Design and PLC Realization of Elevator Control Based on LOOK Algorithm

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Abstract. The LOOK algorithm is widely used in disk scheduling algorithms for its short seek path. Because its dispatching presents the corresponding characteristics of one-way priority and is similar to the elevator dispatching process, the LOOK algorithm is used to realize elevator dispatching. Through PLC logic operation, the elevator can run stably and efficiently with LOOK algorithm. At the same time, it can reduce the average riding and waiting time of passengers, and improve the operation efficiency of elevator.

1. Introduction
With the continuous development of society, there are more and more high buildings, and elevators can be seen everywhere in high-rise buildings. How to respond the passenger calls efficiently, reduce the average ride and waiting time of passengers and improve elevator operation efficiency has always been optimized constantly. The LOOK algorithm is widely used in disk scheduling algorithms for its short seek path. Because there are similarities between its seek method and elevator dispatching, and PLC is widely used in production and life with its high stability. So PLC is used to realize LOOK algorithm to control elevators.

2. Introduction to LOOK algorithm
The LOOK algorithm is a kind of disk scheduling algorithm, which is optimized on the basis of the SCAN algorithm. Assuming the magnetic head is on the outer track. The LOOK algorithm scanning process is that the magnetic head first scans from the outside to the inside in one direction. During the scanning process, the sequence of requests for services is accessed sequentially. When magnetic head scans to the innermost layer service sequence, it scans from the inside to the outside in the reverse direction.

For example, the tracks requested to be accessed are number 98, 137, 122, 14, 133, 65, 78. The magnetic head is at track No. 100 and scans from outside to inside, the innermost layer is track No.0. The scanning sequence is shown in Figure 1:
As shown in Figure 1, the magnetic head starts from track No. 100 and sequentially accesses the tracks which numbers are less than 100 from the outside to the inside. When the last track No. 14 of the requested track is accessed, it will no longer reach the innermost track No. 0. Then the magnetic head reverses direction from inside to the outside in, and continues to visit other requested tracks in sequence. That is, the order of access is 98, 78, 65, 14, 122, 133, 137.

In this way, the moving path of the magnetic head is short and the response speed is fast. And there are many similarities between the access route and the elevator dispatching, so this method is applied to the elevator dispatching and implemented by PLC.

3. Algorithm Design
Take a single 10-floor elevator as an example. According to elevator scheduling requirements, establish up-call unit, down-call unit, internal-call unit, floor unit, and stop unit. Each unit uses a word address of PLC. The 0th to 9th bits of each unit represent the corresponding signals of the call floor.

3.1. Call unit establishment

3.1.1. The establishment of up-call unit
The up-call unit is used to count the up-call signals of the current out call signals. There are 9 up-call signals in a single 10-floor elevator from the 1st floor to the 9th floor. So 9 bit address of PLC are required to indicate whether there is an up-call signal. If there is an up-call signal, the corresponding bit sets 1. On the contrary, the corresponding bit sets 0. The word address unit MW0 is used to establish the up-call unit, and the 0th to 8th bits represent the up-call signals from the 1st floor to the 9th floor. For example, assuming that there are up-call signals on the 1st, 3rd, 4th, 5th, and 9th floor, then:

\[ MW0 = 2^{10}0000000100011101 \]  \tag{1}

3.1.2. The establishment of the down-call unit
The down-call unit is used to count the down-call signals of the current out call signals. There are 9 up-call signals in a single 10-floor elevator from the 2nd floor to the 10th floor. So 9 bit address of PLC are required to indicate whether there is an down-call signal. If there is an down-call signal, the corresponding bit sets 1. On the contrary, the corresponding bit sets 0. The word address unit MW2 is used to establish the down-call unit, and the 1st to 9th bits represent the down-call signals from the 2nd floor to the 10th floor. For example, assuming that there are down-call signals on the 2nd, 3rd, 4th, 5th, and 10th floor, then:

\[ MW2 = 2^{10}000000100011110 \]  \tag{2}

3.1.3. The establishment of the internal-call unit
The internal-call unit is used to count the internal-call signals in the elevator. There are 10 internal-call signals in a single 10-floor elevator from the 1st floor to the 10th floor. Similar to the establishment of
up-call unit and down-call unit, the word address unit MW4 is used to establish internal-call unit. The 0th to 9th bits represent the internal-call signals from the 1st floor to the 10th floor. For example, assuming that there are internal-call signals on the 1st, 2nd, 5th, 8th, and 10th floor, then:

\[
MW4=2^00000010 10010011
\]  
(3)

3.1.4. The establishment of the floor unit

The floor unit is used to indicate the current floor where the car is running. The word address unit MW6 is used to establish floor unit. When the car reaches the floor, the corresponding bit is set 1. For example, if the car reaches the 3rd floor, then:

\[
MW6=2^00000000 00000100
\]  
(4)

3.1.5. The establishment of the stop unit

The stop unit is used to judge whether the car needs to stop at the current floor. This unit is obtained by calculation. The word address unit MW8 is used to establish stop unit. Do the AND operation between MW0 or MW2 and MW6, MW4 and MW6. Put the result in the unit MW8 and MW10 respectively, then:

\[
MW8=\text{MW0 (or MW2) } \& \text{MW6}
\]

\[
MW10=\text{MW4 } \& \text{MW6}
\]

(5)  
(6)

3.2. Algorithm implementation

Assuming that the car is on the 1st floor, the generated call signal is shown in Table 1:

| Call floor | Call signal                  |
|------------|------------------------------|
| 2nd Floor  | Up-call, down-call, internal-call |
| 3rd Floor  | Down-call                    |
| 4th floor  | Up-call                      |
| 8th floor  | Up-call, down-call, internal-call |
| 9th floor  | Down-call                    |

According to the described above and the call signal in Table 1, establish the initial call units which are shown in Table 2

| Address unit          | Binary value                     |
|-----------------------|----------------------------------|
| Up-call unit MW0      | 00000000 10001010                |
| Down-call unit MW2    | 00000001 10000110                |
| Internal-call unit MW4| 00000001 00000010                |
| Floor unit MW6        | 00000000 00000001                |
| Internal-call stop unit MW8 | /                           |
| Outbound-call unit MW10| /                             |

First judge the elevator running direction. Use the up-call unit, down-call unit, and internal-call unit to subtract the floor unit in turn. If the result is greater than 0, the elevator goes up. And if it is less
than 0, the elevator goes down. In the above mentioned call, since MW0-MW6, MW2-MW6, and MW4-MW6 are all greater than 0, it is judged that the elevator goes up.

Secondly, judge the elevator response signal. According to the LOOK algorithm, the signal that the elevator responds has nothing to do with the sequence of signal generation. It is only respond from low to high according to the position of the call signal in order to reduce the no-load running of the elevator, save the running distance of the elevator and also improve the response speed. Because the direction of the elevator is upward, the elevator does not respond to the down-call signal, but only responds to the up-call and internal-call signals. At the same time, for floors without call signals, although the elevator passes by, it does not respond to a stop. So when the car moves up to the 2nd floor, first shift the floor unit MW6 left 1 bit, that is, turn the unit MW6 to 2#00000000 00000010. Then do the AND operation with the internal-call unit and the up-call unit respectively. If one of MW8 or MW10 is not 0, a stop response is required, then:

\[
MW8 = MW4 \land MW6 = 2#00000000 00000010 \tag{7}
\]
\[
MW10 = MW0 \land MW6 = 2#00000000 00000010 \tag{8}
\]

Since both MW8 and MW10 are greater than 0, the car stops and responds to the up signal of the 2nd floor and 2nd floor calls. As the elevator car continues to go up, when it reaches the 3rd floor, it still only judges whether there are up-call and internal-call signals according to the elevator running direction. At this time, the floor table MW6=2#00000000 00000100, then

\[
MW8 = MW4 \land MW6 = 2#00000000 00000000 \tag{9}
\]
\[
MW10 = MW0 \land MW6 = 2#00000000 00000000 \tag{10}
\]

Since both MW8 and MW10 are equal to 0, the car only passes through 3 floors and does not respond to stop. And so on, until the elevator car responds to the 8th floor up-call and internal-call signals.

After the car reaches the 8th floor and responds to the up-call and internal-call signals, since there are no other up-call and internal-call signals, it should respond to the down-call signal. But at this time, there are down-call signals on the upper and lower sides of the car, and the elevator runs in the upward direction before responding. Therefore, first determine whether there is an up-call signal higher than the floor of the current car. That is, subtract the floor unit from the next call unit MW2. At this time, the result is greater than 0, the elevator should continue to run in the upward direction and respond to the down-call signal of the highest floor. Then reverse the elevator running direction, and eliminate the down-call and internal-call signals of each floor in turn.

4. Software design

According to the design of the algorithm and the characteristics of elevator operation, the software design of the PLC elevator control based on the LOOK algorithm is shown in Figure 2:
Is the call signal higher than the current floor?

Yes

- Elevator goes up
  - Shift the floor unit left 1 bit
  - Do "AND" operation between floor unit and up-call unit or internal-call unit

No

- Elevator goes down
  - Shift the floor unit right 1 bit
  - Do "AND" operation between floor unit and down-call unit or internal-call unit

Is the stop unit greater than 0?

Yes

- Elevator stops and eliminates response signal

No

Figure 2. The flow chart of elevator control based on LOOK algorithm

When the car stops at a certain floor, first determine the up and down direction of the car according to the call signals and the position of the car. Dispatching the elevator goes up or down.

Secondly, as the elevator runs to the next floor, Do "AND" operation between the floor unit and internal-call unit, the up-call unit or the down-call unit respectively to obtain the result of stop unit. If the stop unit is 0, the elevator continues to run. If the stop unit is greater than 0, then respond the signal at the current floor, that is, the car stops and eliminates the corresponding call signal.

After completing the response, the above process is repeated continuously until the elevator reaches the highest floor in the direction. Then the elevator will reverse the direction and respond the opposite direction based on the judgment between the call signal and the current floor.

5. Summary

It can be seen that during the running process of the elevator, the no-load running only exists when it picks up the first passenger by using the LOOK algorithm to dispatch elevators. The number of no-load operations of the elevator is reduced, and the running efficiency of the elevator is improved. Because of it the average waiting time of passengers is reduced. In addition, using PLC to control elevator dispatching has highly stability and easy to implement.

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