Example of CAN schedulability analysis

The goal is to determine the worst-case response time of each message of the configuration in table 1. This configuration includes 4 stations interconnected by a CAN bus with a bandwidth of 500 Kb/s. Each station transmits one message with an identifier on 11 bits.

Message	Station	Identifier	Period	Deadline	Data bytes
A	1	5	0.8 ms	0.5 ms	2 bytes
B	2	12	1.2 ms	0.7 ms	4 bytes
D	3	23	1.2 ms	0.9 ms	6 bytes
E	4	36	1.2 ms	0.9 ms	6 bytes

Table 1: The first congiguration

The worst-case transmission time of each message can be computed using the following formula:

$$\begin{array}{lcll} C_i & = & MaxL_i \times \tau_{bit} & \\ & \text{with} & & \\ MaxL_i & = & 55 + 10 \times S_i & \text{for identifiers on 11 bits} \\ \tau_{bit} & = & \text{Transmission time of one bit} & \end{array}$$

For the configuration in table 1, we have $\tau_{bit} = 2\ \mu s$, since the bandwidth of the CAN bus is 500 Kb/s. Then we have:

$$\begin{array}{lclcl} C_A & = & (55 + 10 \times 2) \times 2 & = & 150\ \mu s \\ C_B & = & (55 + 10 \times 4) \times 2 & = & 190\ \mu s \\ C_D & = & (55 + 10 \times 6) \times 2 & = & 230\ \mu s \\ C_E & = & (55 + 10 \times 6) \times 2 & = & 230\ \mu s \end{array}$$

The worst-case response time computations for the four messages are illustrated in figure 1.

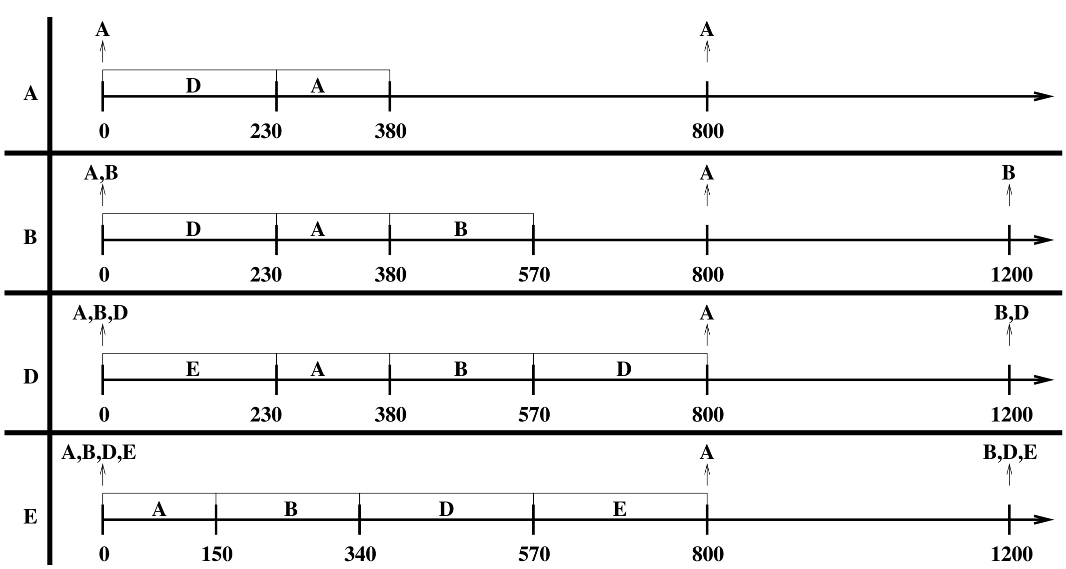

Figure 1: Worst-case analysis of the first configuration

The worst-case response times for messages A, B, D and E are respectively 380 μs, 570 μs, 800 μs and 800 μs. Consequently, all the messages respect their deadlines.
The second configuration is described in table 2. The only difference with the first configuration in table 1 is the addition of message C.

Message	Station	Identifier	Period	Deadline	Data bytes
A	1	5	0.8 ms	0.5 ms	2 bytes
B	2	12	1.2 ms	0.7 ms	4 bytes
C	2	14	1.2 ms	0.7 ms	4 bytes
D	3	23	1.2 ms	0.9 ms	6 bytes
E	4	36	1.2 ms	0.9 ms	6 bytes

Table 2: The second congiguration

Message C has exactly the same characteristics as message B. Then the transmission time for one frame of message C is $C_C = 190\ \mu s$.
The worst-case response time computations for the five messages are illustrated in figure 2.

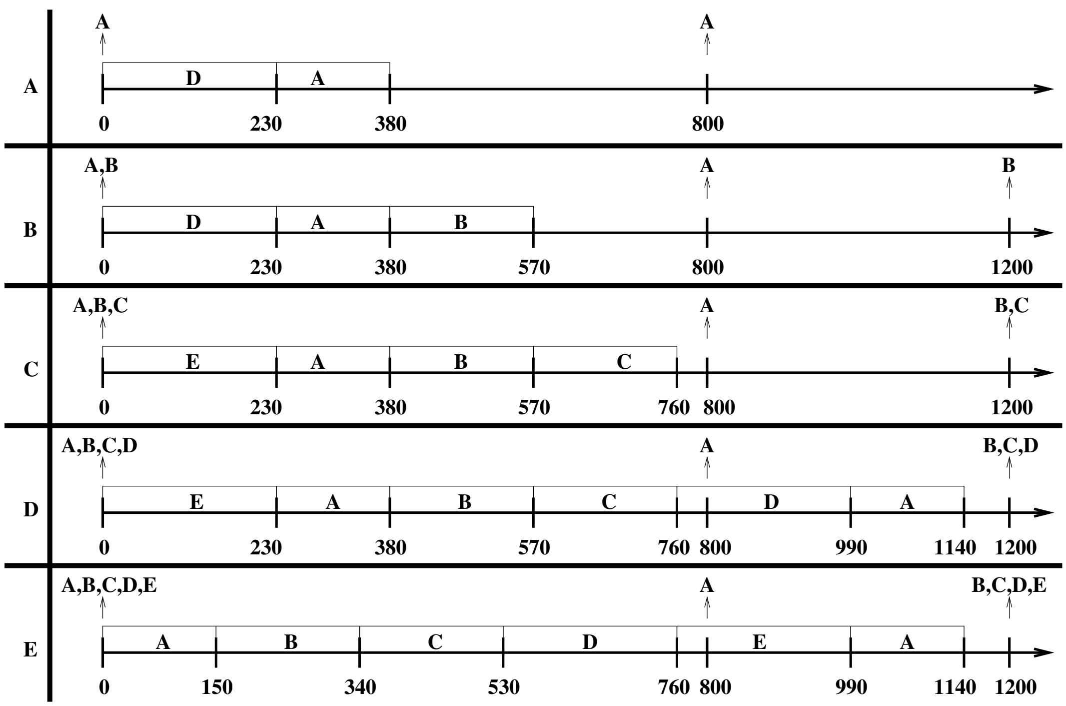

Figure 2: Worst-case analysis of the first configuration

The worst-case response times for messages A, B, C, D and E are respectively 380 μs, 570 μs, 760 μs, 990 μs and 990 μs. Consequently, messages C, D and E can miss their deadlines.
Let's consider more precisely the architecture of the considered configuration. Figure 3 shows the interconnected stations with their messages. Since there is no common clock between the stations, we cannot make any assumption on the offset between the generation instant of frames from two messages with different source stations, e.g. A from station 1 and B from station 2. Conversely messages B and C are both generated by station 2 and they are scheduled, based on the local clock of station 2. Therefore it is possible. to organize this schedule in order to distribute the load from station 2 as much as possible. Since messages B and C have the same periods (1200 μs), il is possible to generate one frame (from B or C) every 600 μs, as depicted in Figure 4. It comes to impose an offset of 600 μs between the two messages. This leads to the configuration in table 3.
The worst-case response time computations for the four messages are illustrated in figure 5.
The worst-case response times for messages A, B, C, D and E are respectively 380 μs, 570 μs, 570 μs, 800 μs and 800 μs. Consequently, all the messages respect their deadlines.

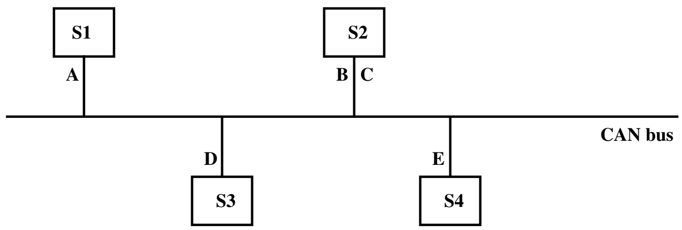

Figure 3: Architecture overview

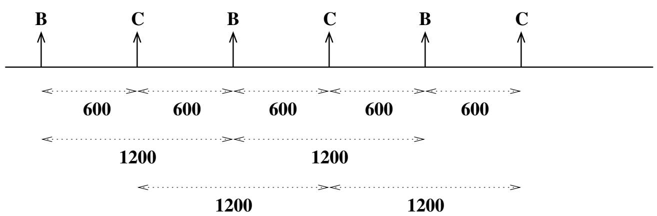

Figure 4: Station 2 scheduling

Message	Station	Identifier	Period	Deadline	Data bytes
A	1	5	0.8 ms	0.5 ms	2 bytes
BC	2	12	0.6 ms	0.7 ms	4 bytes
D	3	23	1.2 ms	0.9 ms	6 bytes
E	4	36	1.2 ms	0.9 ms	6 bytes

Table 3: The second configuration modified

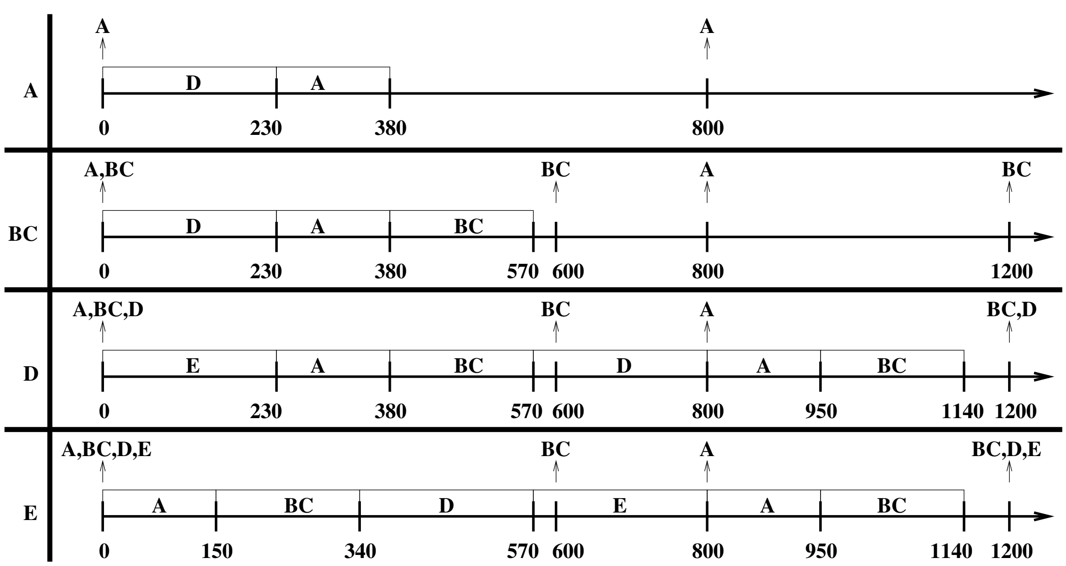

Figure 5: Worst-case analysis of the second configuration modified