Example 1 (Embedded system). The embedded system comprises a processor, sensors and an actuator. The main processor, connected to ports M_{in} and M_{out}, reads data coming from sensors, and passes instructions to the actuator through port *Input* and *Output*, respectively. The system fails to get an input only when no data flows through each probabilistic filter. A complete round, which starts when a data comes in and stops when the output data is written successfully, should be accomplished in a certain period of time, otherwise the system sends out a timeout signal.

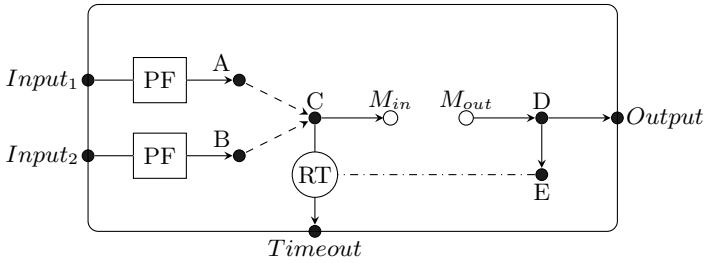

Fig. 1. Embedded System

A *probabilistic filter*, **PF** in short, drops data with a certain probability, i.e. $1 - p$; while **RT** with time bound t_{max}, which stands for *reset timer*, can be reset.

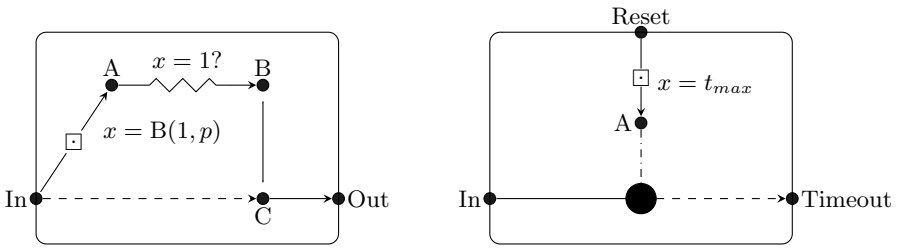

Fig. 2. Probablistic Filter (left) and Reset Timer (right)

There are 8 locations in the STA_r of the embedded system, consisting of triples which symbolizes the configuration of two probabilistic filters and the reset timer. The STA_r is represented by *JANI*; elements are ommited except locations and edges.

```
\begin{verbatim}
// the embedded system
{
```

```
locations: [
  // loc_num [inv] <initial> : loc_conf
  1 <initial>: (init, init, waiting),
  2: (init, ready, waiting),
  3: (ready, init, waiting),
  4: (ready, ready, waiting),
  5 [t <= t_max] : (init, init, timing),
  6 [t <= t_max] : (init, ready, timing),
  7 [t <= t_max] : (ready, init, timing),
  8 [t <= t_max] : (ready, ready, timing)
],
edges: [
  // src_loc -> dst_loc (act) [guard] <: update_func>
  1 -> 2 (i) : buf_2 = B(1, p),
  2 -> 1 (Input_2),
  1 -> 3 (i) : buf_1 = B(1, p),
  3 -> 1 (Input_1),
  1 -> 4 (i) : buf_1 = B(1, p), buf_2 = B(1, p),
  4 -> 1 (Input_1, Input_2),
  2 -> 4 (i) : buf_1 = B(1, p),
  4 -> 2 (Input_1),
  3 -> 4 (i) : buf_2 = B(1, p),
  4 -> 3 (Input_2),
  2 -> 3 (i, Input_2) : buf_1 = B(1, p),
  3 -> 2 (i, Input_1) : buf_2 = B(1, p),

  5 -> 6 (i) : buf_2 = B(1, p),
  6 -> 5 (Input_2),
  5 -> 7 (i) : buf_1 = B(1, p),
  7 -> 5 (Input_1),
  5 -> 8 (i) : buf_1 = B(1, p), buf_2 = B(1, p),
  8 -> 5 (Input_1, Input_2),
  6 -> 8 (i) : buf_1 = B(1, p),
  8 -> 6 (Input_1),
  7 -> 8 (i) : buf_2 = B(1, p),
  8 -> 7 (Input_2)
  6 -> 7 (i, Input_2) : buf_1 = B(1. p),
  7 -> 6 (i, Input_1) : buf_2 = B(1, p),

  1 -> 1 (M_out, Output) : Output = M_out,
  2 -> 2 (M_out, Output) : Output = M_out,
  3 -> 3 (M_out, Output) : Output = M_out,
  4 -> 4 (M_out, Output) : Output = M_out,

  7 -> 5 (Input_1, M_in) [buf_1 = 1, t = t_max] : t = 0,
```

```
7 -> 5 (Input_1, M_in, Timeout) [buf_1 = 1, t = t_max] :
    t = 0, M_in = Input_1, Timeout = TIMEOUT,
7 -> 5 (Input_1, M_in, M_out, Output) [buf_1 = 1] :
    t = 0, M_in = Input_1, Output = M_out,
7 -> 5 (Input_1, M_in, M_out, Output, Timeout)
    [buf_1 = 1, t = t_max] :
    t = 0, M_in = Input_1, Output = M_out, Timeout = TIMEOUT,
6 -> 5 (Input_2, M_in) [buf_2 = 1, t = t_max] : t = 0,
6 -> 5 (Input_2, M_in, Timeout) [buf_2 = 1, t = t_max] :
    t = 0, M_in = Input_2, Timeout = TIMEOUT,
6 -> 5 (Input_2, M_in, M_out, Output) [buf_2 = 1] :
    t = 0, M_in = Input_2, Output = M_out,
6 -> 5 (Input_2, M_in, M_out, Output, Timeout)
    [buf_2 = 1, t = t_max] :
    t = 0, M_in = Input_2, Output = M_out, Timeout = TIMEOUT,
8 -> 6 (Input_1, M_in) [buf_1 = 1, t = t_max] : t = 0,
8 -> 6 (Input_1, M_in, Timeout) [buf_1 = 1, t = t_max] :
    t = 0, M_in = Input_1, Timeout = TIMEOUT,
8 -> 6 (Input_1, M_in, M_out, Output) [buf_1 = 1] :
    t = 0, M_in = Input_1, Output = M_out,
8 -> 6 (Input_1, M_in, M_out, Output, Timeout)
    [buf_1 = 1, t = t_max] :
    t = 0, M_in = Input_1, Output = M_out, Timeout = TIMEOUT,
8 -> 7 (Input_2, M_in) [buf_2 = 1, t = t_max] : t = 0,
8 -> 7 (Input_2, M_in, Timeout) [buf_2 = 1, t = t_max] :
    t = 0, M_in = Input_2, Timeout = TIMEOUT,
8 -> 7 (Input_2, M_in, M_out, Output) [buf_2 = 1] :
    t = 0, M_in = Input_2, Output = M_out,
8 -> 7 (Input_2, M_in, M_out, Output, Timeout)
    [buf_2 = 1, t = t_max] :
    t = 0, M_in = Input_2, Output = M_out, Timeout = TIMEOUT,
8 -> 5 (Input_1, Input_2, M_in) [buf_1 = 1, t = t_max] :
    t = 0, M_in = Input_1,
8 -> 5 (Input_1, Input_2, M_in) [buf_2 = 1, t = t_max] :
    t = 0, M_in = Input_2,
8 -> 5 (Input_1, Input_2, M_in, M_out, Output) [buf_1 = 1] :
    t = 0, M_in = Input_1, Output = M_out,
8 -> 5 (Input_1, Input_2, M_in, M_out, Output) [buf_2 = 1] :
    t = 0, M_in = Input_2, Output = M_out,
8 -> 5 (Input_1, Input_2, M_in, Timeout) [buf_1 = 1, t = t_max] :
    t = 0, M_in = Input_1, Timeout = TIMEOUT,
8 -> 5 (Input_1, Input_2, M_in, Timeout) [buf_2 = 1, t = t_max] :
    t = 0, M_in = Input_2, Timeout = TIMEOUT,
8 -> 5 (Input_1, Input_2, M_in, M_out, Output, Timeout)
    [buf_1 = 1, t = t_max] :
```

```
    t = 0, M_in = Input_1, Output = M_out, Timeout = TIMEOUT,
8 -> 5 (Input_1, Input_2, M_in, M_out, Output, Timeout)
    [buf_2 = 1, t = t_max] :
    t = 0, M_in = Input_2, Output = M_out, Timeout = TIMEOUT,

5 -> 1 (M_out, Output) [t < t_max] : Output = M_out,
    5 -> 1 (i) [t = t_max]
5 -> 1 (Timeout) [t = t_max] : Timeout = TIMEOUT,
5 -> 1 (M_out, Output, Timeout) [t = t_max] :
    Output = M_out, Timeout = TIMEOUT,
6 -> 2 (M_out, Output) [t < t_max] : Output = M_out,
    6 -> 2 (i) [t = t_max]
6 -> 2 (Timeout) [t = t_max] : Timeout = TIMEOUT,
6 -> 2 (M_out, Output, Timeout) [t = t_max] :
    Output = M_out, Timeout = TIMEOUT,
7 -> 3 (M_out, Output) [t < t_max] : Output = M_out,
    7 -> 3 (i) [t = t_max]
7 -> 3 (Timeout) [t = t_max] : Timeout = TIMEOUT,
7 -> 3 (M_out, Output, Timeout) [t = t_max] :
    Output = M_out, Timeout = TIMEOUT,
8 -> 4 (M_out, Output) [t < t_max] : Output = M_out,
    8 -> 4 (i) [t = t_max]
8 -> 4 (Timeout) [t = t_max] : Timeout = TIMEOUT,
8 -> 4 (M_out, Output, Timeout) [t = t_max] :
    Output = M_out, Timeout = TIMEOUT,

3 -> 5 (Input_1, M_in) [buf_1 = 1] : t = 0, M_in = Input_1,
3 -> 5 (Input_1, M_in, M_out, Output) [buf_1 = 1] :
    t = 0, M_in = Input_1, Output = M_out,
2 -> 5 (Input_2, M_in) [buf_2 = 1] : t = 0, M_in = Input_2,
2 -> 5 (Input_2, M_in, M_out, Output) [buf_2 = 1] :
    t = 0, M_in = Input_2, Output = M_out,
4 -> 6 (Input_1, M_in) [buf_1 = 1] : t = 0, M_in = Input_1,
4 -> 6 (Input_1, M_in, M_out, Output) [buf_1 = 1] :
    t = 0, M_in = Input_1, Output = M_out,
4 -> 7 (Input_2, M_in) [buf_2 = 1] : t = 0, M_in = Input_2,
4 -> 7 (Input_2, M_in, M_out, Output) [buf_2 = 1] :
    t = 0, M_in = Input_2, Output = M_out,
3 -> 6 (i, Input_1, M_in) [buf_1 = 1] :
    t = 0, M_in = Input_1, buf_2 = B(1, p),
3 -> 6 (i, Input_1, M_in, M_out, Output) [buf_1 = 1] :
    t = 0, M_in = Input_1, buf_2 = B(1, p), Output = M_out,
2 -> 7 (i, Input_2, M_in) [buf_2 = 1] :
    t = 0, M_in = Input_2, buf_1 = B(1, p),
2 -> 7 (i, Input_2, M_in, M_out, Output) [buf_2 = 1] :
```

```
        t = 0, M_in = Input_2, buf_1 = B(1, p), Output = M_out
    4 -> 5 (Input_1, Input_2, M_in) [buf_1 = 1]: t = 0, M_in = Input_1
    4 -> 5 (Input_1, Input_2, M_in) [buf_2 = 1]: t = 0, M_in = Input_2
    4 -> 5 (Input_1, Input_2, M_in, M_out, Output) [buf_1 = 1]:
        t = 0, M_in = Input_1, Output = M_out,
    4 -> 5 (Input_1, Input_2, M_in, M_out, Output) [buf_2 = 1]:
        t = 0, M_in = Input_2, Output = M_out,
  ]
}
\end{verbatim}
```