4 Software engineering and data communications: an automatic laminating plant

4.1 Enviromental model

4.1.1 Context diagram [1]

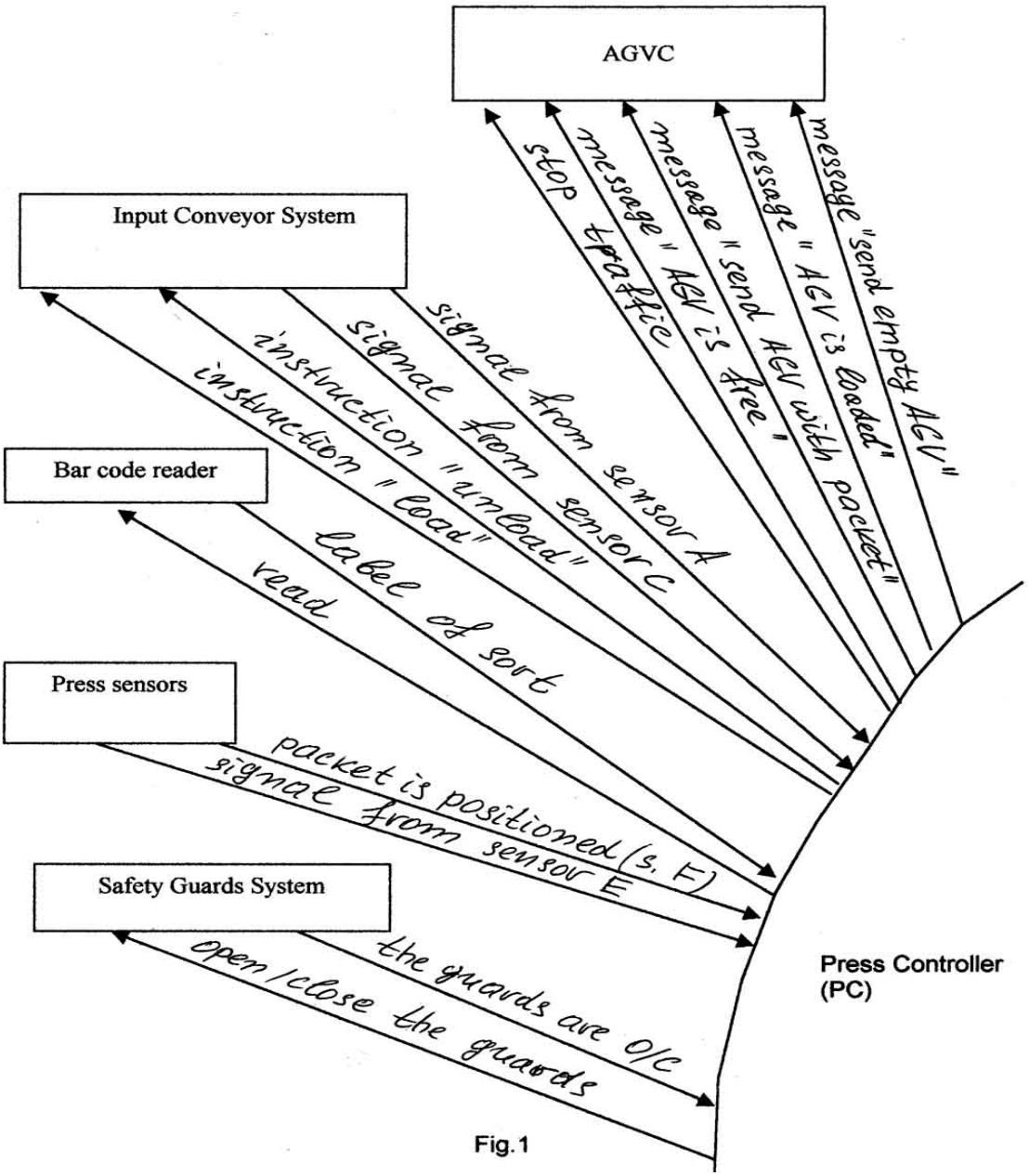
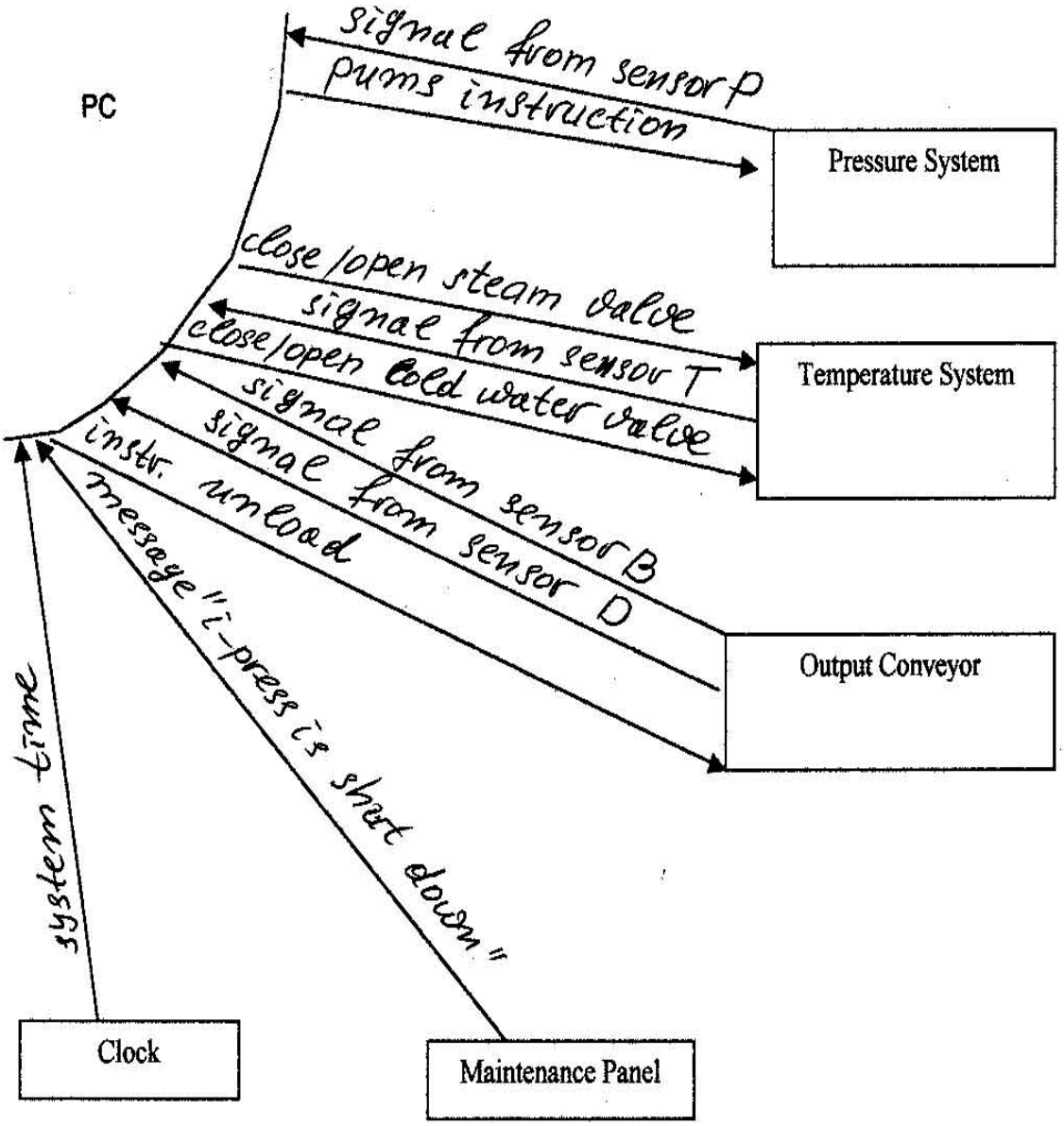


Fig.1



CONTEXT DIAGRAM – CONTINUATION

4.1.2 Event list for press controller (pc)

i-Input Conveyor's Viewpoint i=1,2,3,4		
1. Press works (press process enable)	Direct	C/D
2. conveyor is empty (request a AGV for conveyor)	Direct	D
3. AGV arrived (start a press packets unloading)	Direct	C
4. Press packet is on the conveyor (send a message to AGVC that AGV is free)	Direct	C

5. Press empty (instructs the conveyor to load the press pack and read a bar code)	Direct	C
Safety guards system Viewpoint		
1. Packet is correctly positioned (instructs to close the safety guars)	Direct	C/D
2. Platen's Temperature is normal (instructs to open the safety guars)	Indirect	C
Pressure Viewpoint		
1. Safety guards are closed (instructs to close the press platens and set the appropriate hydraulic pressure)	Direct	C
2. Pressure is setting (control and support the pressure duration of the bonding cycle)	Indirect	C
3. Cycle is over – timer (instructs to shut of the pressure)	Temporal	C
Temperature Viewpoint		
1. Safety guards are closed (Open a steam valve)	Direct	C
2. Temperature is setting (control of steam valve)	Indirect	C
3. Cycle is over – timer (instructs to shot of the steam valve and open cold water valve)	Temporal	C
4.Platen's temperature is normal (instructs to close water valve and open press platens and safety guards)	Indirect	C
i-Output Conveyor's Viewpoint i=1,2,3,4		
1. Safety guards are open (instructs to unloading a laminate)	Direct	C
2. Conveyor is empty (Instructs to unloading a laminate)	Direct	C
3. Laminate is on the conveyor (request a empty AGV)	Direct	C
4. AGV arrived (instructs to load the laminate on the AGV)	Direct	C
5. Laminate is on the AGV (message to AGVC)	Direct	C
Maintenance Viewpoint		
1. i – press shut down (send message to AGVC)	Direct	C
2. Laminate is on the output conveyor (send message to AGVC)	Direct	C
3. Press packet is on the input conveyor (send message to AGVC)	Direct	C

4.2 Behavioural model

The basic sub-systems include [2]:

1. Pack unloading control sub-system;
2. Pack loading control sub-system;
3. Laminate unloading control sub-system;
4. Safety guards control sub-system;
5. Pressure control sub-system;
6. Temperature control sub-system;
7. Traffic control sub-system;

The reason for introducing this particular distribution into the system is based on the design and functional purpose of controlled devices. The pressure and temperature control sub-systems are classical type feedback systems. The following sensor designations have been introduced for shortness in the above Figures:

A – "AGV with pack in position available at the input conveyor" sensor;
B – "empty AGV available at the output conveyor" sensor;
C – "pack in position on the input conveyor" sensor;

D – "laminate in position on the output conveyor" sensor;
E – "pack present into the press" sensor;
F – "pack positioning into the press" sensor;
T – thermocouple;
P – pressure sensor.

4.2.1 Low level data / control flow diagrams

Sub-System Controlling Laminate Press Pack Positioning On The Input Conveyor

The sub-system controlling laminate press pack positioning on the input conveyor receives signals from the following sensors and devices [2]:

- maintenance panel signal (press in use/out of use)
- sensor C (pack available/not available)
- sensor A (AGV available/not available)

The sub-system generates the following output signals:

- message to the AGV controller that AGV has been unloaded;
- instruction to unload pack from the AGV (this instruction is supplied to the AGV unloading drives)

The events that control the process are [3]:

- AGV arrival;
- Press operating condition;
- Pack positioned on the conveyor.

Figure 2 shows the data/control flow diagram.

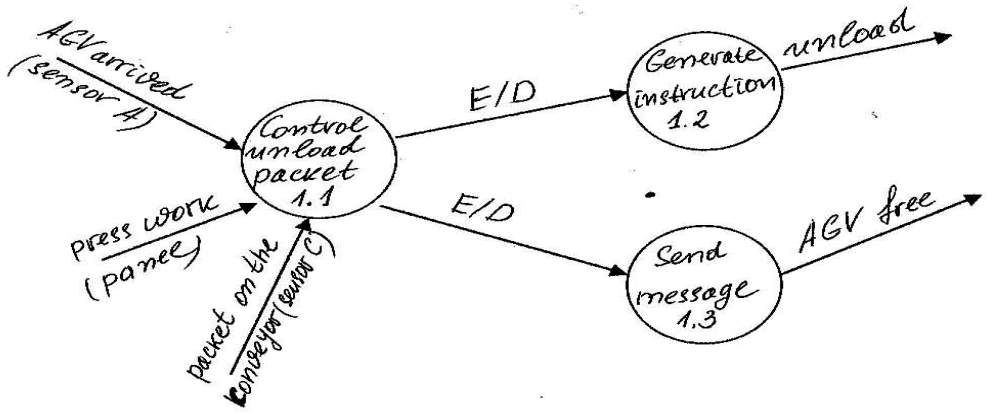


Figure 2

Sub-System Controlling Laminate Press Pack Positioning In The Press

The sub-system controlling the laminate press pack positioning in the press receives signals from the following sensors and devices [3]:

- maintenance panel signal (press in use/out of use);
- sensor C (pack available/not available);
- sensor E (pack available/not available);
- bar code identification on the pack.

The sub-system generates the following output signals [4]:

- message to the AGV controller to send an AGV loaded with press laminate packs;
- Instruction to load the pack from the conveyor into the press and simultaneously read the bar code information;

The stored data are the temperature, pressure and pressing time. The events controlling the process include [3]:

- press empty;
- press operating condition;
- conveyor empty.

Figure 3 shows the data/control flow diagram.

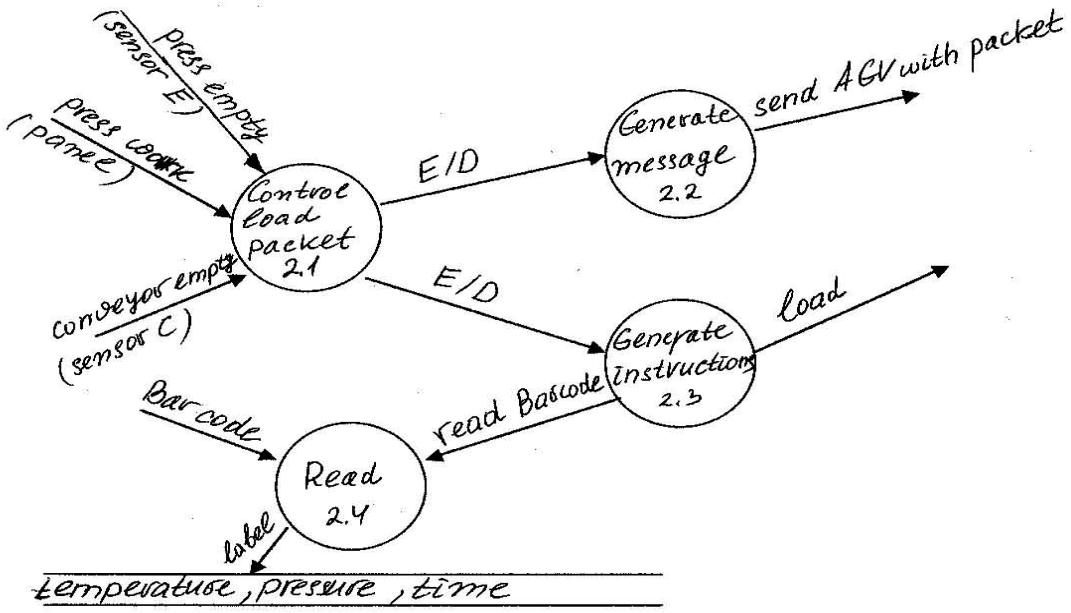


Figure 3

Safety Guards Control Sub-System

The safety guards control sub-system receives signals from the following sensors and sub-systems [5]:

- sensor F;
- temperature control sub-system ("shut safety guards" instruction);
- pack loading control sub-system ("shut safety guards" instruction);

The sub-system generates safety guards shut or open instructions. The event controlling the process is [4]:

- pack accurately positioned (sensor F).

Figure 4 shows the data/control flow diagram.

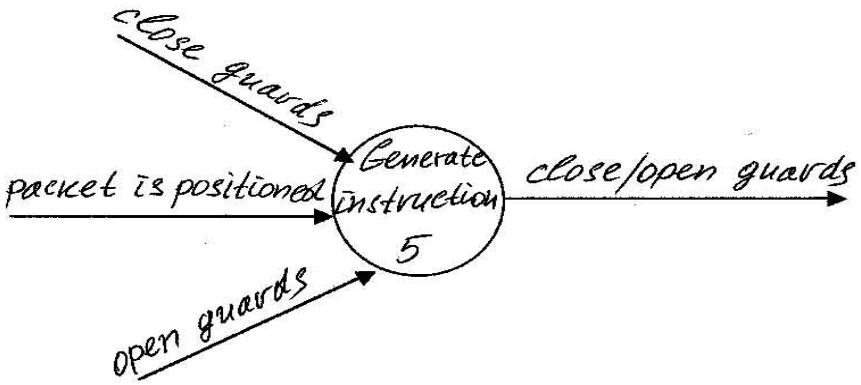


Figure 4

Temperature Control Sub-System

The Temperature control sub-system receives signals from the following sensors and sub-systems [4]:

- sensor T;
- sub-system controlling loading of press packs into the press required press temperature, down temperature and press time);
- system time timer

The sub-system generates the following output signals [4]:

- steam valve open/shut off instruction
- cold water valve open/shut off instruction;
- safety guards open instruction.

The events involved in the control of the process are [4]:

- safety guards closed;
- required temperature is reached;
- required pressing time is complete;
- platen temperature is low;

Figure 5 shows the data/control flow diagram.

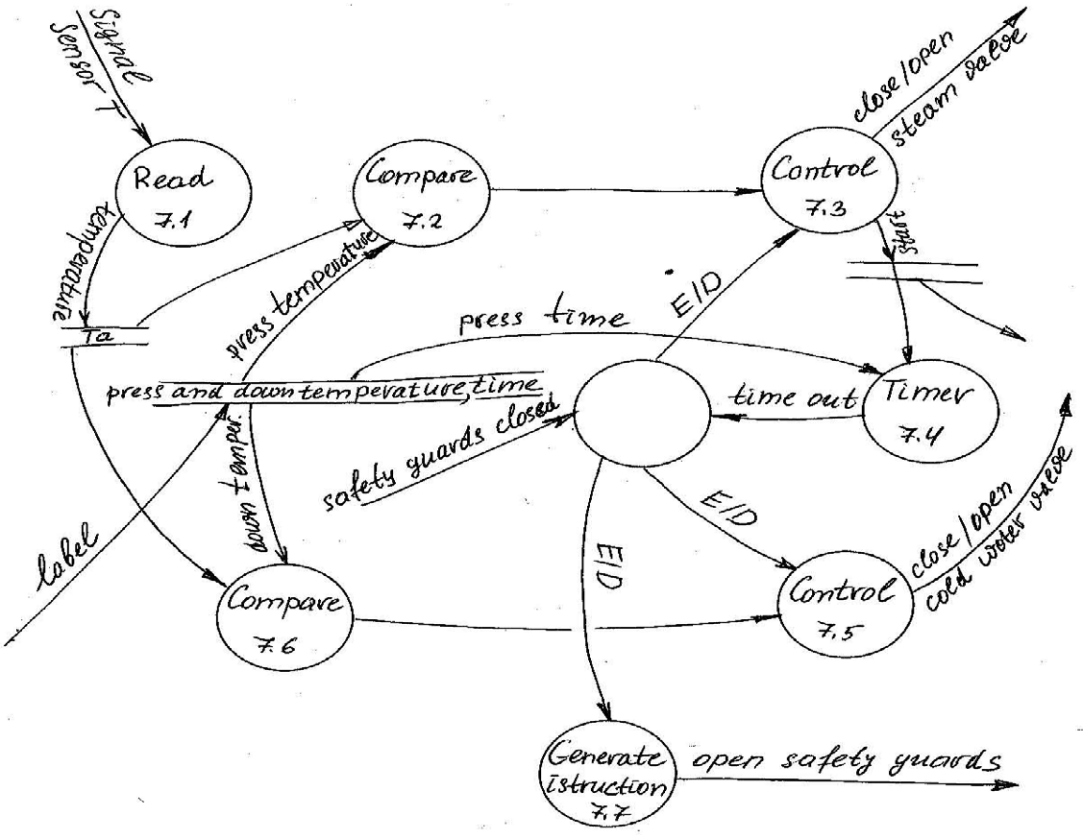


Figure 5

Pressure Control Sub-System

The pressure control sub-system receives signals from the following sensors and devices [5]:

- signal from sensor P;
- process start signal from the temperature control sub-system;
- bar code reader indication (pressure and time).

The sub-system generates the following signals [5]:

- pump control instruction;

Figure 6 shows the data/control flow diagram.

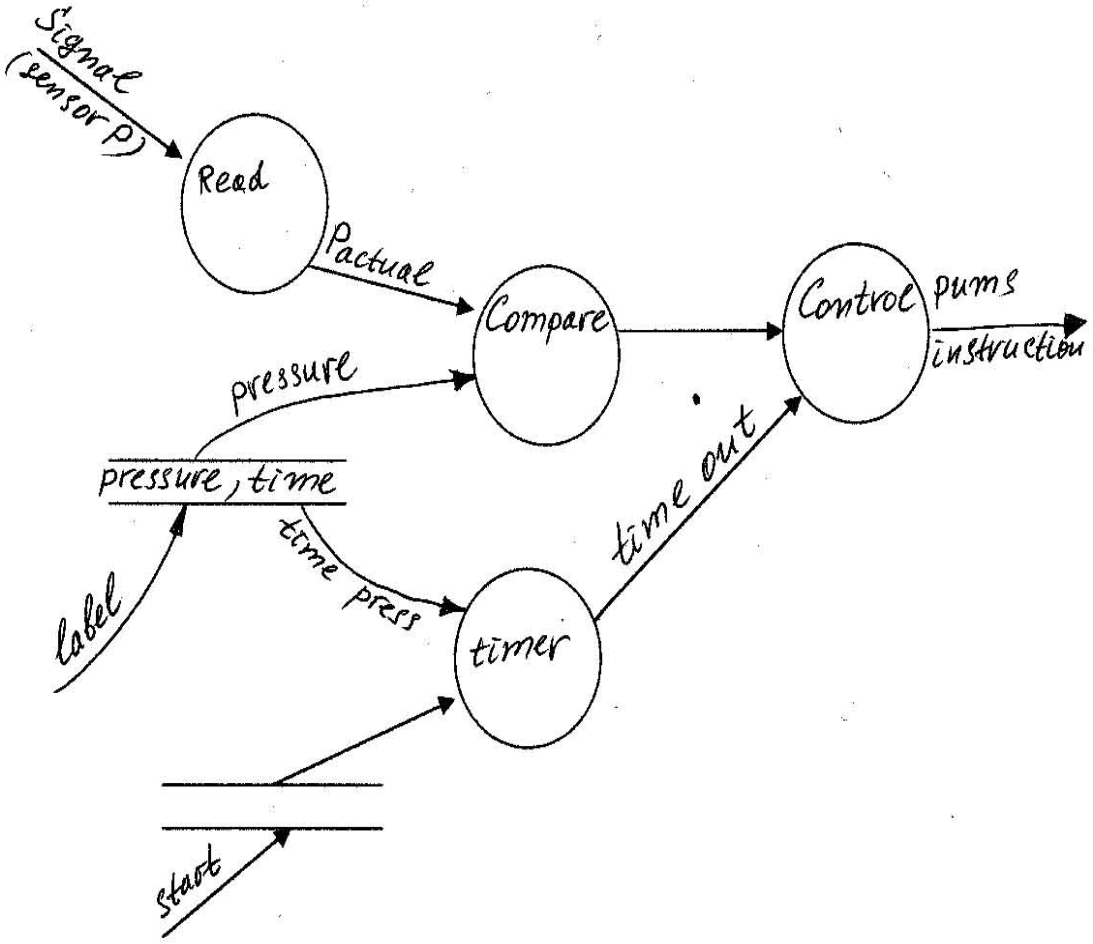


Figure 6

AGV Traffic Control Sub-System During Maintenance Shutdowns

The AGV traffic control sub-system receives signals from the following sensors and devices [4]:

- signal from the maintenance panel (press in use/out of use);
- sensor A (a pack is in position/not available in the input conveyor);
- sensor B (a pack is in position/not available in the output conveyor).

The sub-system generates the following output signals [5]:

- message to the AGV controller to stop the AGV traffic
- message to send an empty AGV to carry away other packs left on the conveyors of presses which are out of use;

Figure 7 shows the data/control flow diagram.

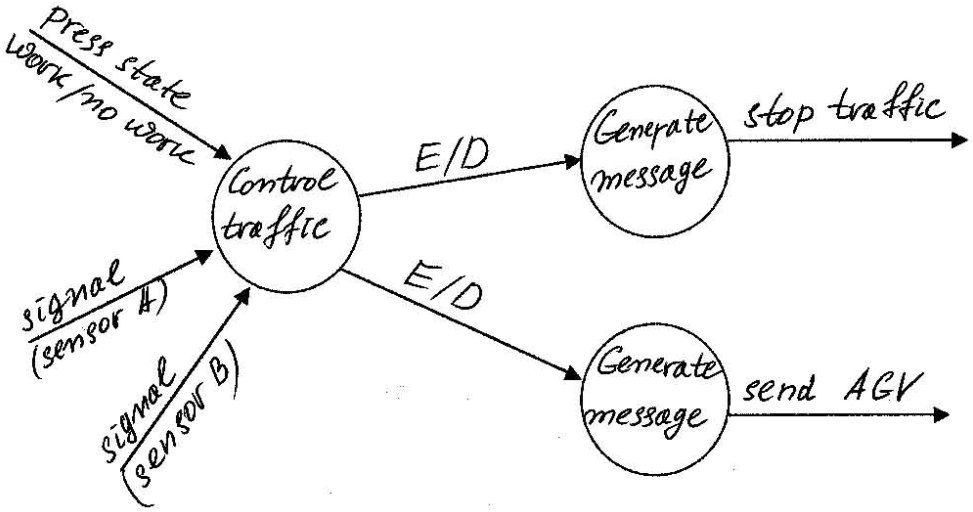


Figure 7

Laminate Unloading Control Sub-System

The laminate unloading control sub-system receives signals from the following sensors and devices [5]:

- "laminate in position on the conveyor" signal from sensor D;
- sensor B (AGV available in position by the output conveyor).

The sub-system generates the following output signals [6]:

- laminate load instruction;
- "AGV loaded" message to the AGV controller

The event which controls the process is "safety guards opened" [6]. Figure 8 shows the data/control flow diagram.

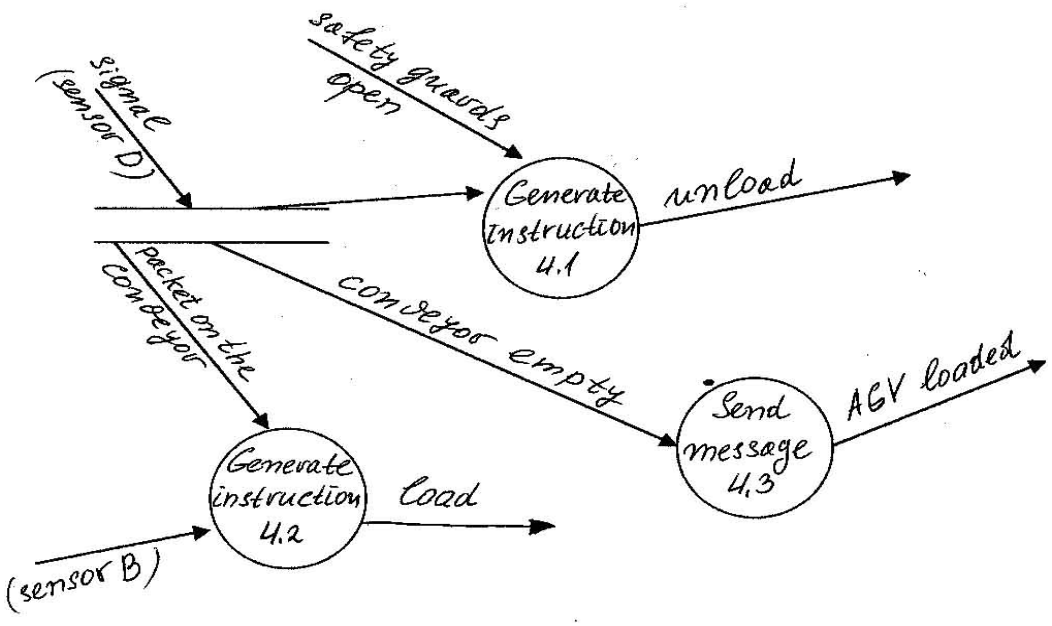


Figure 8

4.2.2 Low level state transition diagrams

Sub-System Controlling Laminate Press Pack Positioning On The Input Conveyor [7]

Figure 9 shows the state transition diagram.

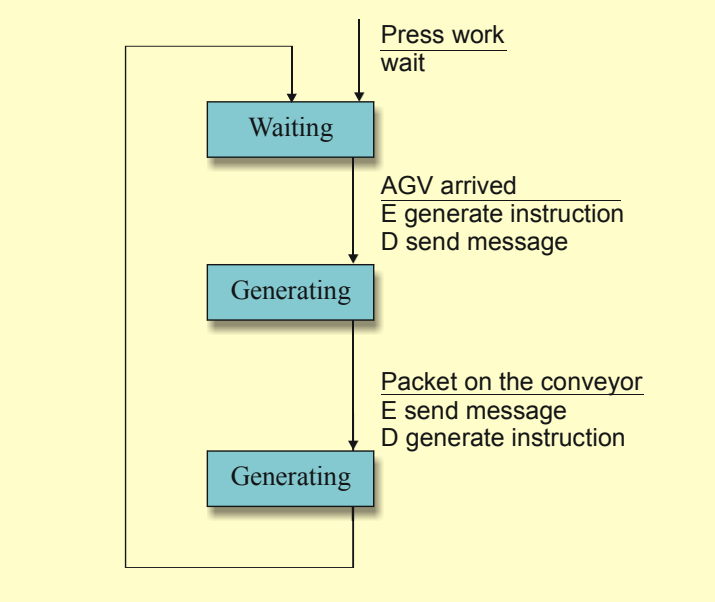


Figure 9

Sub-System Controlling Laminate Press Pack Positioning In The Press

Figure 10 shows the state transition diagram [7].

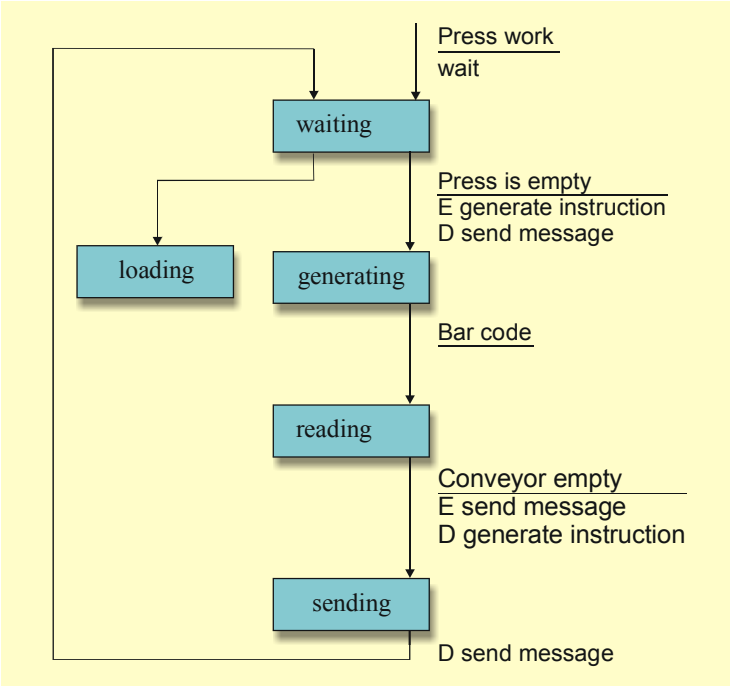


Figure 10

Safety Guards Control Sub-System

Figure 11 shows the state transition diagram [7].

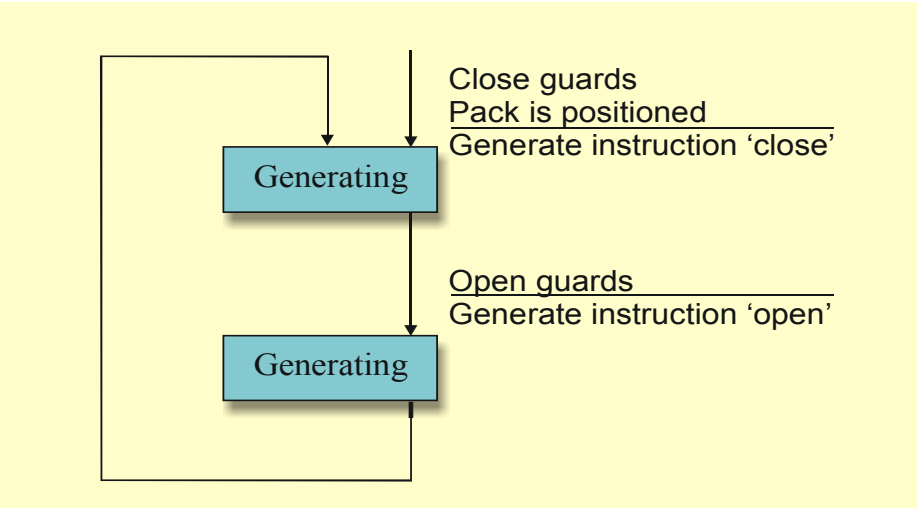


Figure 11

Temperature Control Sub-System

The state transition diagram is shown in Figure 12 [8].

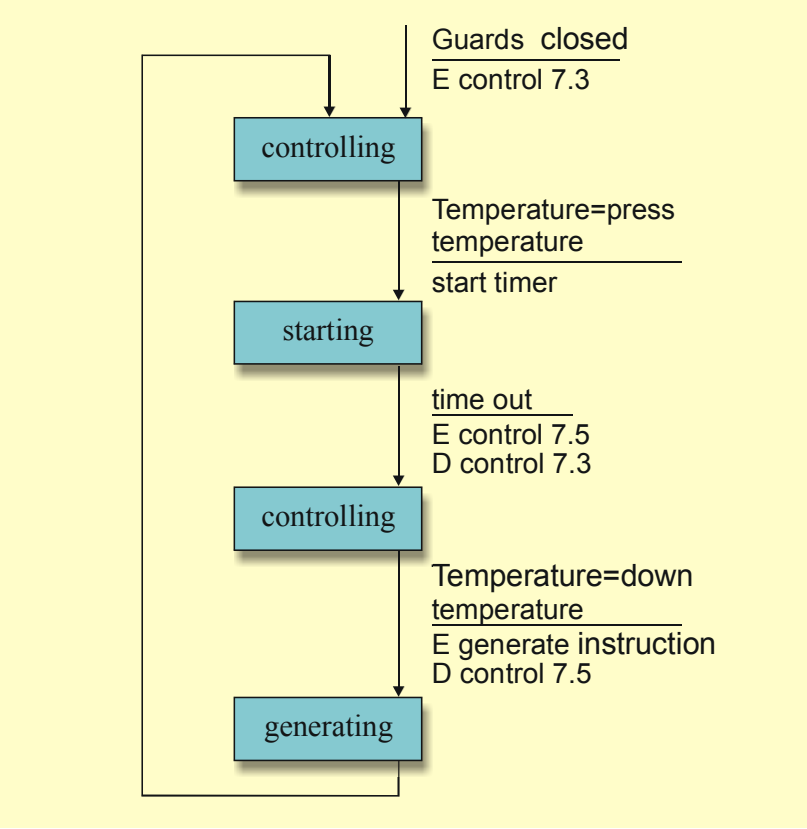


Figure 12

Pressure Control Sub-System

Figure 13 shows the State transition diagram [8].

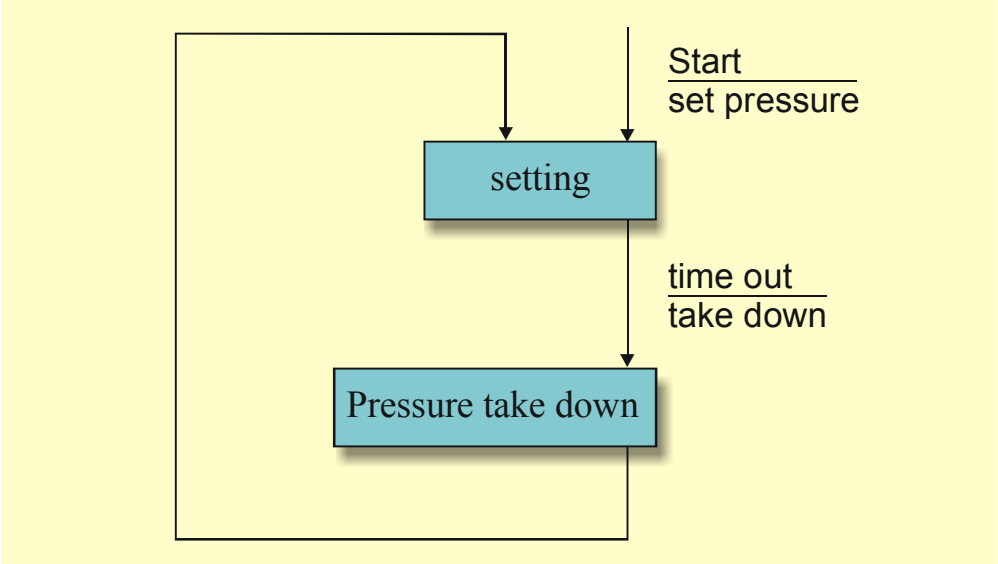


Figure 13

AGV TRAFFIC Control Sub-System During Maintenance Shutdowns

Figure 14 shows the state transition diagram [9].

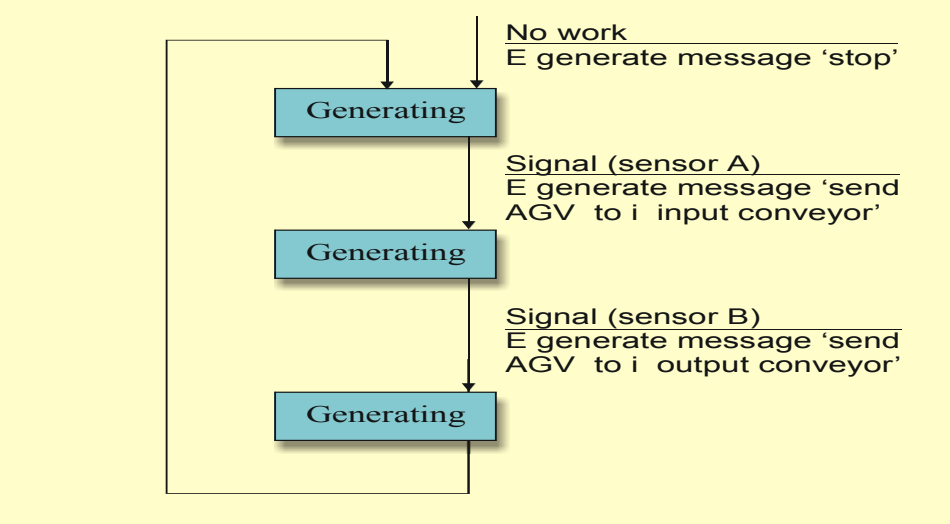


Figure 14

Laminate Unloading Control Sub-System

Figure 15 shows the state transition diagram [10].

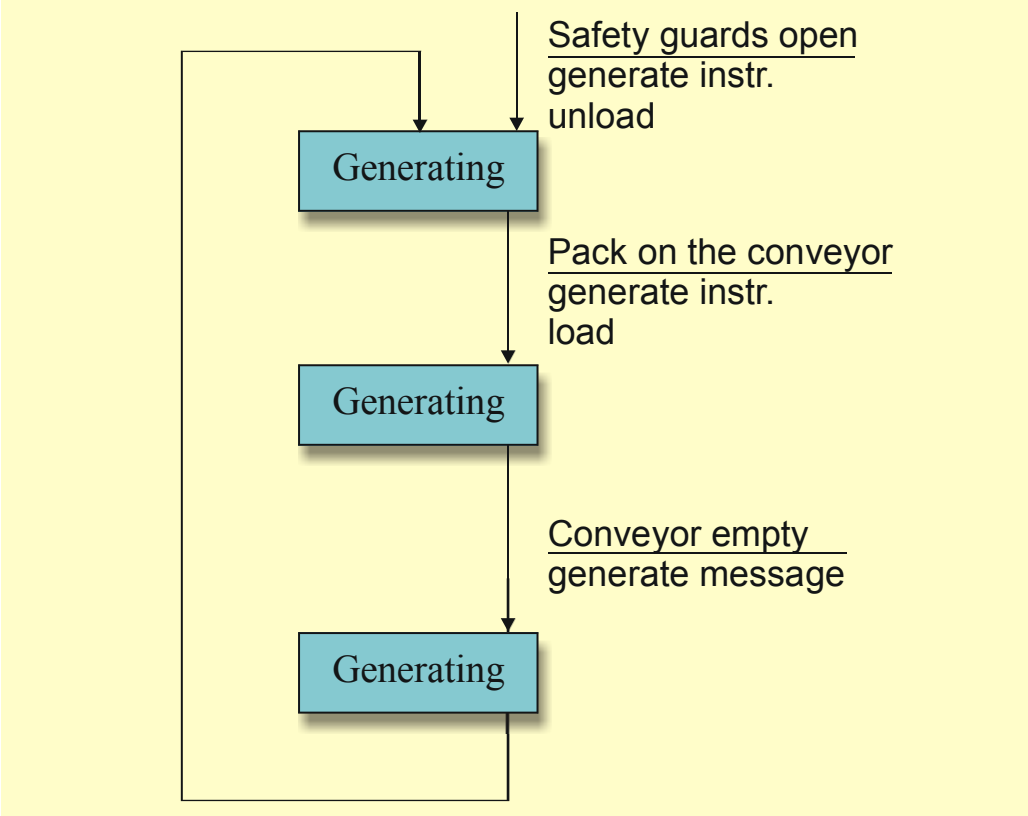


Figure 15

4.2.3 Top level data/control flow diagram [10]

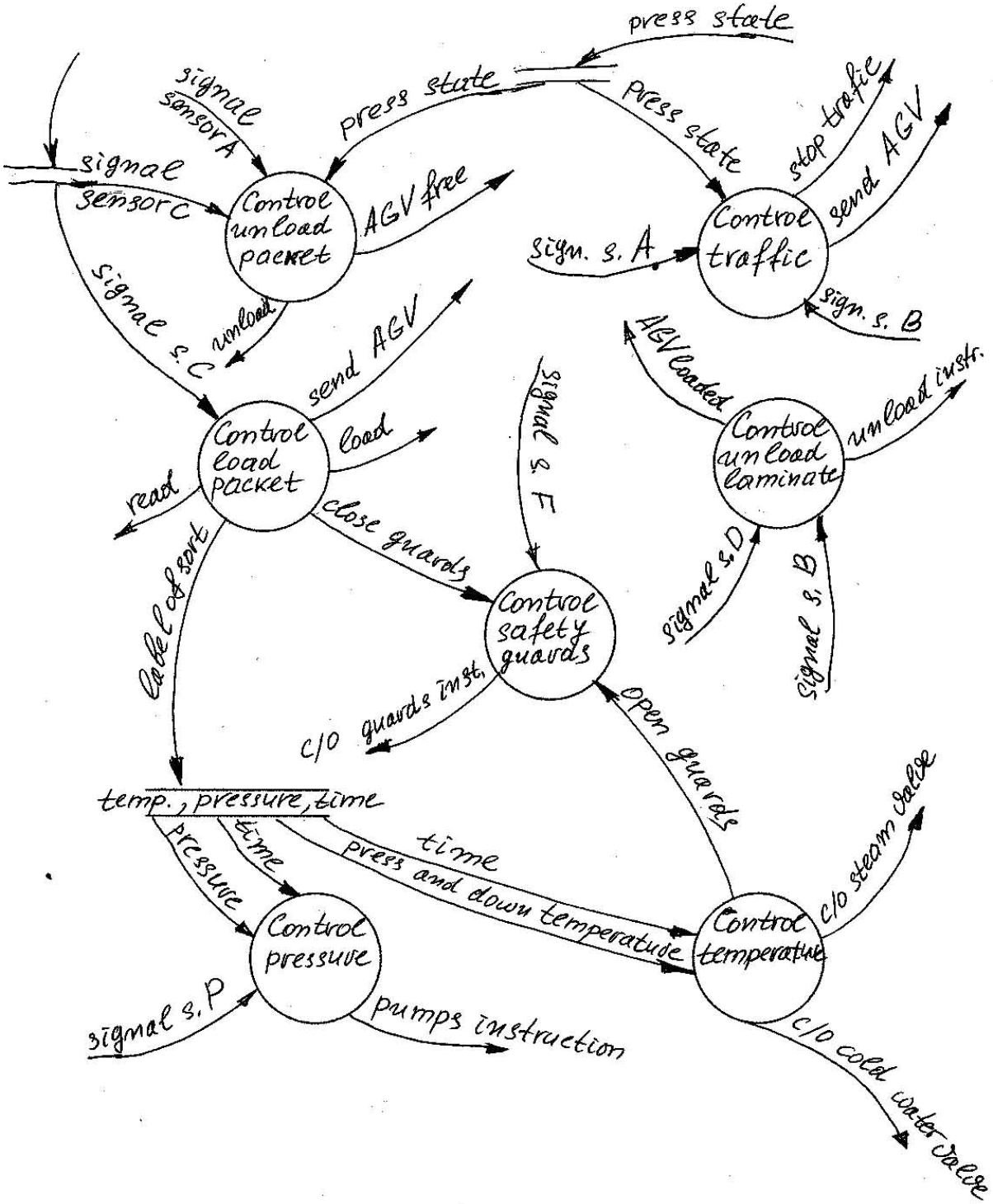


Figure 16

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