most safety critical information can interrupt the driver** when he is performing a secondary task
    (no SMS or low priority info arrive to the driver when he is using an HMI menu)
- The **amount of information** contemporary displayed is **limited**
- A **time frame is introduced after the end of a critical situation** before to give any message to the driver
- A **time to calm is introduced between subsequent messages**
- The **output modality is adapted** to the current Driver – Vehicle – Environment condition: it can be **enhanced**, **extended in time** or **simplified**
- If an information must be displayed and its **output channel** **is busy it can be redirected to another channel**.
- **No information or user task is lost**: if a high priority information must interrupt another, the previous one is recovered at the end of the interrupting one.

Thank you for your attention !

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