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Design of Onboard Local Area Networks

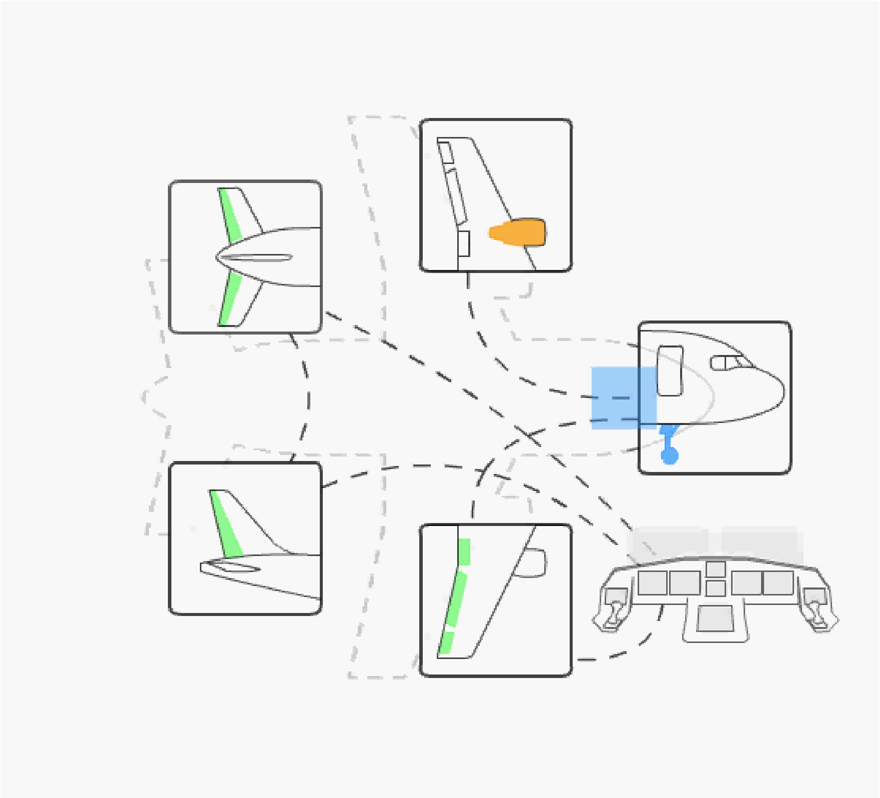
*Pakharev Sergey, Elena Suvorova, **Alexey Syschikov***

{sergey.pakharev, suvorova, alexey.syschikov}@guap.ru

What is BLAN?

BLAN (on-Board Local Area Network) – a kind of local area network that is used in aircrafts and spacecrafts to communicate devices: sensors, control systems, actuators etc.

The network is constructed from terminal nodes (on-board devices) network switches and network channels.

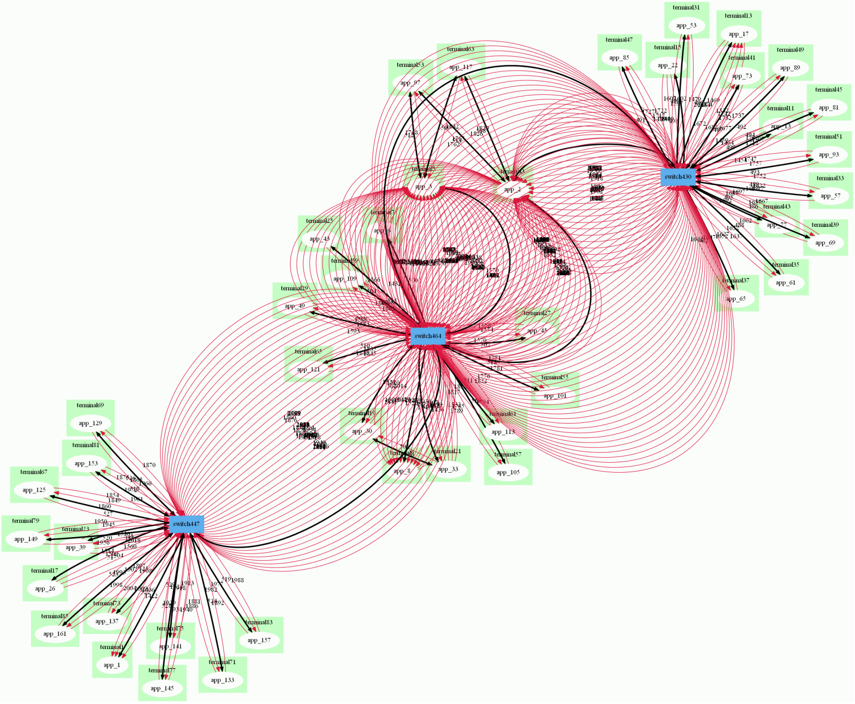


Problems, officer?

Modern on-board solutions is a large size networks with hundreds of nodes

It’s nearly impossible to design it manually

Engineers and designers need tool for automated design of on-board local area networks with optimal structures and characteristics according to user requirements and constraints



43 nodes
128 channels

What profit brings the solution?

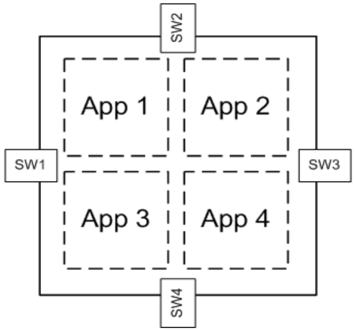
Benefits that can be obtained by using the presented automation method and tool:

- reduce the network design time
- find optimal design solution
- make the creation of on-board networks easier
- evaluating of the developed network quality
- generate data for network configuration

Onboard SpaceWire networks

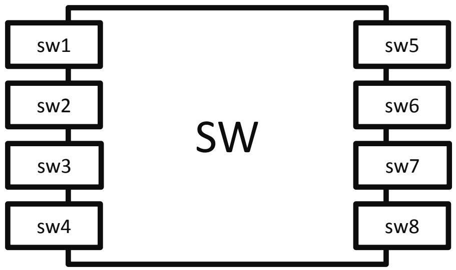
SpaceWire is a novel standard for aircraft and spacecraft onboard networks. It is based on the IEEE 1355 standard. Typical SpaceWire network structure consists of:

terminal nodes
(on-board devices)



Terminal nodes generates data flows and performs various tasks

network nodes
(switches, routers etc.)



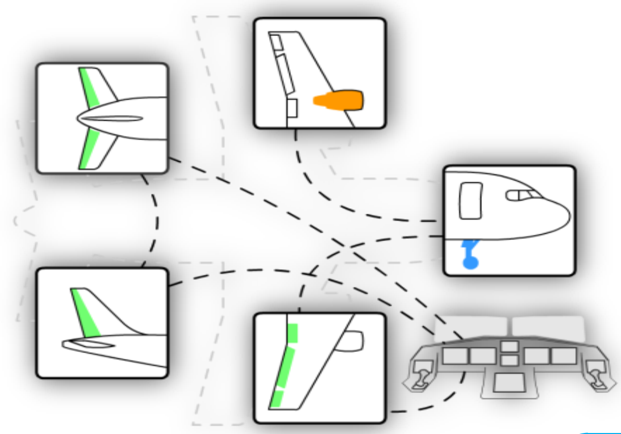
Routing switches provide direct traffic transfer between its input and output ports

communication links

- Physical channels
- Logical channels

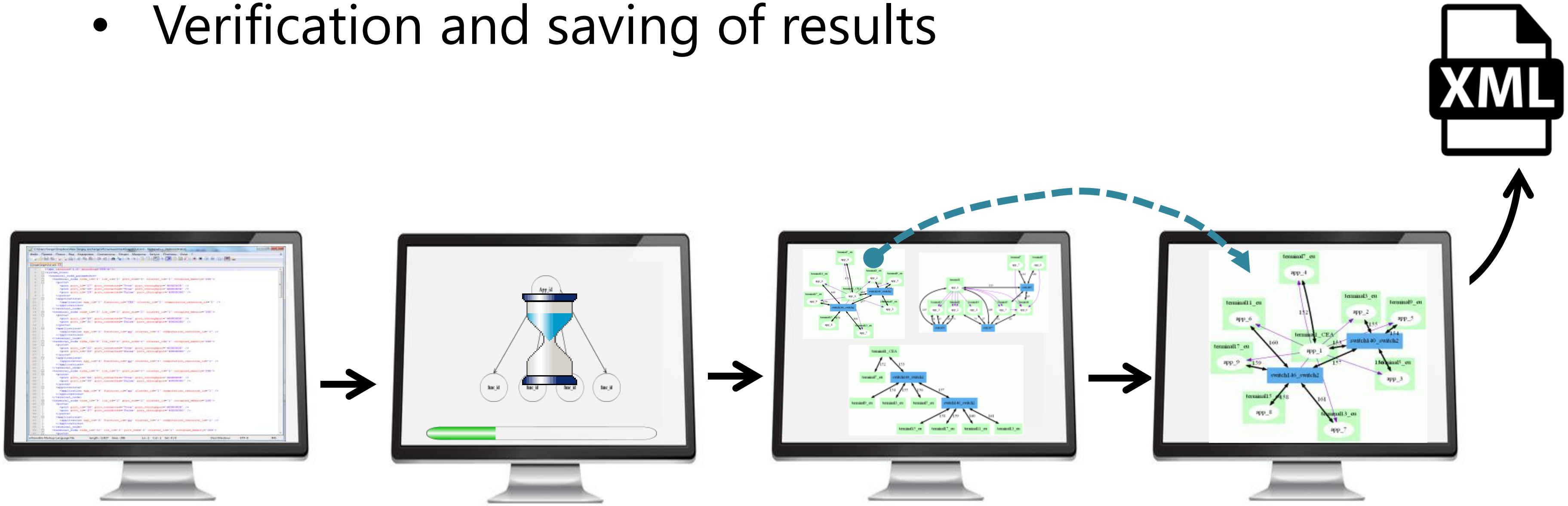
Channels connect nodes. Logical channels are virtual representation of data paths.

Another important characteristic of a terminal node is a physical cluster number where it is located. Cluster is an abstract entity that reflects a physical co-location of system devices



Software operation stages

- Loading and verification of source data
- Network construction
  - building of regular structures
  - building of a network with arbitrary structure
- Choosing the best solution
- Verification and saving of results

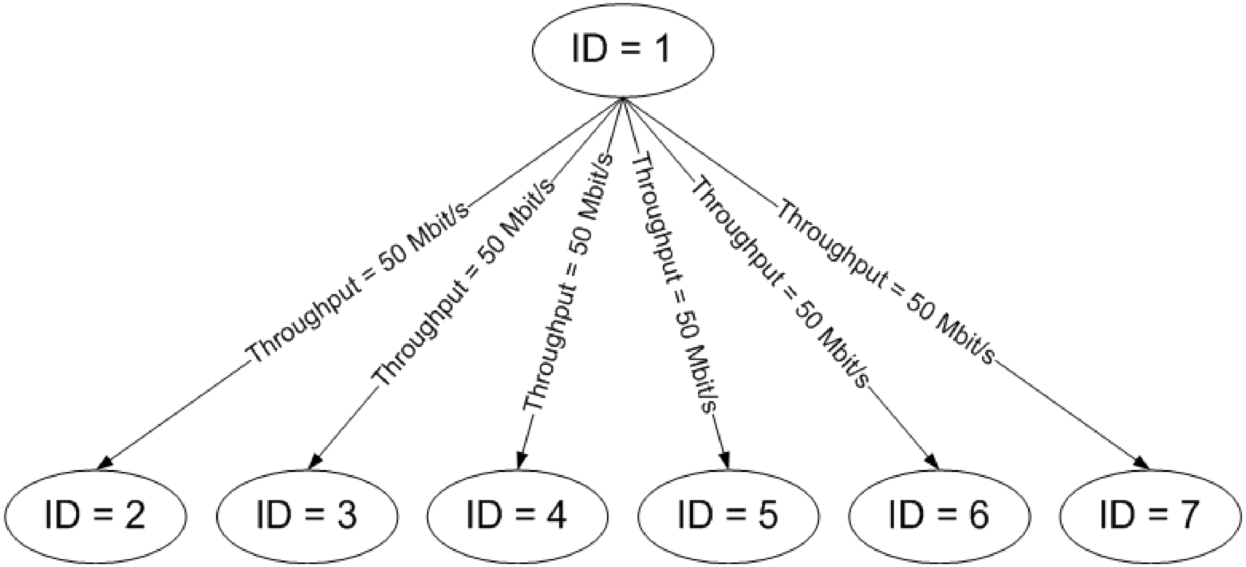


Regular structures construction

Currently implemented regular structure: ordinal trees

Parameters of the regular tree structure:

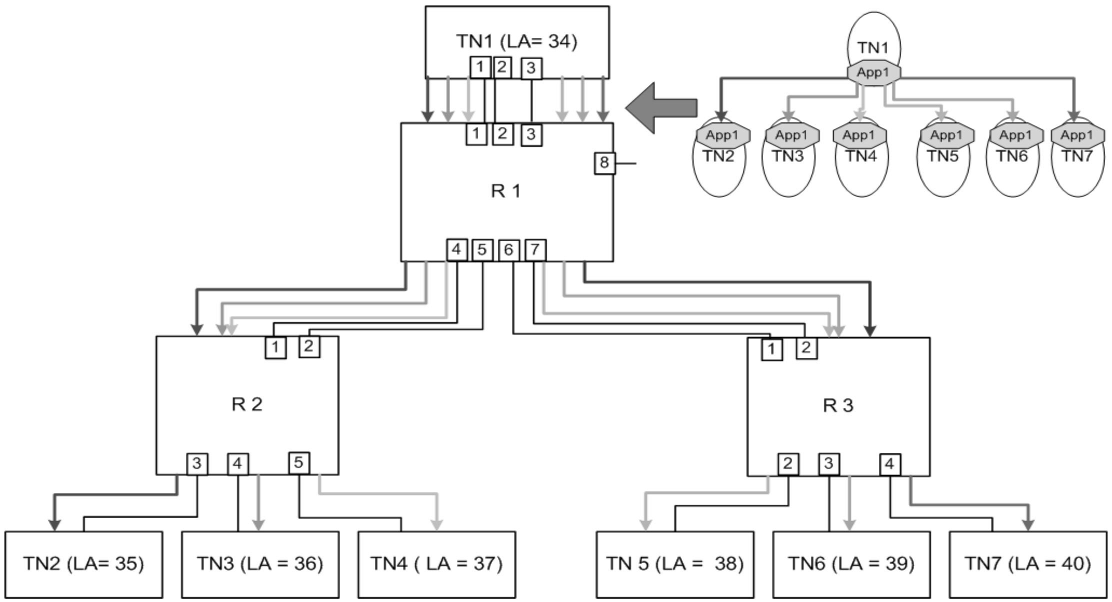
- all logical channels are unidirected
- all logical channels have same characteristics
- all elements are located in the same cluster
- all logical channels originate from/to a single root



Construction of the tree structure

To solve the task of the tree part of the network construction one must perform the following steps:

- select a set of functional units, satisfying the parameters of the structure
- build a tree from leaves to the root
- take into account technical characteristics of devices
- form physical channels, reserve ports for following structures

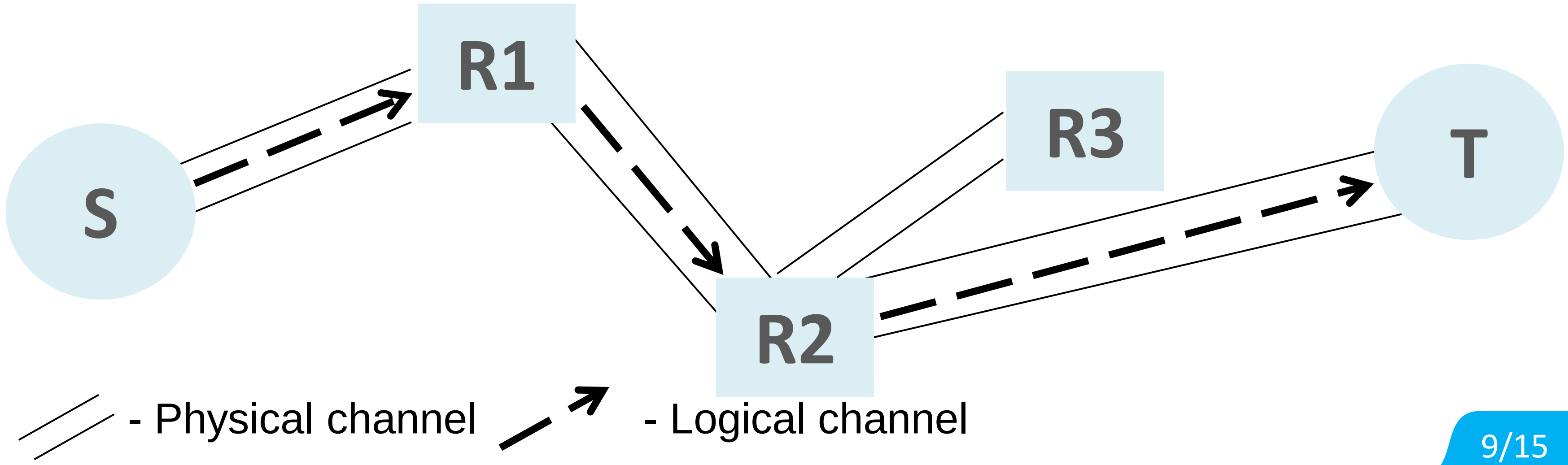


If necessary, one or more layers of switches (R) are added to the tree structure.

Construction of irregular structure

"Arbitrary structure" is an irregular set of BLAN communications. This structures are constructed with the "brute-force": depth-first search algorithm, including following steps:

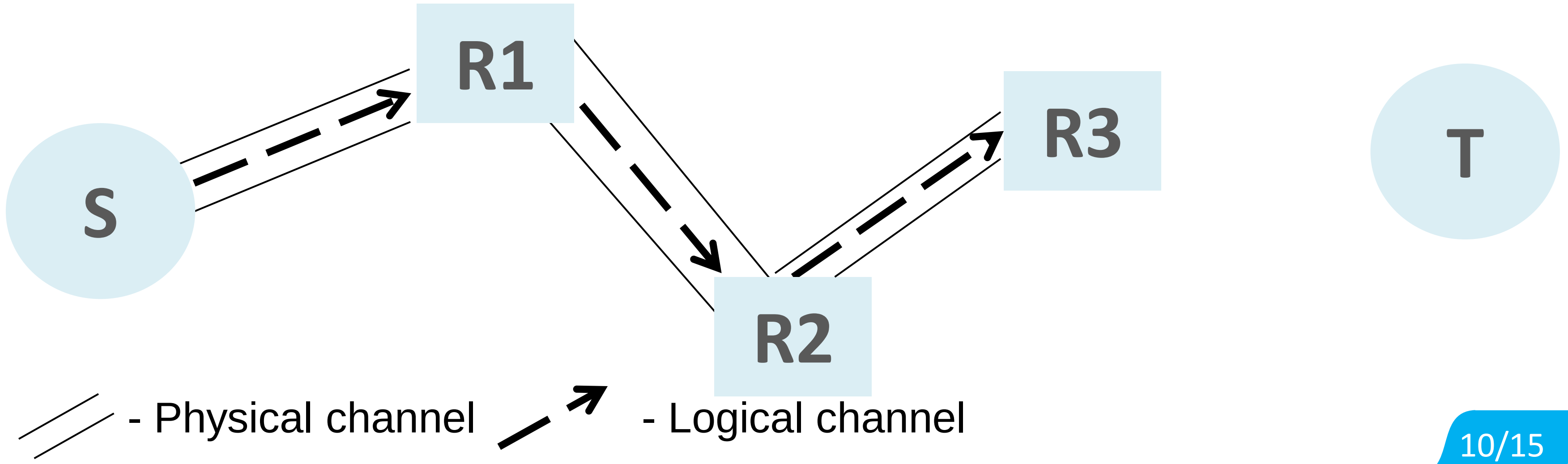
- create a direct physical link from the last point (node) of the logical channel path to its destination node



Construction of irregular structure

"Arbitrary structure" is an irregular set of BLAN communications. This structures are constructed with the "brute-force": depth-first search algorithm, including following steps:

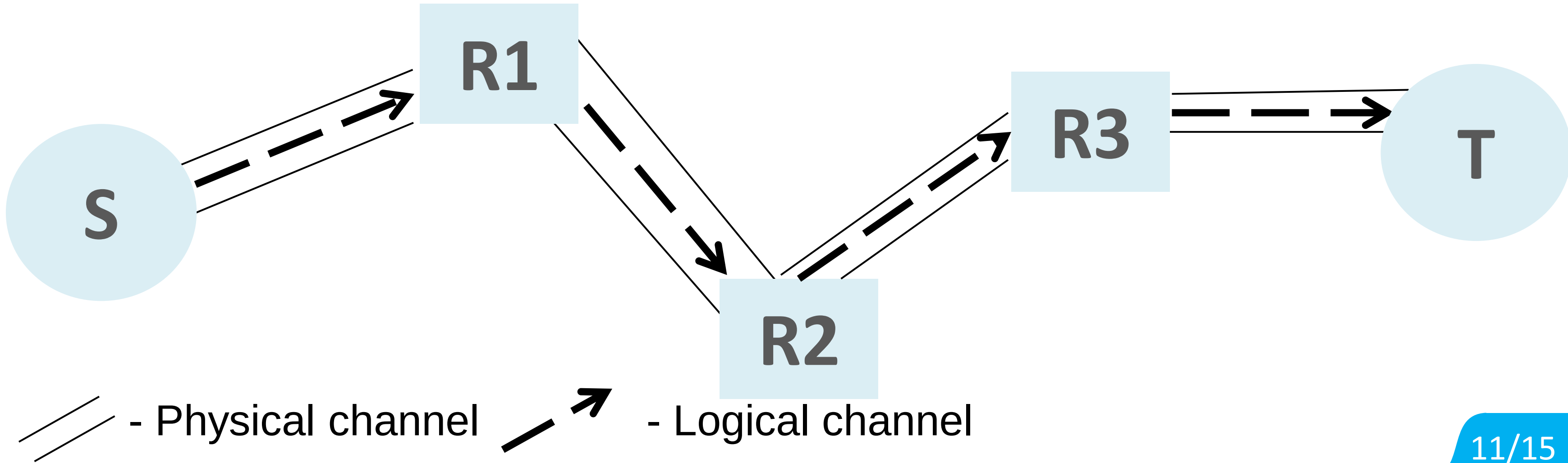
- allocate a logical channel to an existing physical channel that connects the last point (node) in the logical channel path with any switch or to the receiver node



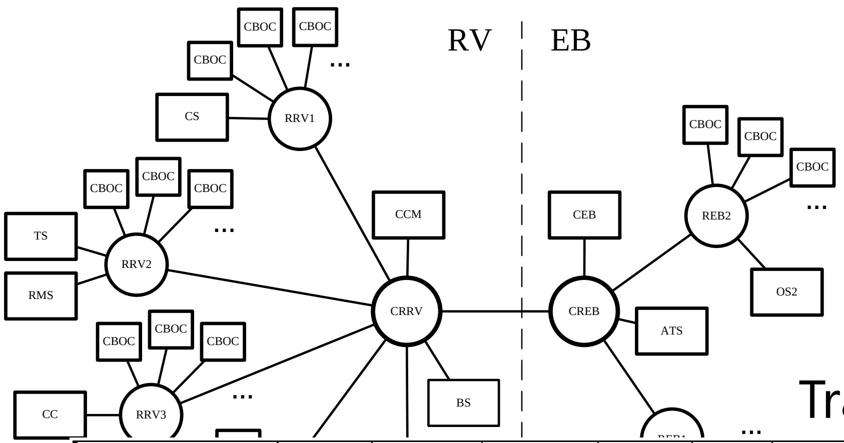
Construction of irregular structure

"Arbitrary structure" is an irregular set of BLAN communications. This structures are constructed with the "brute-force": depth-first search algorithm, including following steps:

- construct a direct physical channel from the last point (node) in the logical channel path to the switch with direct connection to the destination node



Use case: satellite on-board network



Traffic in Mbit/s.

Receivers / Senders	ATS	OREC	CBOC	CEB	ISS	CC	OMS	TS	CCM
ATS	-	-	-	-	-	-	-	-	-
OREC	-	-	-	-	-	2	-	-	5
OS	-	-	-	-	-	1	1	-	3
CBOC	-	-	-	-	-	-	0.5	-	0.08
CEB	-	-	-	-	-	0.1	2	-	2
ISS	-	-	-	-	-	15	3	-	2
CC	35	-	-	-	-	-	2	-	0.2
OMS	5	-	-	-	3	0.1	-	-	5
RMS	-	-	-	-	-	1	1	-	1
BS	-	-	-	-	-	-	0.1	-	-
CS	-	-	-	-	-	-	0.2	-	-
TS	-	15	-	-	15	50	0.1	-	0.01
CCM	5	5	0.08	2	2	5	1	0.01	-

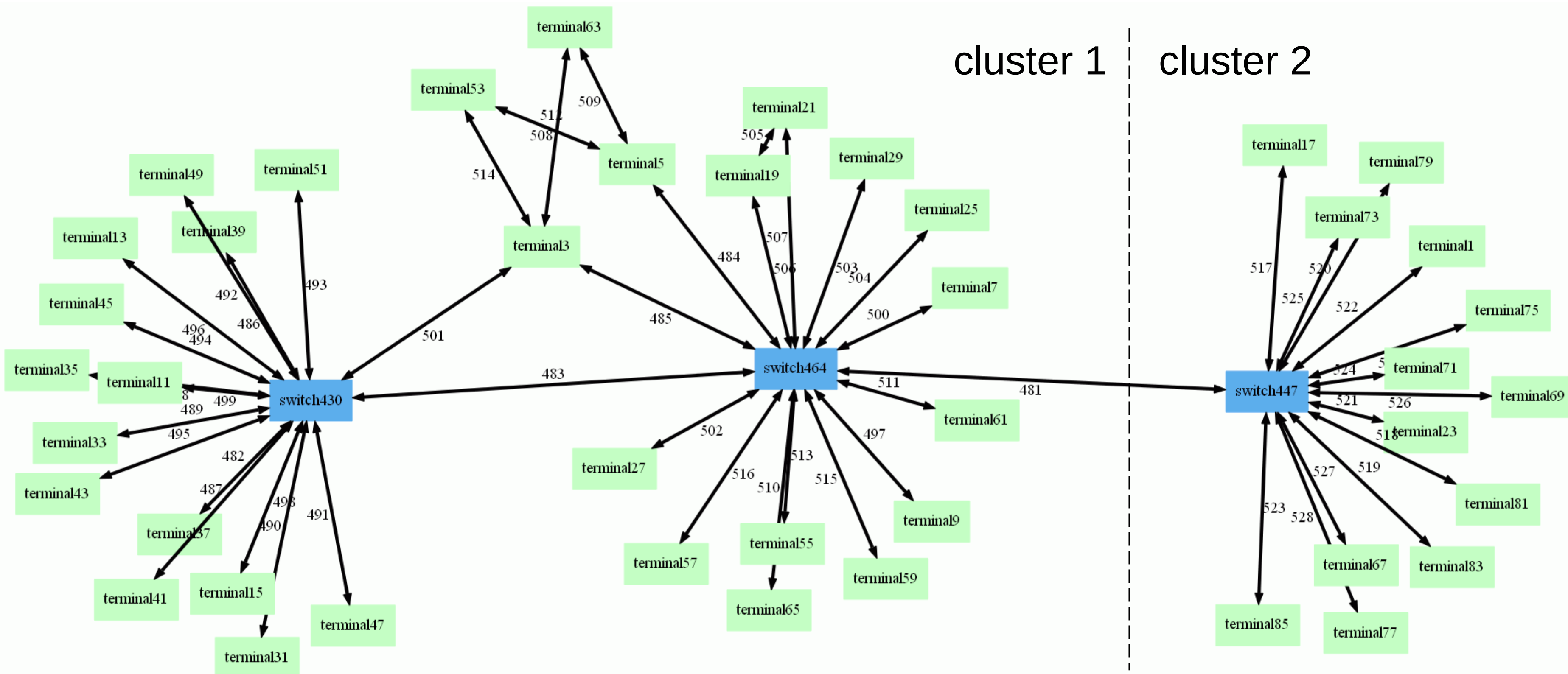
ATS	Automated Test System
OREC	Onboard Radio Engineering Complex
OS	Onboard Systems
CBOC	Control Block of Onboard Complex
RV	Re-entry Vehicle
EB	Engine Bay
CEB	Computer of the EB
RRV	Router of RV
REB	Router of EB
ISS	International Space Station
CC	Cosmonaut Consoles
OMS	Onboard Measurement System
RMS	Radiation Monitoring System
BS	Bearing System
CS	Communication System
TS	Telemetric System
CCM	Central Computing Machine
CRRV	Central RRV
CREB	Central REB

The input structure contains:

- 43 terminal nodes located in two physical clusters
- 128 logical channels, which are mainly the connections from multiple CC nodes to three on-board nodes: ATS, OMS and CCM

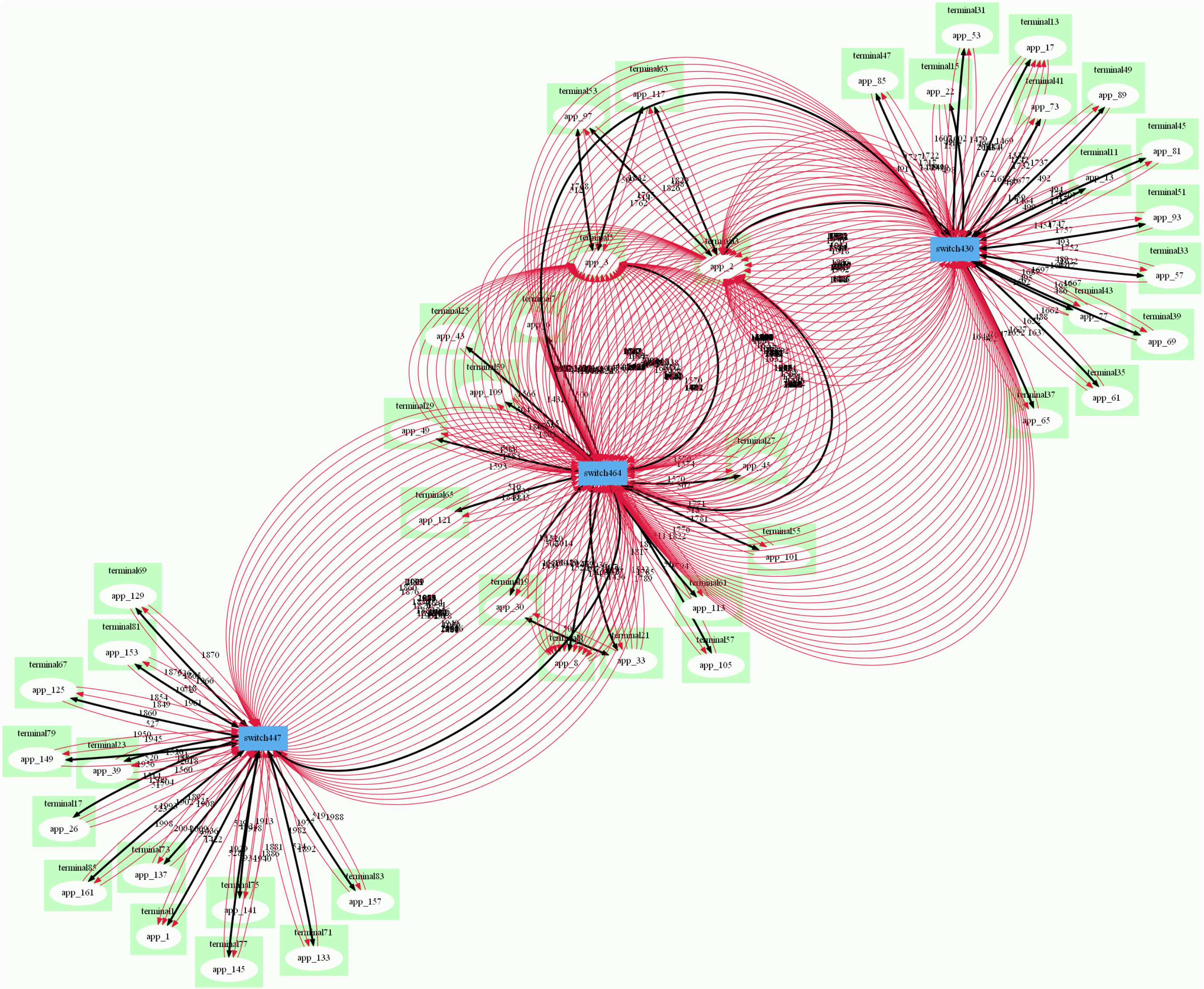
Use case results

Physical structure of constructed network



Use case results

Channel routes over the physical structure



Conclusions

- We develop the algorithm, method and tool for automated onboard local area networks construction
- The presented solution significantly reduces the time required for designing on-board networks
- The developed technology utilize all aspects, abilities and features of the SpaceWire standard to achieve best characteristics of designed networks
- We plan to extend the tool with more regular structures, increase the performance and reduce the calculation time
- We can extend the technology to support more communication standards