JobList Configuration of FlexRay Interface
Version 1.2
2014-03-19
Application Note AN-ISC-8-1140

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Restrictions Customer confidential - AUTOSAR only
Abstract This application notes describes how the FlexRay Interface JobList is configured.

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1.0 Overview

The following application note describes how to configure the FRIF Job List.

1.1 What is the Job List about?

Receive and transmit buffers of the FlexRay CC (communication controller) may only be accessed at well defined points in time in order to avoid concurrent access to the buffers by the hardware and the software. To provide this synchronous access, the FlexRay Interface defines a FlexRay Job List for each cluster. The cluster's FlexRay Job List is executed by its Job List Execution (JLE) function using an absolute timer of the FlexRay CC.

1.1.1 Communication Jobs

A FlexRay Job List is a list of communication jobs that are sorted according to the time when they shall be executed. This start time defines when the respective JLE function shall be called. The communication operations specify the actual actions to process within the communication job.

According the AUTOSAR SWS the FlexRay Interface supports the following communication operations that can be performed for each receive or transmit buffer:

- Decoupled Transmission
- Receive and Indicate
- Tx Confirmation

1.2 Job List Configuration

As the FRIF Job List configuration is difficult and error-prone, GENy offers the possibility to calculate the scheduling of the communication operations. The FlexRay Interface supports the following configuration mechanisms (SchedulingAlgorithms) in GENy:

- Default
- Concatenated Jobs
- User Defined

1.2.1 Scheduling Algorithm – Default

The **default** scheduling algorithm divides the FlexRay cycle into x segments of the same size, where x is the number of Tx or Rx jobs. Depending on the start slot and end slot of these segments the start time of the corresponding task and the maximum ISR delay is automatically calculated.

Example:

For a cycle with a length of 5000 macro ticks which is divided into a static segment of 3000 macro ticks length and a dynamic segment of 2000 macro ticks length, the following segments (Segment 0 and Segment 1 in Figure 1) arise:

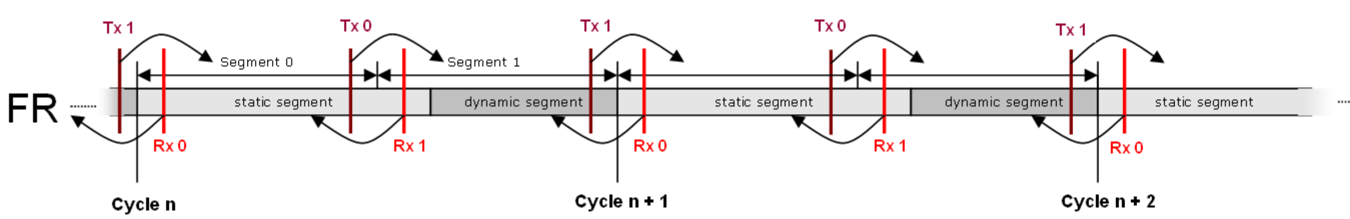


Figure 1 – **Default** Scheduling Algorithm

Note:	A TxConf job is needed if a Tx job performs the decoupled transmission for a FlexRay frame with at least one PDU that shall be confirmed to the upper layer component. The Default Scheduling Algorithm takes the first job after the last slot of the Tx job as TxConf job. In the example above Rx1 is the TxConf job for Tx1 (because it is the first job after Segment 0) and Rx0 is the TxConf job for Tx0 (because it is the first Job after Segment 1).

1.2.2 Scheduling Algorithm – Concatenated Jobs

In contrast to the default algorithm the **Concatenated Jobs** algorithm configures the start time of an Rx and the following Tx FRIF job to the same macrotick parameter and enables the Job Concatenation Enable option. As one timer interrupt is used to activate an Rx and Tx FRIF job, this algorithm can be used to reduce the interrupt load of the FlexRay Interface.

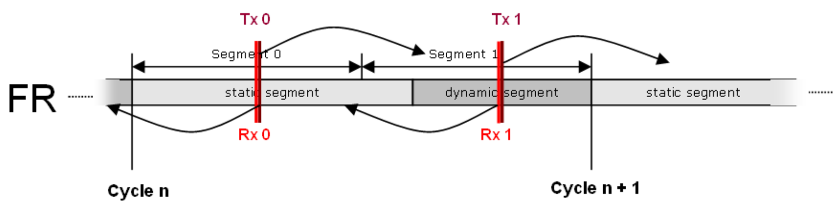


Figure 2 – **Concatenated Jobs** Scheduling Algorithm

Note:	Due to the job concatenation it is not possible to achieve both shortest possible indication times after reception and latest data for transmission. For example in the picture above the concatenated jobs Rx0 and Tx0 can either be placed at the beginning of the cycle with the consequence that the data indications for frames in Segment 1 will be given to the upper layer components as soon as possible. Or Rx0 and Tx0 can be placed just before the start of Segment 1 to reduce the age of the transmitted data.

1.2.3 Scheduling Algorithm – User Defined

Beside the automated job placement GENy offers the possibility to configure the following job parameters manually:

- Start Slot and End Slot (or assignment of single frames to a Job)
- Macrotick
- Maximum permissible ISR delay
- TxConf Job

1.3 Synchronisation of BSW main functions

For deterministic communication behaviour on FlexRay it is necessary to synchronize the main function of FlexRay relevant BSW modules to the global time of the FlexRay CC. If the main functions are not synchronized it is possible that obsolete data is received or updated PDUs are not transmitted during the FlexRay cycle.

For example if an application task shall receive PDU data at the beginning of the FlexRay cycle and the response should be transmitted at the end of the same cycle, it is necessary that this ApplTask is scheduled between the Rx receive slot and the Tx transmit slot. If the task is not synchronised and the task drift causes the application to transmit PDU data after the FlexRay slot is expired, the PDU will be transmitted in the next cycle as shown in Figure 3.

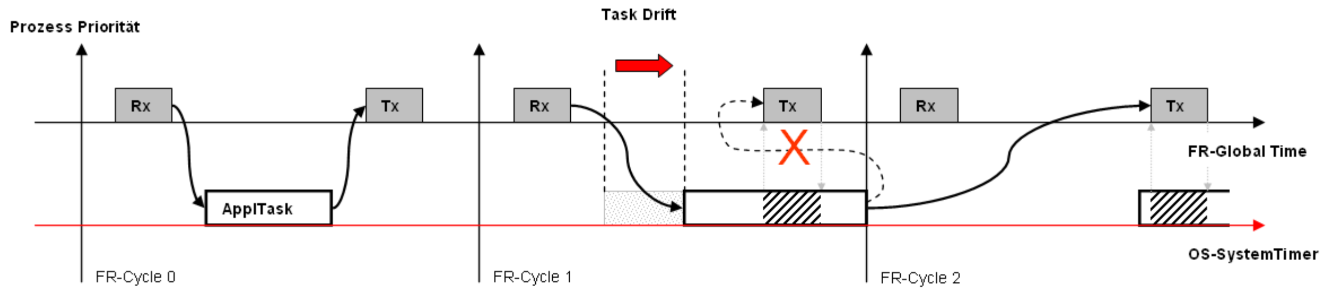


Figure 3 – Unsynchronized application behaviour on FlexRay

There are several ways to synchronize BSW modules to the FlexRay global time:

1. Using synchronized schedule tables of the AUTOSAR OS
2. Cancel and set relative alarms in the FlexRay timer or cycle start ISR (like the MICROSAR SCHM does)
3. Calling the BSW main function directly in the context of the FlexRay timer or cycle start ISR

Note:	Calling the BSW main function only in the context of the FlexRay timer or cycle start ISR has the disadvantage that the main function won't be called if the FlexRay bus loses synchronization.

2.0 Configuration aspects

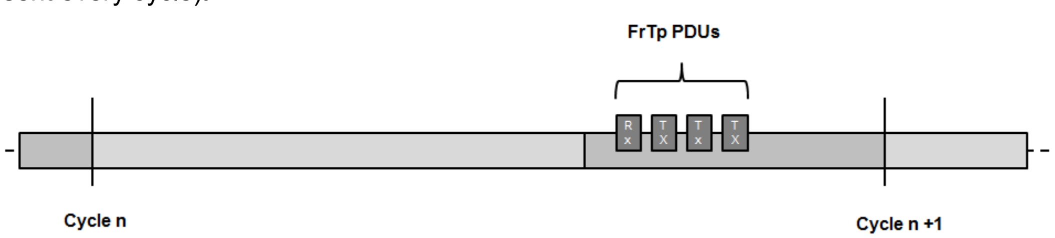
For optimal BSW behaviour some configuration aspects shall be considered by the integrator as described in this section. Using the example of FRTP this chapter explains the details of:

- FRIF job placement and configuration
- Main function placement
- FRIF PDU settings
- Task priorities and interruptibilities
- Duration of critical sections or resource locks
- SystemTimer tick time

Note:	These settings are also relevant for non-FRTP modules like COM, PDUR, FRNM and FRXCP

Note:	Some FRNM specific details are also provided where applicable.

In the following example the FRTP PDUs are all transmitted and received during the dynamic segment of the FlexRay cycle as depicted below. The corresponding frames have a cycle repetition 1 (meaning that they could be sent every cycle).



Note:	With AUTOSAR 3.2.2 FRTP only the last Tx PDU of a PDU pool is confirmed by the FlexRay Interface to reduce the CPU and interrupt load.

2.1 PDUs with decoupled transmission

If FRTP PDUs are configured to use decoupled transmission, the transmission rate of the FlexRay Transport Layer strongly depends on the positioning of the FRTP main function and the Rx, Tx and TxConf FRIFJobs of the FRTP frames.

Note:	If the FRTP PDUs are sent with immediate transmission (the message buffers are written in the context of the FRTP main function) only the start times of the Rx and TxConf jobs are relevant for the placement of the FRTP main function.

2.1.1 Optimal BSW main function placement

2.1.1.1 FRTP Main Function placement

To achieve optimal throughput for segmented TP transmission it is recommended to place the SCHM Task which executes the FRTP main function between the Rx and the Tx FRIFJob of the TP frames. The Rx FRIFJob should handle the TxConfirmation as depicted in Figure 4.

In this scenario the TP Tx PDUs in the dynamic segment are sent in cycle n and in the following cycle these PDUs are confirmed and the FRTP Rx PDUs (i.e. flow control or tester response) are received. Hence the first consecutive frame is sent in the next cycle after the flow control and each consecutive frame is sent every cycle (according the cycle repetition in ECUC database).

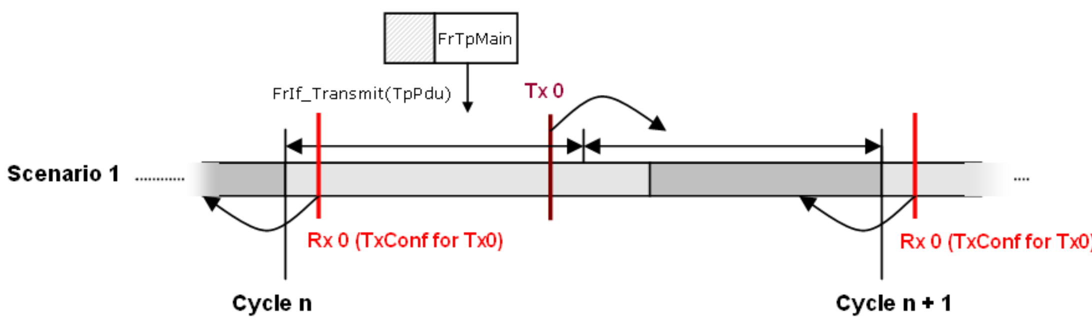


Figure 4 – **FRTP Scenario 1** – optimal FrTp main function placement for TP frames in the dynamic segment

Note:	The FRTP main function must be called at least once per FlexRay cycle (between two Rx job activations that handle the FRTP PDUs). Otherwise data loss is imminent.

2.1.1.2 FRNM Main Function placement

For the moment when the FRNM main function shall be executed, the SCHM task that calls the FRNM main function should be placed between the Rx FRIF job that receives the last NM vote and the first Tx FRIF job that sends one of the FRNM Tx PDUs. This can be seen in Figure 5.

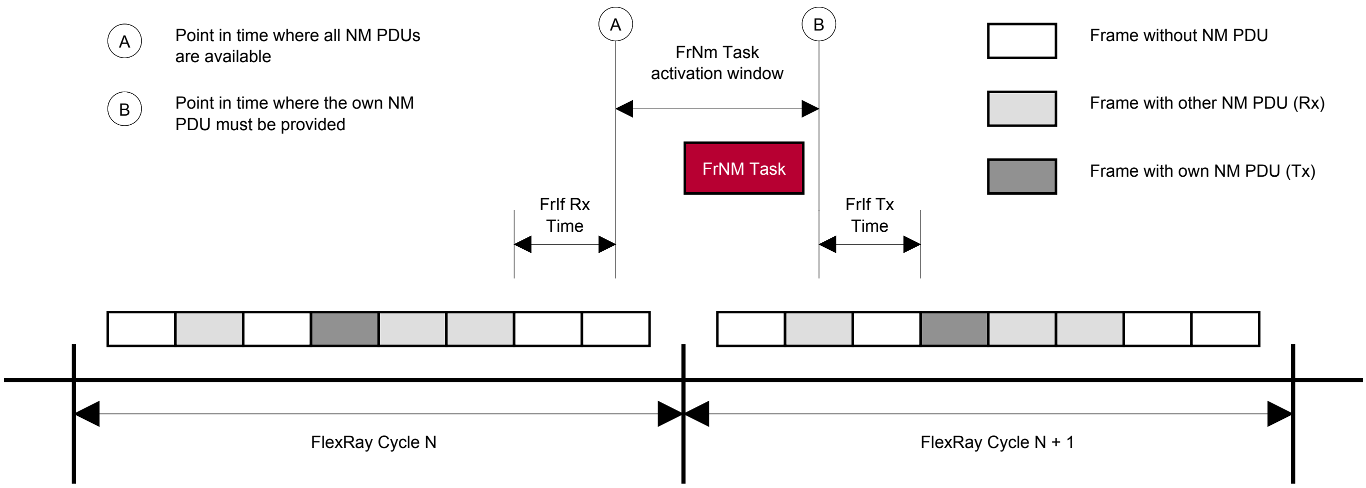


Figure 5 – FRNM Main Function – Window for task activation

The FRNM Task function should always be executed either at the beginning of a FlexRay Cycle or at the end of a FlexRay cycle. If it shall be executed at the beginning of a FlexRay Cycle, the configuration parameter ‘Main Across Fr Cycle’ needs to be TRUE, otherwise FALSE. Note that this parameter is usually defined by the OEM.

It is necessary that all NM Vote and Data PDUs have been received until the FRNM main function is called (Moment A in the figure). It is also necessary that the FRNM main function has finished execution before the Moment B in the figure where the FRIF TX Job is started. At this point of time, the data of the TX NM PDUs needs to be provided to the FRIF.

Note:	If the NM PDUs are in the dynamic segment (e.g. ‘Pdu Schedule Variant’ is 2) but not at the beginning of the dynamic segment the corresponding FRIF job is always scheduled in the next FR cycle. This means in this case the ‘Main Across Fr Cycle’ must be set to TRUE. If ‘Main Across Fr Cycle’ is set to FALSE, the FRNM PDUs must be at the beginning of the dynamic segment. In this case an additional Rx job is necessary where the ‘End Slot’ attribute of is set to the slot ID of the last FRNM frame. The start time of this Rx Job in ‘Macrotick’ should be scheduled after the last FRNM frame and before the FRNM main function in the same cycle.

Note that it is difficult to determine Moment A in the figure, because it depends on the worst-case execution time (WCET) of the Rx Job that processes the last NM PDU. This Rx Job can be identified in GENy using the ‘Is Last FrIf Rx Task for Nm’ attribute. This WCET should be measured by the integrator because the jobs runtime is affected by the application behaviour in the RX Indication functions.

The latest point in time for Moment A in the figure starting from the beginning of a FlexRay Cycle boundary can be determined by the following settings of the FRIF RX Job *j* that processes the last NM PDU in one FlexRay Cycle:

$Macrotick(j) + Max\ Isr\ Delay(j) + t_{WCET}(j)$

where $t_{WCET}(j)$ denotes the worst-Case execution time of the FrIf_JobListExec_0() routine.

Note:	The FRNM Main Function has to be called once in each FlexRay cycle.

In the dual channel use case for ‘Sync PDU Wake-up Master’ nodes, the send requests of the FRNM Sync PDUs[1] are also issued by the FRNM Main Function. These send requests, if required, are issued in a certain cycle of each FRNM Voting Cycle called the ‘Sync Pdu Tx Request Cycle Offset’.

The following constraints have to be considered for ‘Sync PDU Wake-up Master’ nodes about the configuration:

[1] This feature is OEM-specific and may not be available and/or relevant in your delivery

- In each ‘Sync Pdu Tx Request Cycle Offset’ cycle, all FRNM PDUs of other nodes in the current Voting Cycle have been received after the Rx Job List has been executed and before the FRNM Main Function has been executed.
- The ‘Sync Pdu Tx Request Cycle Offset’ needs to be configured to a cycle offset in the Voting Cycle, so that the transmission request of the NM Sync PDUs can be issued in that cycle in order to send the NM Sync PDUs in the same Voting Cycle.

These constraints are illustrated by an example in Figure 6.

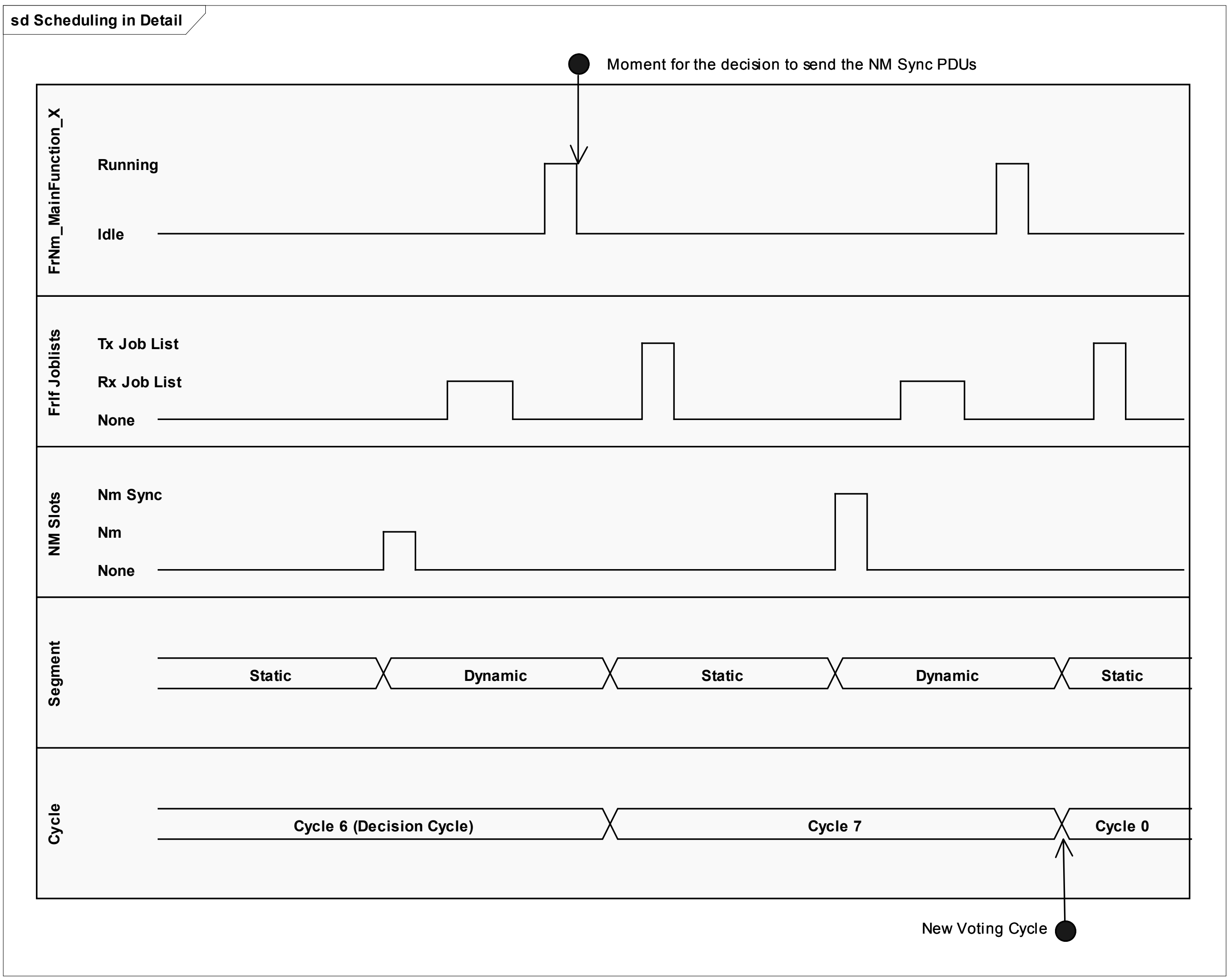


Figure 6 – FRNM Scheduling for Sync PDU Wake-up Master node

As it can be seen, two FlexRay cycles are shown in the example. These FRNM configuration parameters apply here: ‘Voting Cycle’ = ‘Data Cycle’ = 8, ‘Main Across Fr Cycle’ = FALSE, ‘Sync Pdu Tx Request Cycle Offset’ = 6.

After NM PDUs may have been sent/received in the beginning of the Dynamic Segment in Cycle 6 and the RX Job for FRNM PDUs in the FrIf RX Joblist has been executed, the FrNm_MainFunction_X may be executed and within this context, the transmit request for the NM Sync PDUs may be issued. It has to be assured that execution of the FRNM Main Function has been finished before the cycle end (because of ‘Main Across Fr Cycle’ = FALSE).

Afterwards the FrIf TX Joblist may be processed in the next FlexRay Cycle and the Transmission of the NM Sync PDUs may take place at the beginning of the Dynamic Segment in Cycle 7.

In this example it must be ensured that all NM RX PDUs from Cycle 0 to 6 have been received and processed by FRNM when the ‘Moment for the decision to send the NM Sync PDUs’ arrives. Because the send request for the NM Sync PDUs is issued at the end of Cycle 6 FrIf can transmit them in the next cycle.

For details about the FRNM Main Function usage and details about the ‘Sync PDU Wake-up Master’ also refer to the ‘AUTOSAR FlexRay Network Management Technical Reference’ document.

2.1.2 Wrong FRIFJob configurations

For optimal FRTP throughput the integrator should ensure that task preemption by a high prior interrupt and/or jitter of the SCHM task does not cause the FRTP main function to be called after the Tx job or before the Rx job as shown in Figure 7.

The jitter of the SCHM task is affected by non-preemptive tasks (even if they have lower priority), long duration of critical sections with locked interrupts/resources or large OS SystemTimer tick times. If the jitter or the preemption cannot be avoided it is recommended to draw the FRIFJobs manually apart.

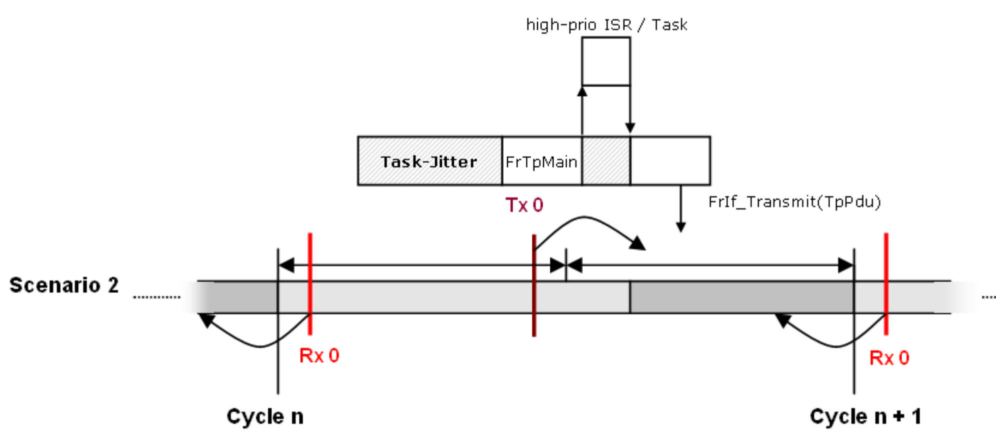


Figure 7 – **FRTP Scenario 2** suboptimal FRTP main function placement caused large task jitter or preemption

Note:	It is not possible to achieve optimal FRTP transmission rates with the scheduling algorithm Concatenated Jobs because the FRTP main function cannot be placed between the Rx and Tx job as depicted in Figure 8.

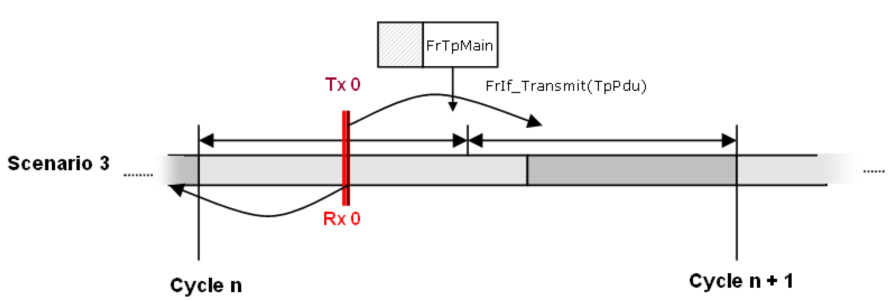


Figure 8 – **FRTP Scenario 3** suboptimal TP (decoupled) transmission rates due to job concatenation

For example if additionally Rx Job 1 in Figure 9 is configured to handle the Tx confirmations for Tx0 FRIFJob the consecutive frames of a segmented TP transfer will only be send every second FRTP main function cycle because the Tx confirmations for the TP frames in the dynamic segment are given in cycle n+1 and not in the same cycle of the FRTP main function. The reason is that in this case the TxConf job polls the transmission state before the FlexRay slot has been transmitted by the communication controller.

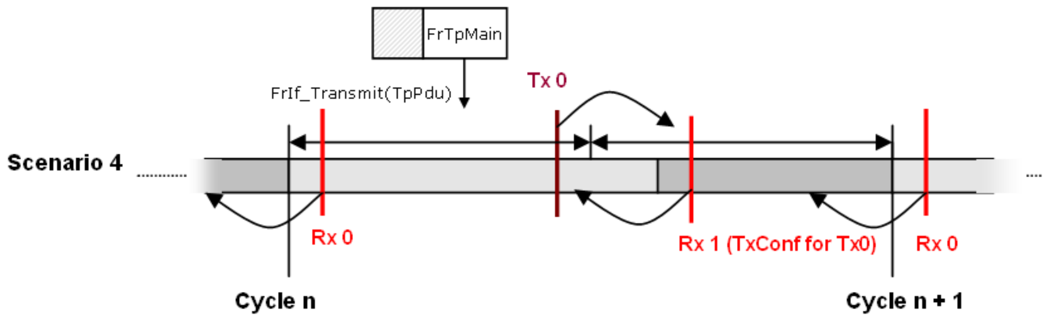


Figure 9 – **FRTP Scenario 4** suboptimal TxConf job configuration

Please ensure that the TxConf job for FRTP PDUs is not scheduled after the Rx job of the FRTP PDUs as depicted in Figure . Otherwise it is possible that during segmented transmission the FRTP state machine handles the reception of a flow control frame before the first frames is confirmed and the transmission of the consecutive frames is delayed. Hence the FRTP transmission rates and OBD response times are affected negatively.

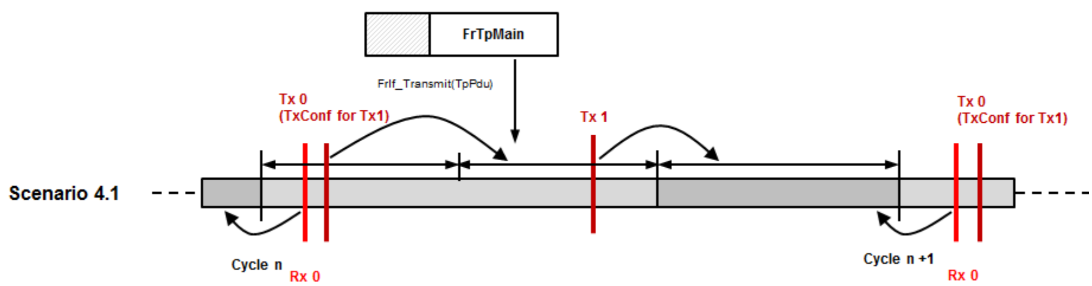


Figure 10 – **FRTP Scenario 4.1** TxConf Task before Rx Task

Note:	If a Rx job handles the Tx confirmation for a Tx job the FlexRay Interface component ensures that the confirmations will be handled before the Rx indications are given to the upper layer components.

2.2 PDUs with immediate transmission

If FRTP PDUs are configured to use immediate transmission, the transmission rate of the FlexRay Transport Layer only depends on the positioning of the FRTP main function and the Rx and TxConf FRIFJobs of the FRTP frames.

The position of the Tx FRIFJob does not matter because the message buffers are written in the context of the FRTP main function. For example in Figure 11 the FRTP PDUs in the dynamic segment will be transmitted in the same cycle as long as the FRTP main function is called before the FlexRay frames are sent on the bus.

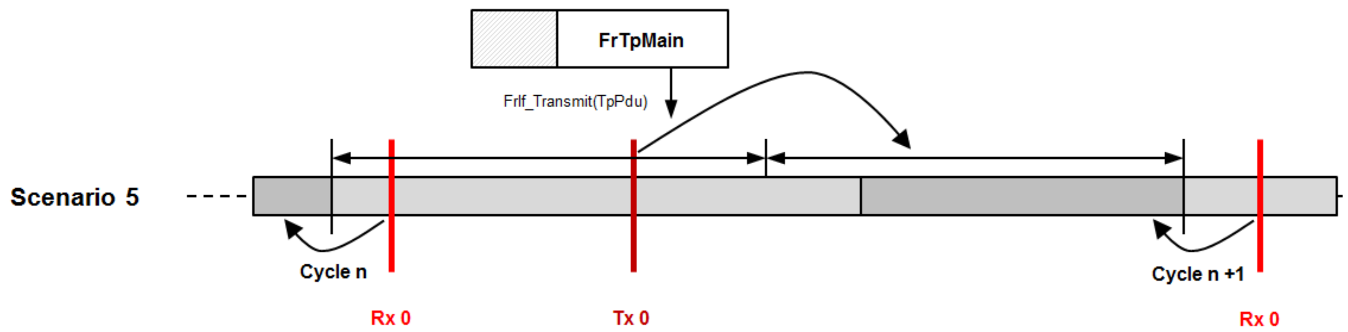


Figure 11 – **FRTP Scenario 5** Tx FRIF jobs don't matter for PDUs with immediate transmission

Note:	FRIF PDUs can only be configured for immediate transmission if the PDU is the only one within the FlexRay frame. Frames with more than one FRIF PDU always use decoupled transmission.

3.0 Contacts

For a full list with all Vector locations and addresses worldwide, please visit http://vector.com/contact/.