Stability of the SpaceWire network's time-code mechanism to various failure types

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Introduction

The time-code mechanism uses for synchronization of SpaceWire networks components.

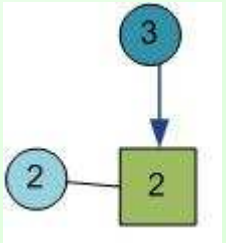
There are a special auxiliary characters which are used in the time-code mechanism. Its name is Time-codes. The Time-codes are a message with highest priority, that allows them to pass through a network with minimum delays, even under strong congestion.

For Time-code are using 6 bits, that allows to encode 64 different values (from 0 to 63).

Time-code source is a terminal node (source-node).

After sending Time-codes in network, devices which will received them, should handle them.

Sending Time-codes is broadcasted.

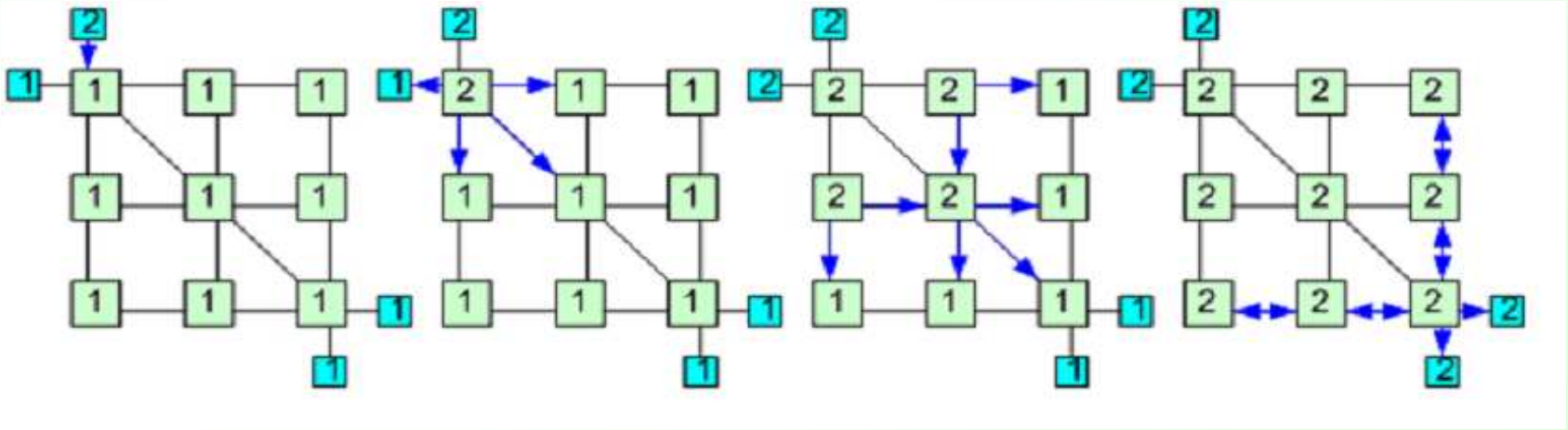


Time-code Mechanism

When device receives a Time-code, it compares new value with old. If new value is correct (value greater than 1), the device should write it over the old value and broadcast this Time-code further in network.

Each device which is accepting Time-code, should pass it to all ports, besides the port through which it are received.

If new Time-code value is not correct (value greater more than 1 or less old value), then device rewrites value of Time-code in itself, but doesn't broadcast it further in network.



Failure types

There are 3 possible type of error in Time-code mechanism:

1. Loss Time-code
2. Not expected apperance of Time-code
3. Apperance Second Time-code source

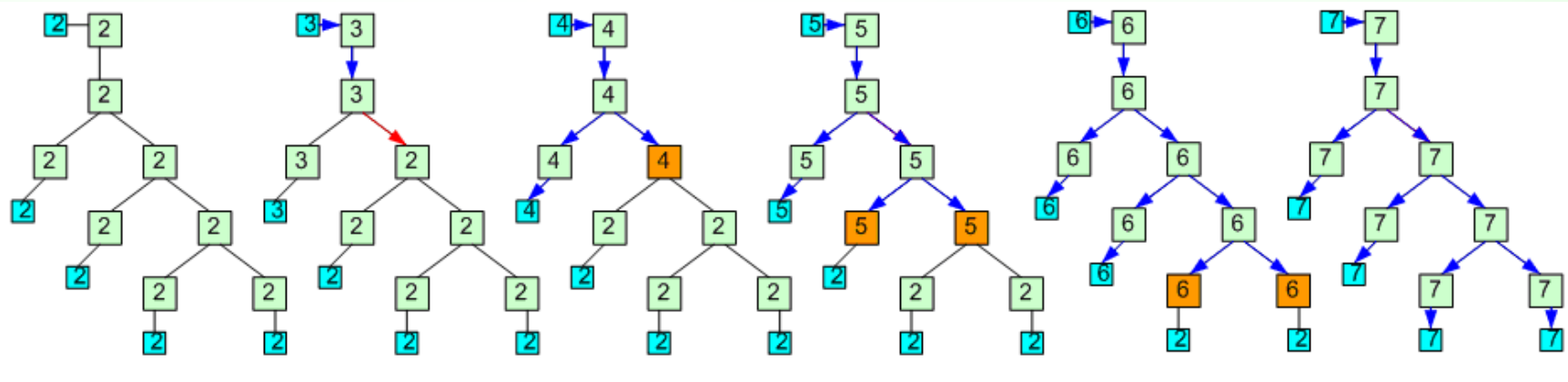
Let's consider these errors and parameters in more details for determine the time of restoring after failure.

Loss Time-code

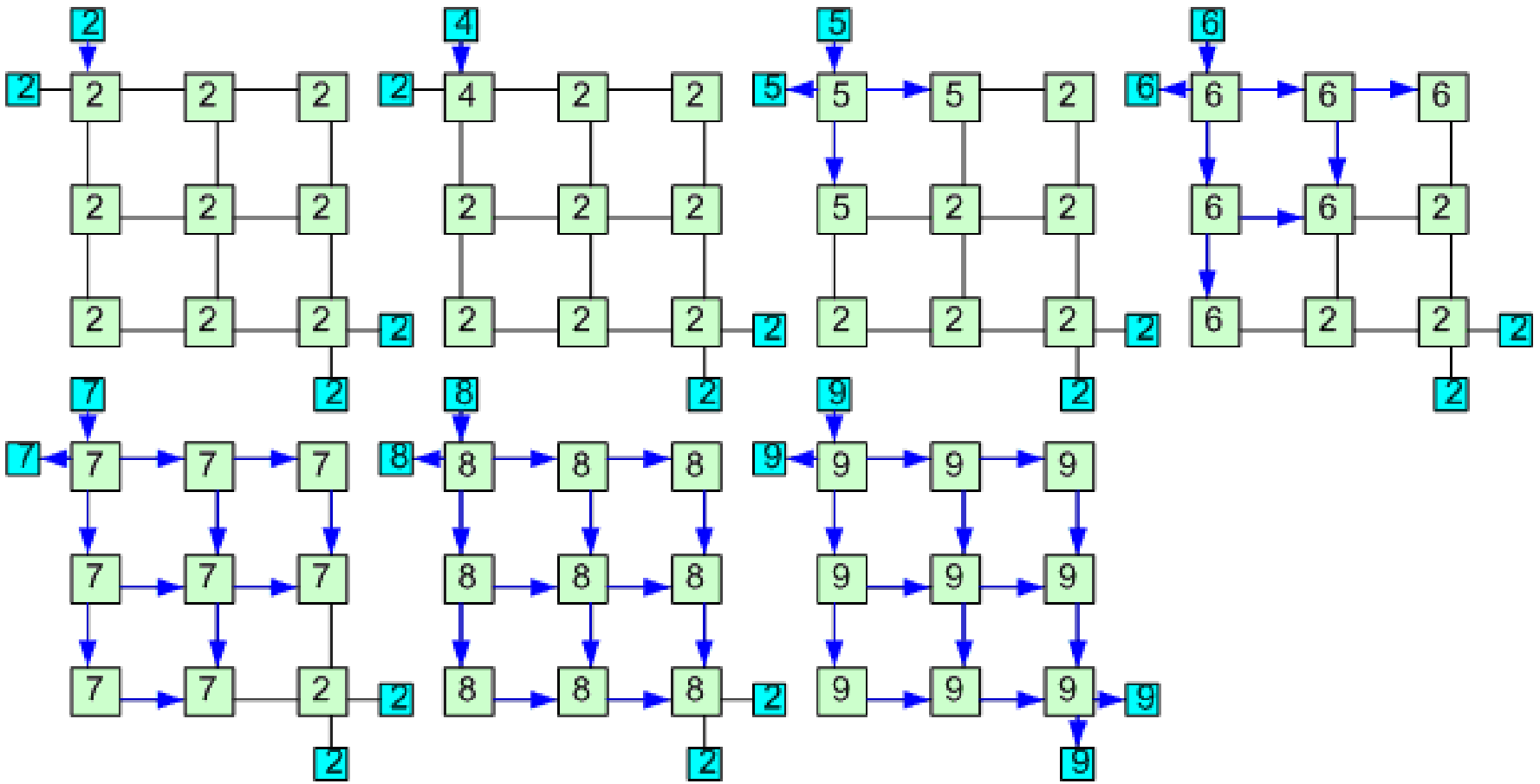
Loss of Time-code can be the result of transmission failure on data link.

Loss of Time-code leads to the following results:

- is temporarily disrupting mechanism of time-codes transmission
- the subsequent devices will receive an invalid value.

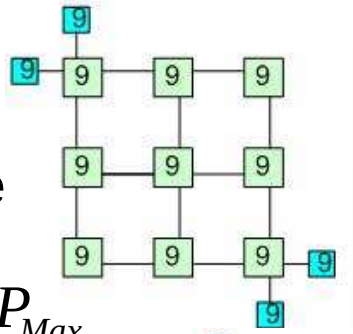


Example of time-code loss

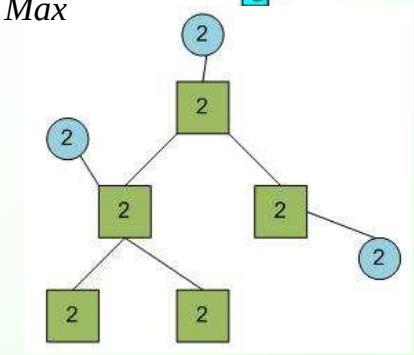


Loss of Time-code parameters

All parametres depend on structure of a network, a speed and a length of information transfer channel.



After loss Time-code it is necessary to send quantity of time codes equal quantity of transitions of the shortest path from the source-node to most remote from it node. $N_{tc} = P_{Max}$

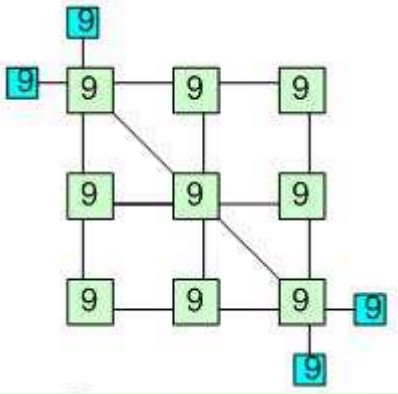


System restoring time will be:

$$T_{re\,\mathrm{cov}\,ery} = (N_{tc} - 1) * T_{gener} + P_{Max} * T_{trans},$$

T_{gener} - the period of generation Time-codes

T_{trans} - time of passing a signal between devices.

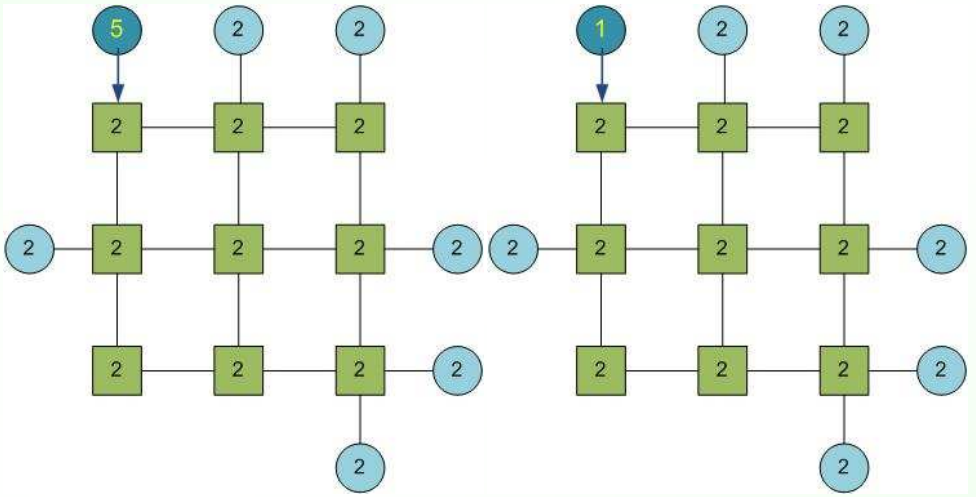


Number of necessary to sending the codes is reduced by adding to the topology of the network of additional links, which reduced the shortest path from the source-node to most remote from it node. $N_{tc} = P_{Max} - K$, where K – a value of reduced path.

Not expected time-code

There are two types of codes which not expected:

- The value greater than expected
- The value less than expected



The value less than expected can appear after an error in the time-code source, after signal distortion of transmission through a data link.

The code greater than expected can appear after an error in the time-code source, after signal distortion of transmission through a data link or after loss signal in transfer (then a expected signal greater than 1).

If device receives not expected time-code (it is greater or less expected code) is the same situation with the loss time-code.

The number of correct time-codes which is necessary for sending after recieving of an invalid code is Ntc=PMax.

Apperance a Second Time-code source

The reason of this error is the node, which was started broadcast time-codes, without being the main source-node in a network.

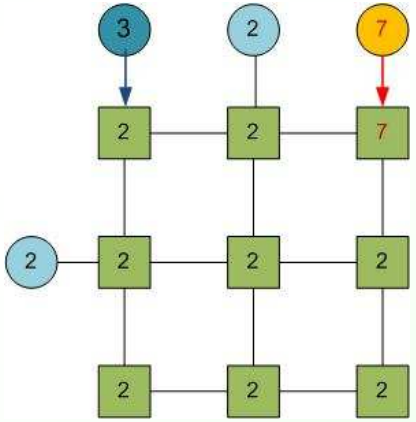
In this case we have two waves of time-codes spread which aimed each other.

There are 2 possible versions:

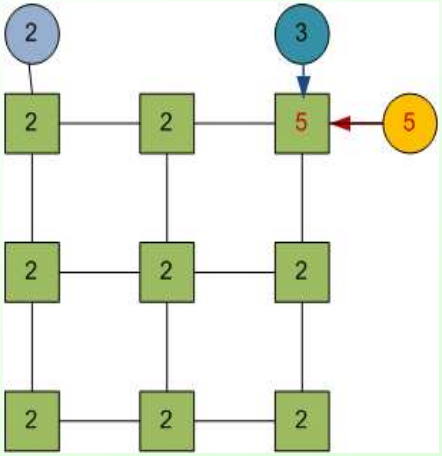
1. The second source refers time-code once.
2. The second source refers time-code permanently.

Restoring after an error «Appearance second source refers time-code once»

- In case of appearance the second source of time-codes (device) at grid topology type it is necessary to transmit 2 valid codes for restoring system.

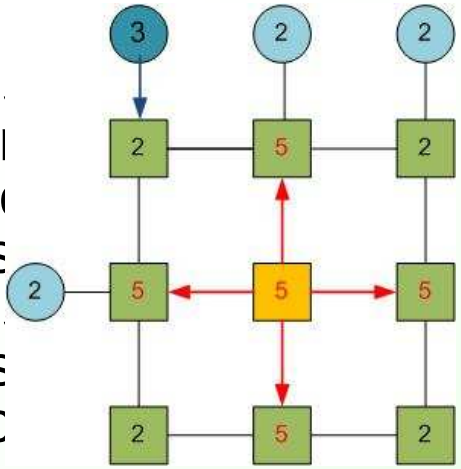


- In a case if source #1 and a source #2 are connected to one router the task is reduced to restoring after recieving not expected time-code. Ntc=PMax.

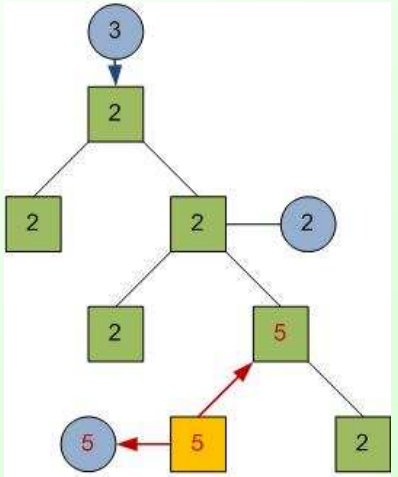


Restoring after an error «Appearance second source refers time-code once»

- In a case if the second source of time-codes i the router, duration of restoring depends o presence additional links, which reduced th shortest path from the source-node to mos remote from it node, and number of the node which are linked to the given device. At wors this task reduced to restoring after reception c not expected time-code. Ntc=PMax.

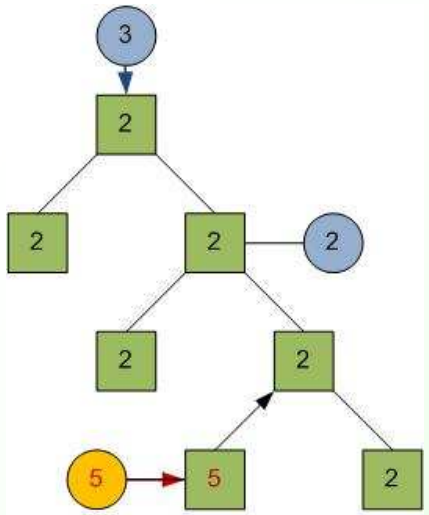


- At the tree type topology problem is reduced to the task of not expected code appearance. In this case PMax will be equal to path from the last node containing a correct time-code, to the node most remote from it.

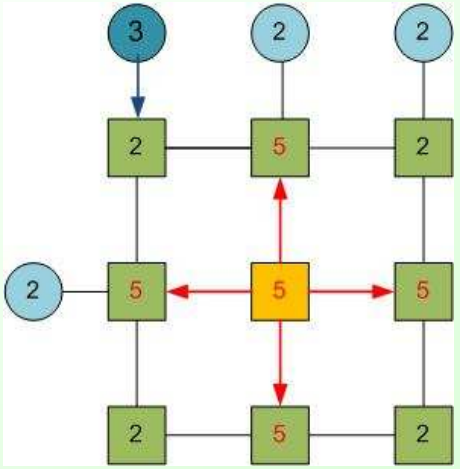


Restoring after an error «Appearance second source refers time-code permanently»

If the second source of time codes – the terminal node, then the device and the router to which it is connected stopped to work normally in a network



If the second source of time codes – the router, working capacity of a network can be completely broken, or all devices connected to the router are out of operation output. It depends on the wave of time codes will pass on a network the first - true or incorrect.



Conclusion

Then higher the connectivity of the network then faster it recovers from transmission erroneous time-codes.

Thank you