Power Saving in Automotive Ethernet

Thomas Suermann, Steffen Müller
NXP Semiconductors

AMAA 2014

NXP – a global innovator

Established in 2006 (formerly a division of Royal Philips)

Net sales: $4.8 billion in 2013, >60% in Asia

Employee base:

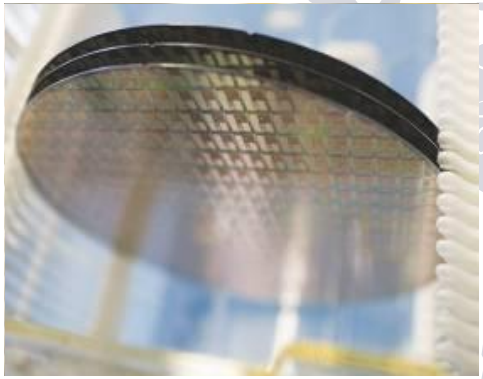
~ 25,000 employees in more than 25 countries

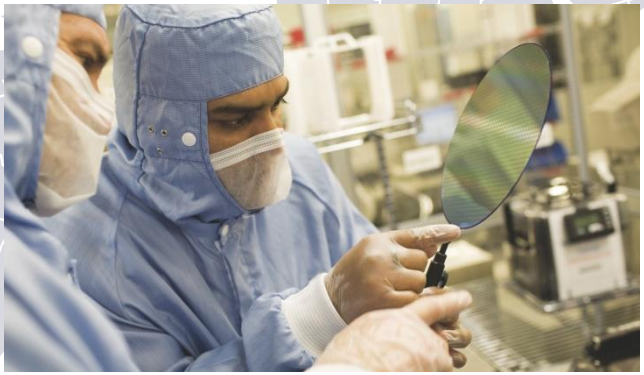
Manufacturing in Asia and Europe

Strong Innovation Pipeline:

- R&D in Asia, Europe and US
- Over $550M / year in R&D
- 3,200 engineers
- 11,000 patents

Global #1 Semiconductor Player in Security and Automotive Connectivity





Secure Connections for a Smarter World

Four Mega Trends are shaping our Society …

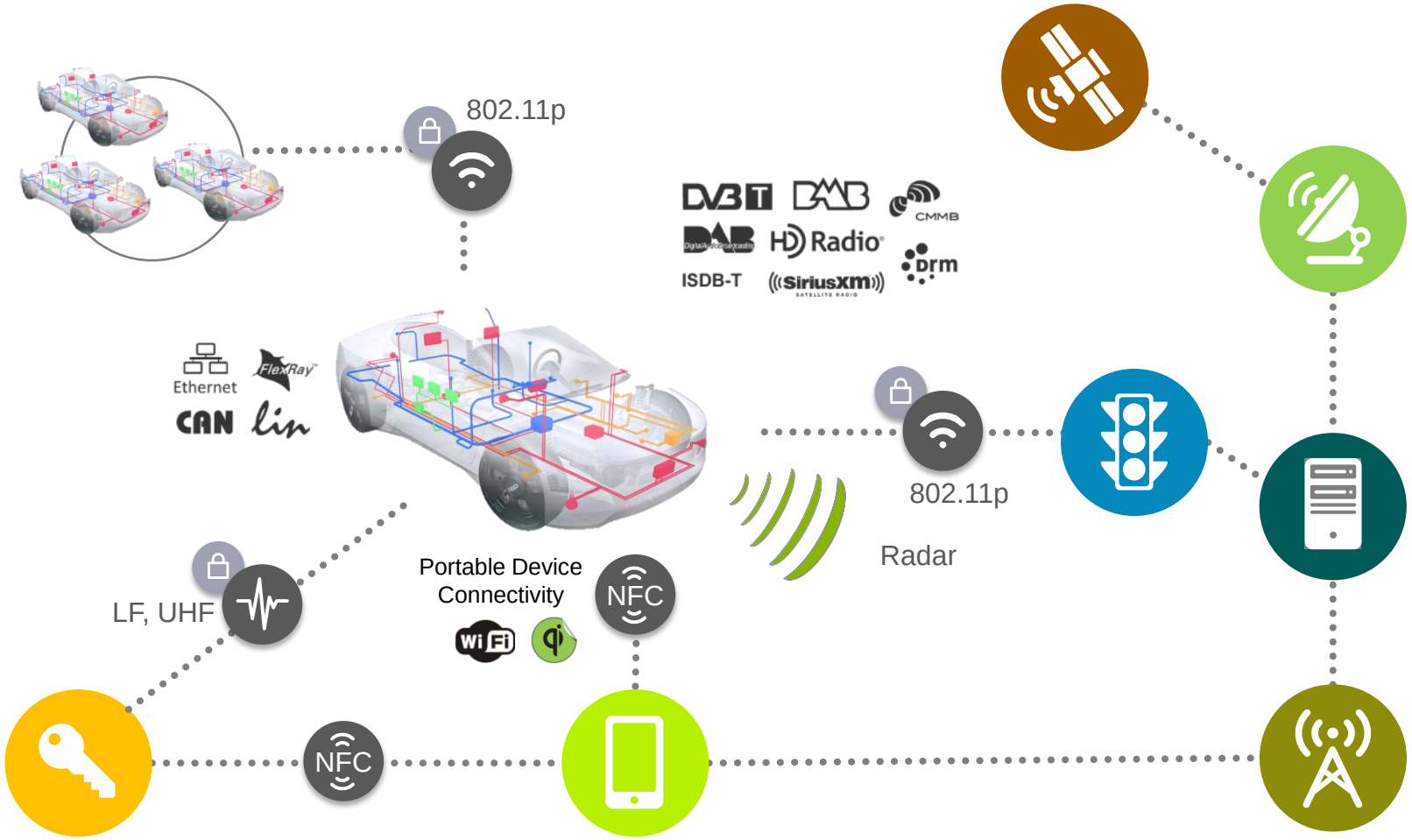
and drive the Electronics Industry

Energy Efficiency, Connected Devices,

Security and Health

Connected Mobility

… enables communication between cars, people, infrastructure, inside the car



NXP Innovation in Automotive Ethernet

PHY

100 Mbps - BroadR-Reach de-facto standard

- Co-founded OPEN Alliance
- IEEE802.3bp (RTPGE)

TJA1100 Single Port PHY

- First True Automotive Open Alliance BroadR-Reach PHY

SWITCH

NXP and TTTech Collaborate on Ethernet Switch

- Joint development of Ethernet Switch solutions

SJA1105 Automotive Ethernet Switch

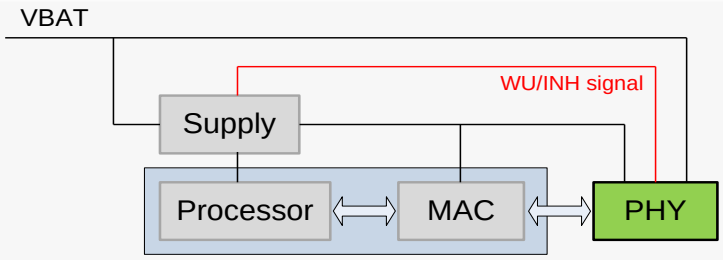
- 5 Port Automotive Ethernet Switch
- Supporting up to GBit communication speed

Automotive Ethernet Boundary Conditions

- Fast transition from sleep to communication (target: 250ms)
- Power consumption of a wake-able port very low (target: 10µA)
- No unintended wake-up due to EMC
- No change in MAC layer
- AUTOSAR network management possible
- Open standard, ready for future (e.g. Gigabit Ethernet)
- No additional hardware needed (keep costs)

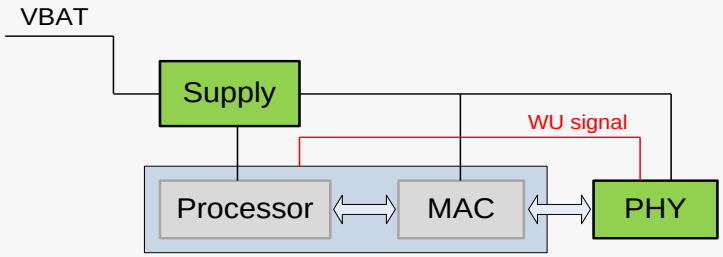
Presentation Focus

Known Ethernet Low Power Approaches



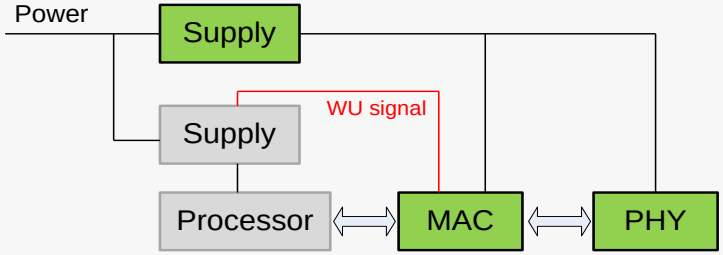
Automotive Low Power with TJA1100

- Supply, Processor and MAC switched off
- PHY keeps partly alive via VBAT (clamp-30)
- Wake-up on link activity detection
- Power consumption in <0.5mW range



Low Power with standard PHYs

- Processor and MAC switched off
- PHY keeps supplied by dedicated regulator
- Wake-up on link activity detection
- Power consumption in 2mW range



Wake-on-LAN (e.g. in PCs)

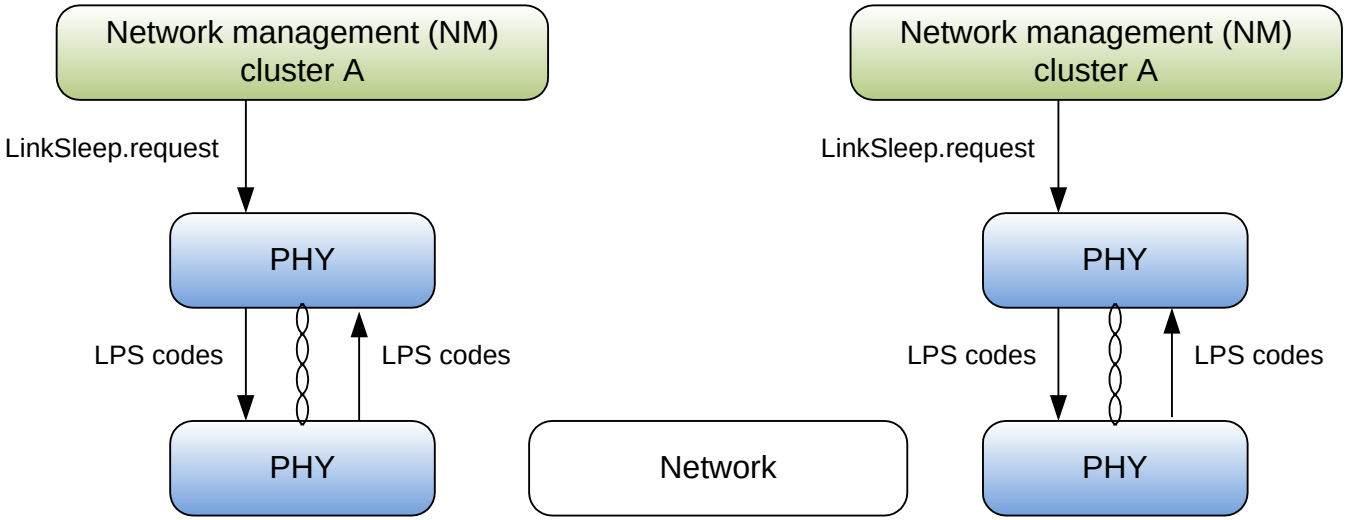
- Only Processor can be switched off
- PHY and MAC keeps supplied by regulator
- Wake-up on Magic Packet frame
- Power consumption in 1W range

WU = wake up

NXP Ethernet Low Power Strategy

- Node / ECU level: all devices and part of PHY are switched off
  - PHY device is „self-supplied“ device connected to battery voltage
  - Part of PHY device can be switched off but activity detector runs
  - Processor and MAC are completely switched off
  - No additional hardware needed, use existing network infrastructure
- Network level: new physical layer services
  - Link Sleep request & Link Sleep Fail indication
  - Wake-up request & Wake-up indication
  - Wake-up request forwarding (only Switch)

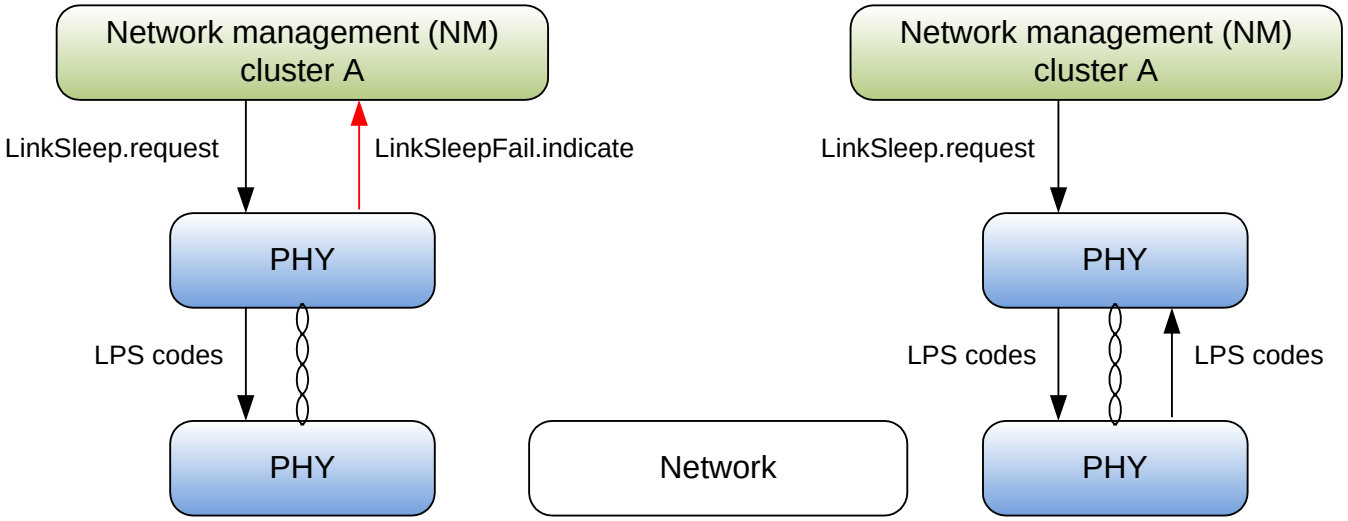
Link Sleep Request



Node is active

Node in sleep

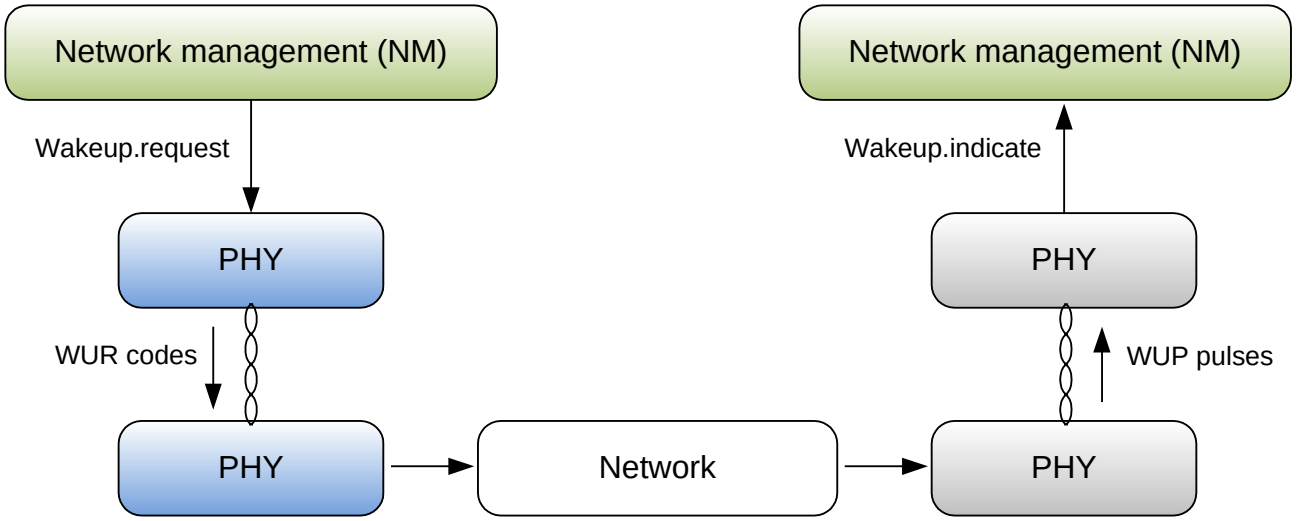
Link Sleep Fail



Node is active

Node in sleep

Wake-up Request and Indication



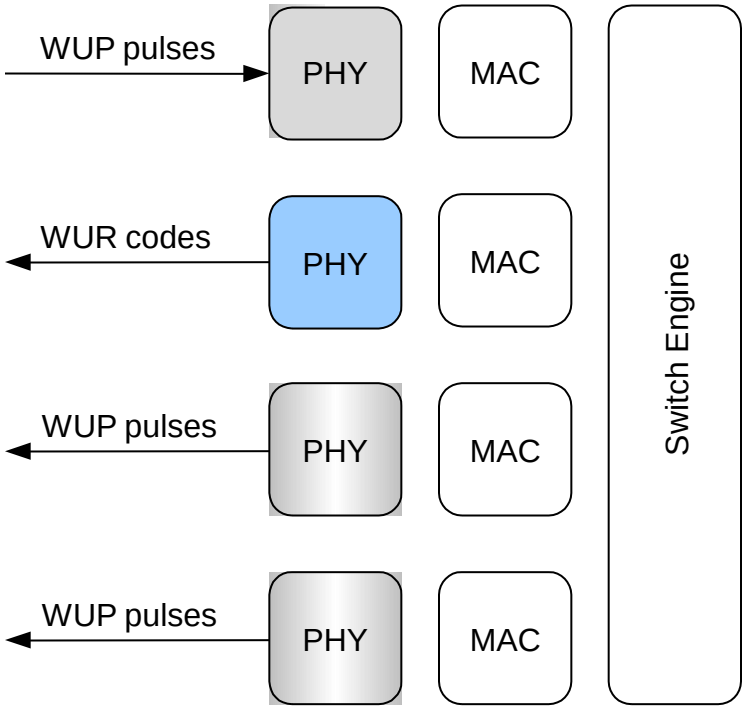
Node is active

Node in sleep

WUR = wakeup request, coded in “Idle Stream”

WUP = wakeup pulse, triggered by bus acticity detector

Wake-up Request Forwarding



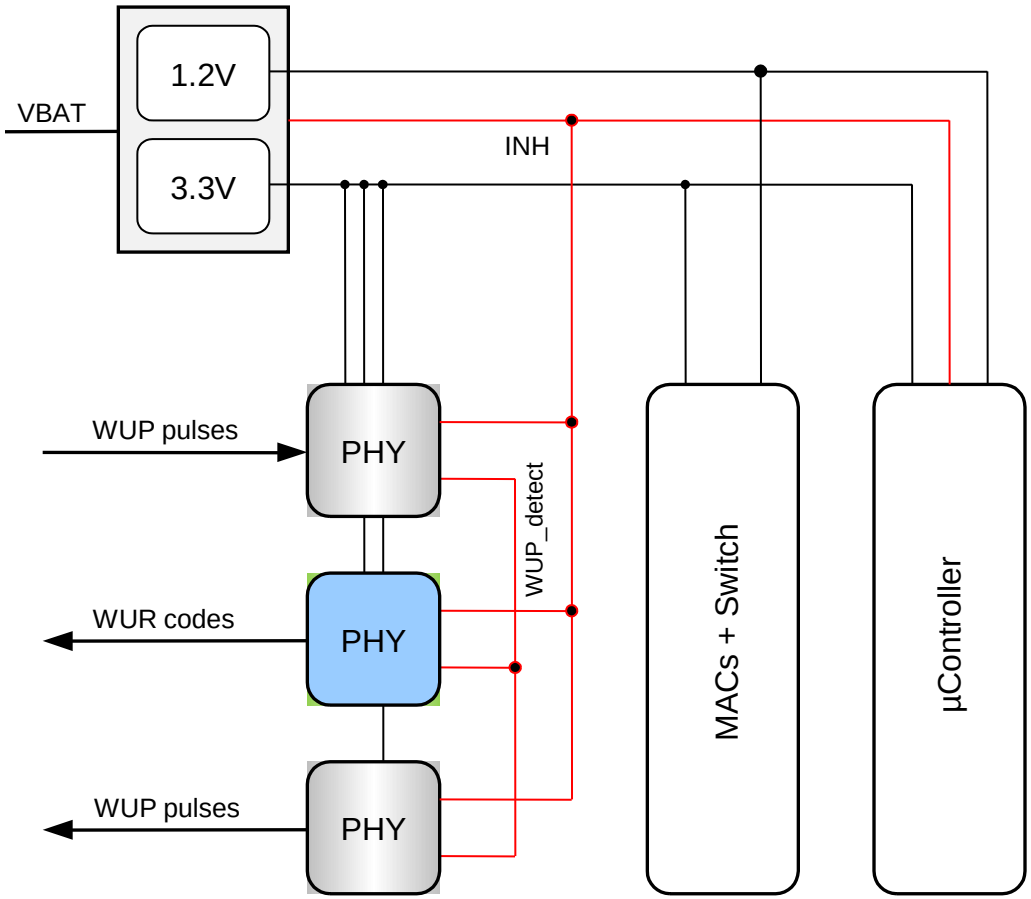
Node is active

Node in sleep

WUR = wakeup request, coded in “Idle Stream”

WUP = wakeup pulse, triggered by bus acticity detector

Example Implementation



Node is active

Node in sleep

MAC + Switch is unchanged

Network Wake-up Concepts

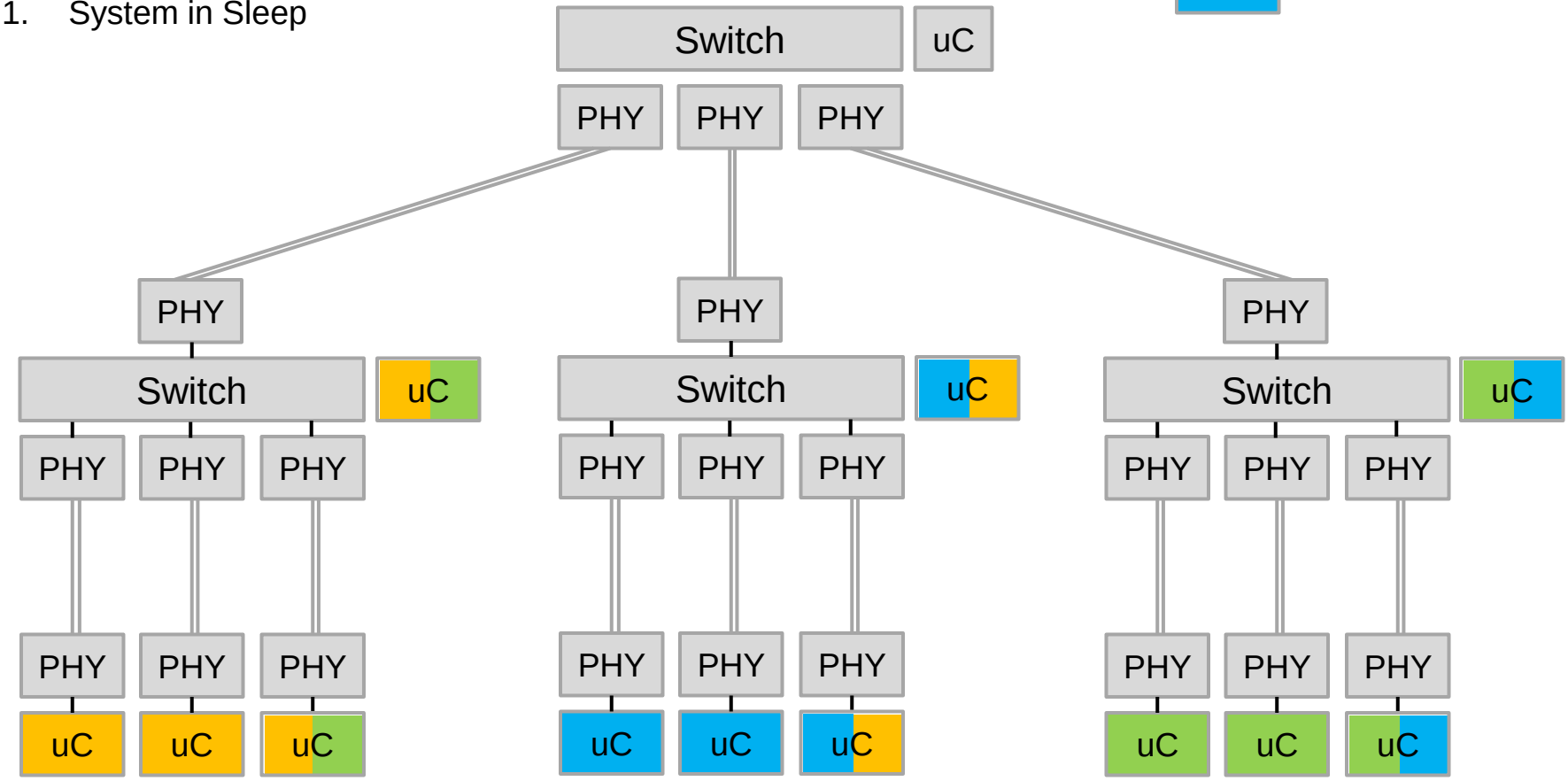
1. Selective wakeup

uC Funct. Cluster A

uC Funct. Cluster B

uC Funct. Cluster C

1. System in Sleep



Network Wake-up Concepts

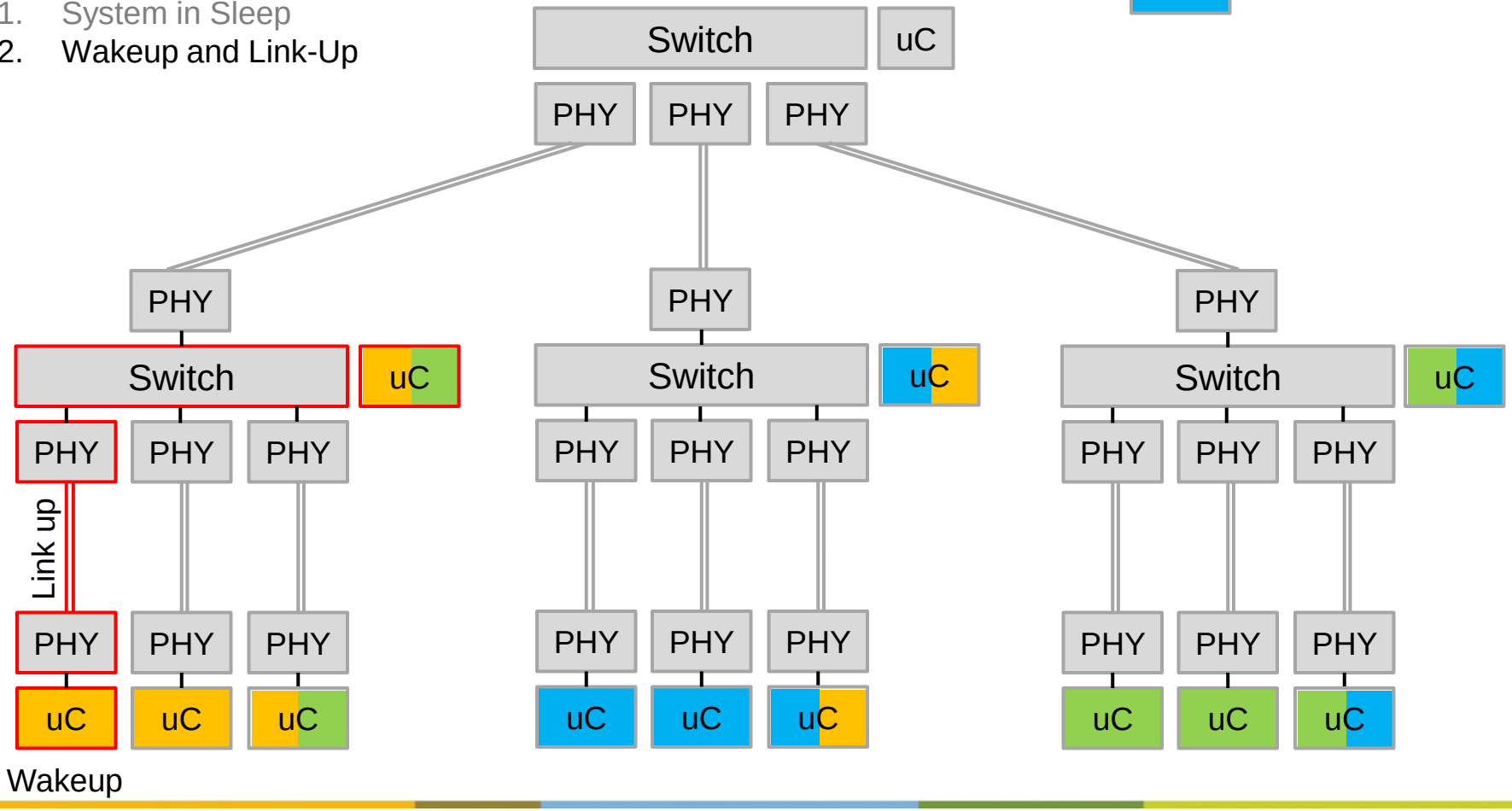
1. Selective wakeup

uC Funct. Cluster A

uC Funct. Cluster B

uC Funct. Cluster C

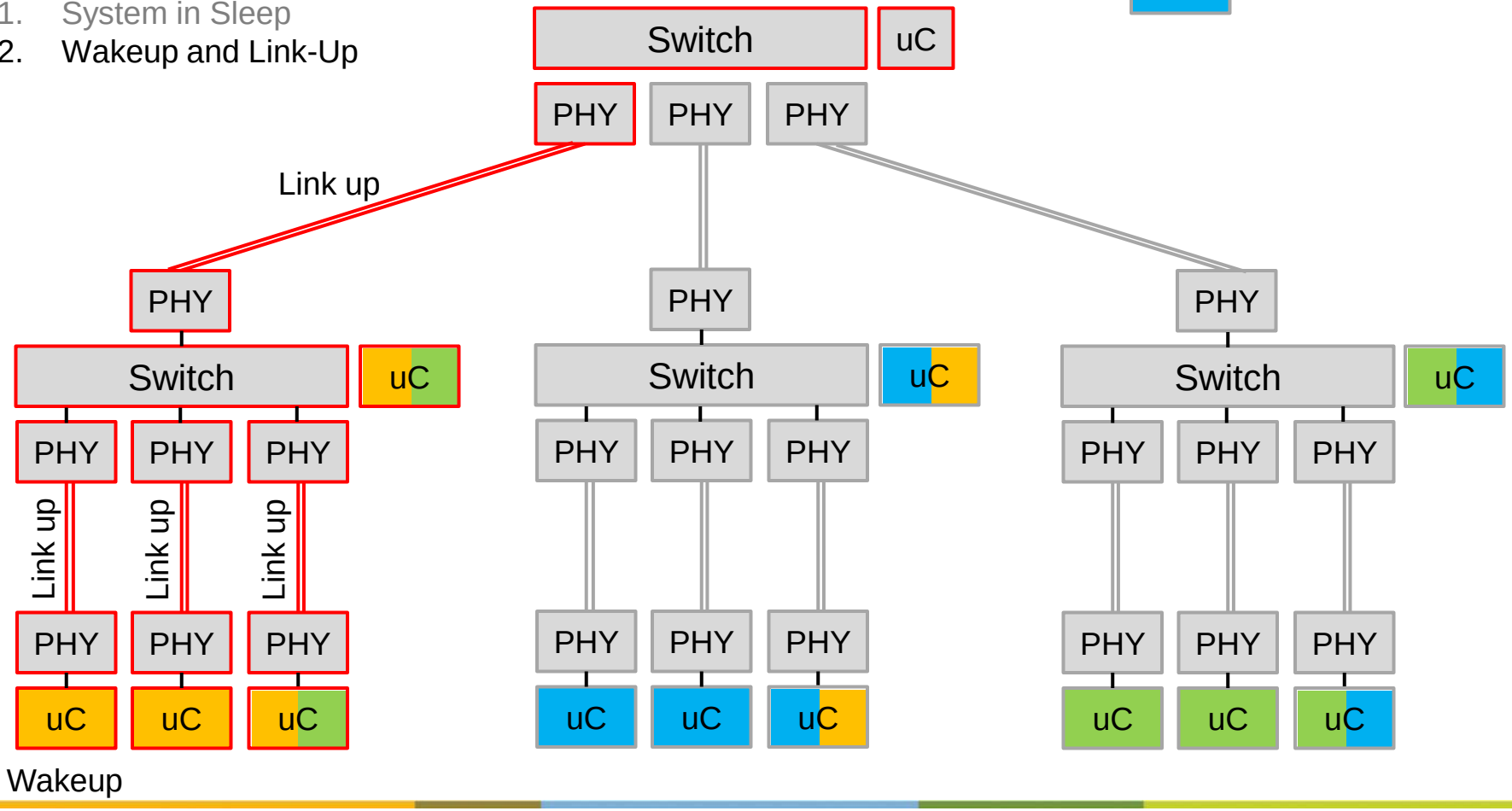
1. System in Sleep
2. Wakeup and Link-Up



Network Wake-up Concepts

1. Selective wakeup

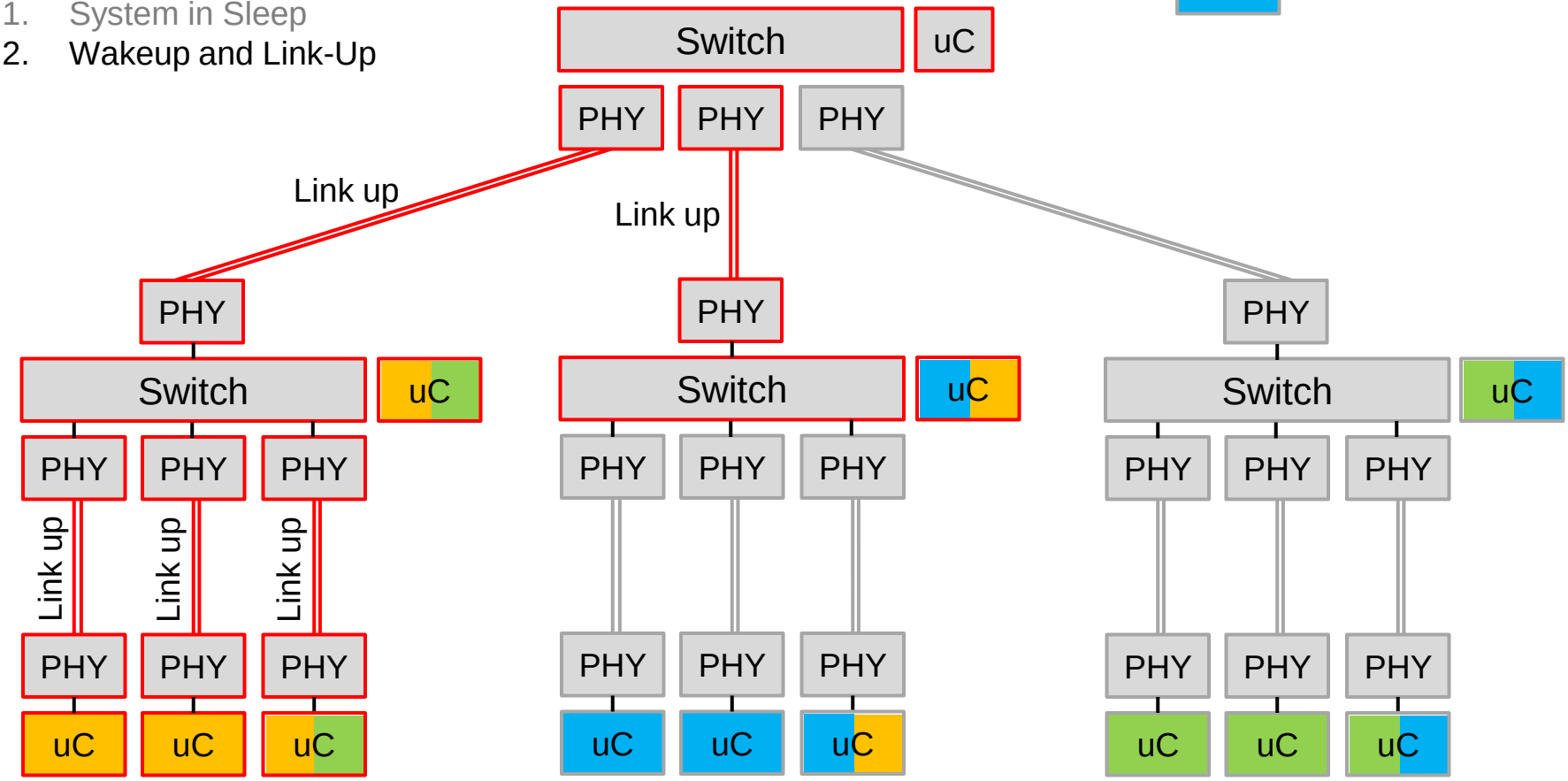
1. System in Sleep
2. Wakeup and Link-Up



Network Wake-up Concepts

1. Selective wakeup

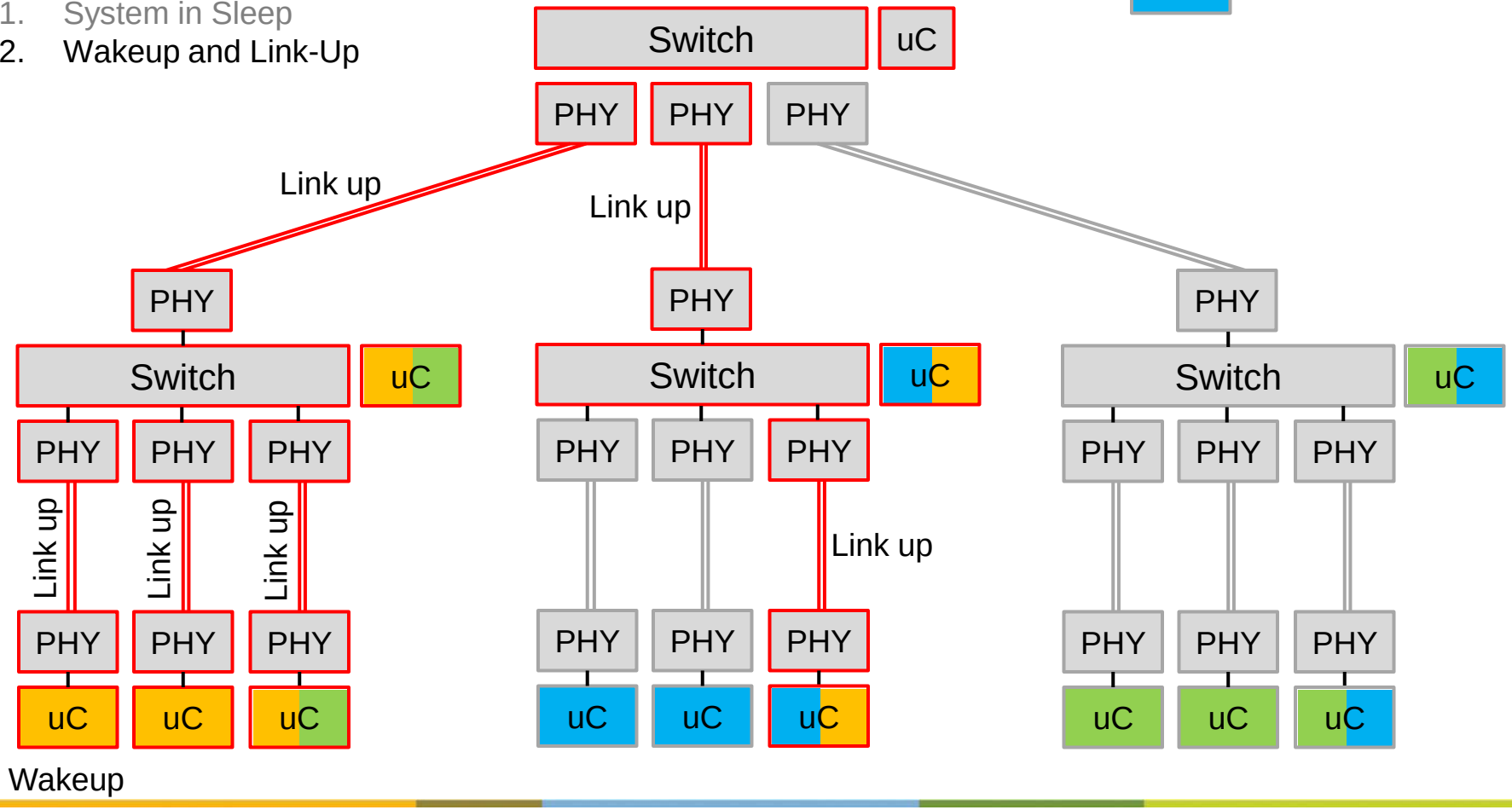
1. System in Sleep
2. Wakeup and Link-Up



Network Wake-up Concepts

1. Selective wakeup

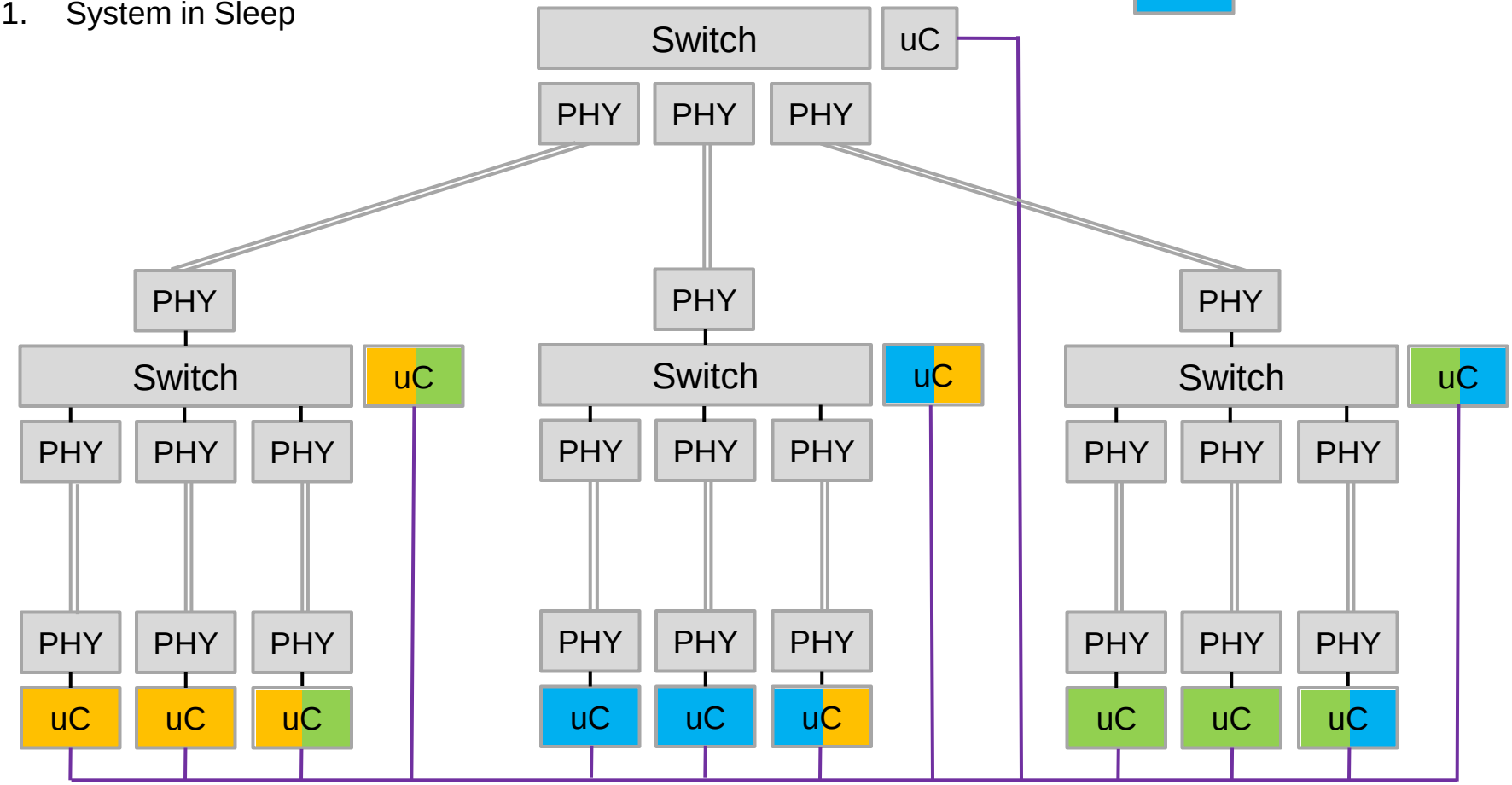
1. System in Sleep
2. Wakeup and Link-Up



Network Wake-up Concepts

2. Global wakeup with activation line

1. System in Sleep



Network Wake-up Concepts

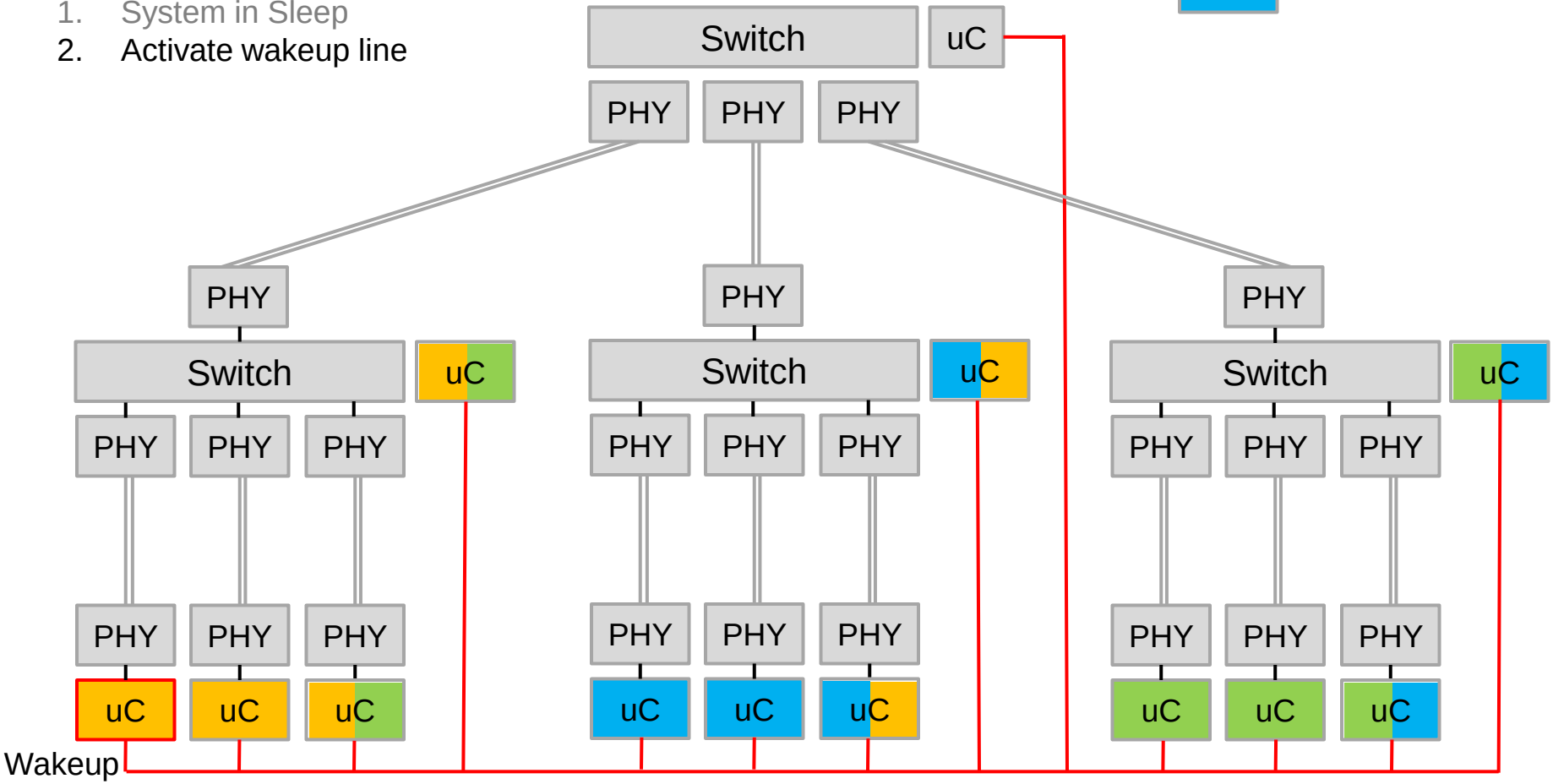
2. Global wakeup with activation line

uC Funct. Cluster A

uC Funct. Cluster B

uC Funct. Cluster C

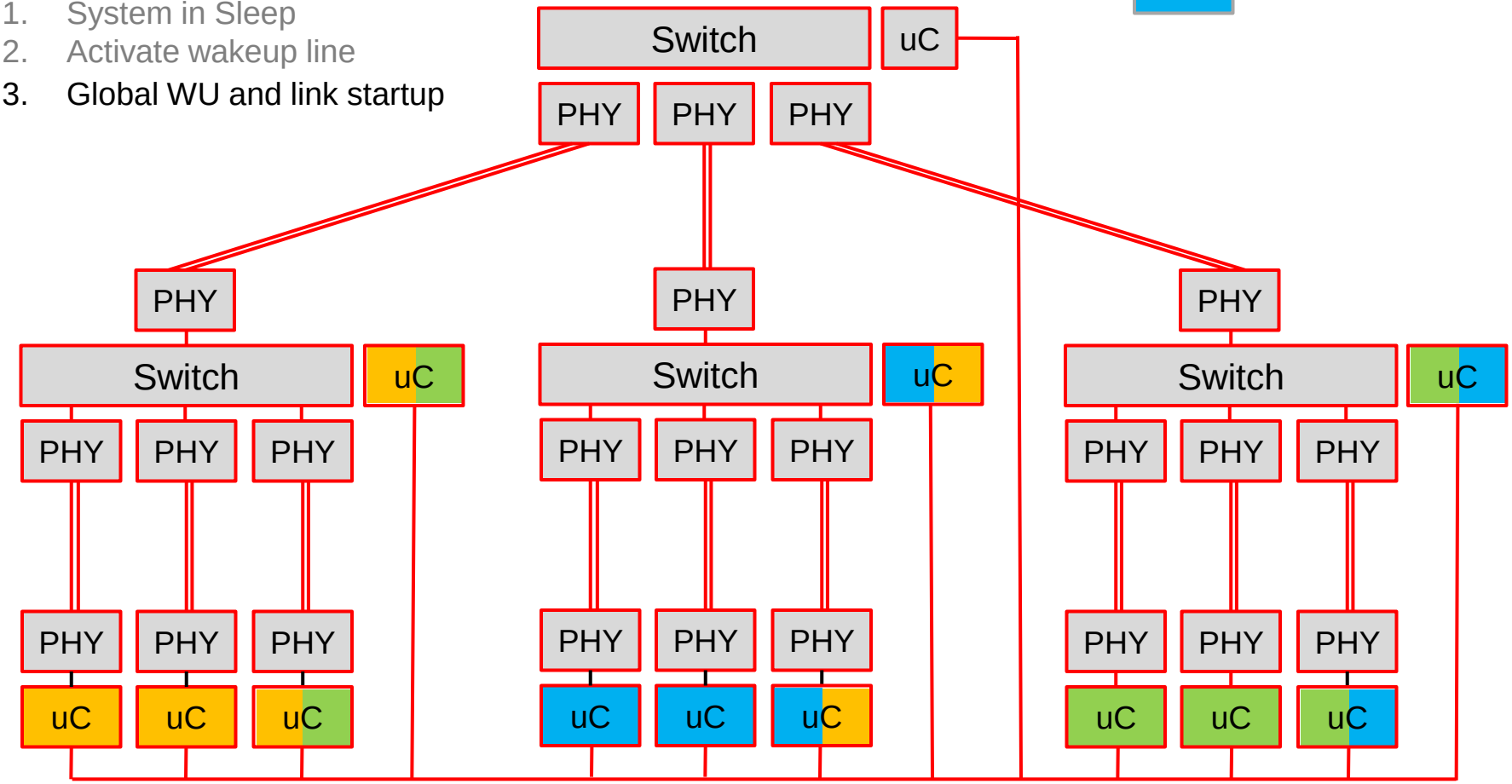
1. System in Sleep
2. Activate wakeup line



Network Wake-up Concepts

2. Global wakeup with activation line

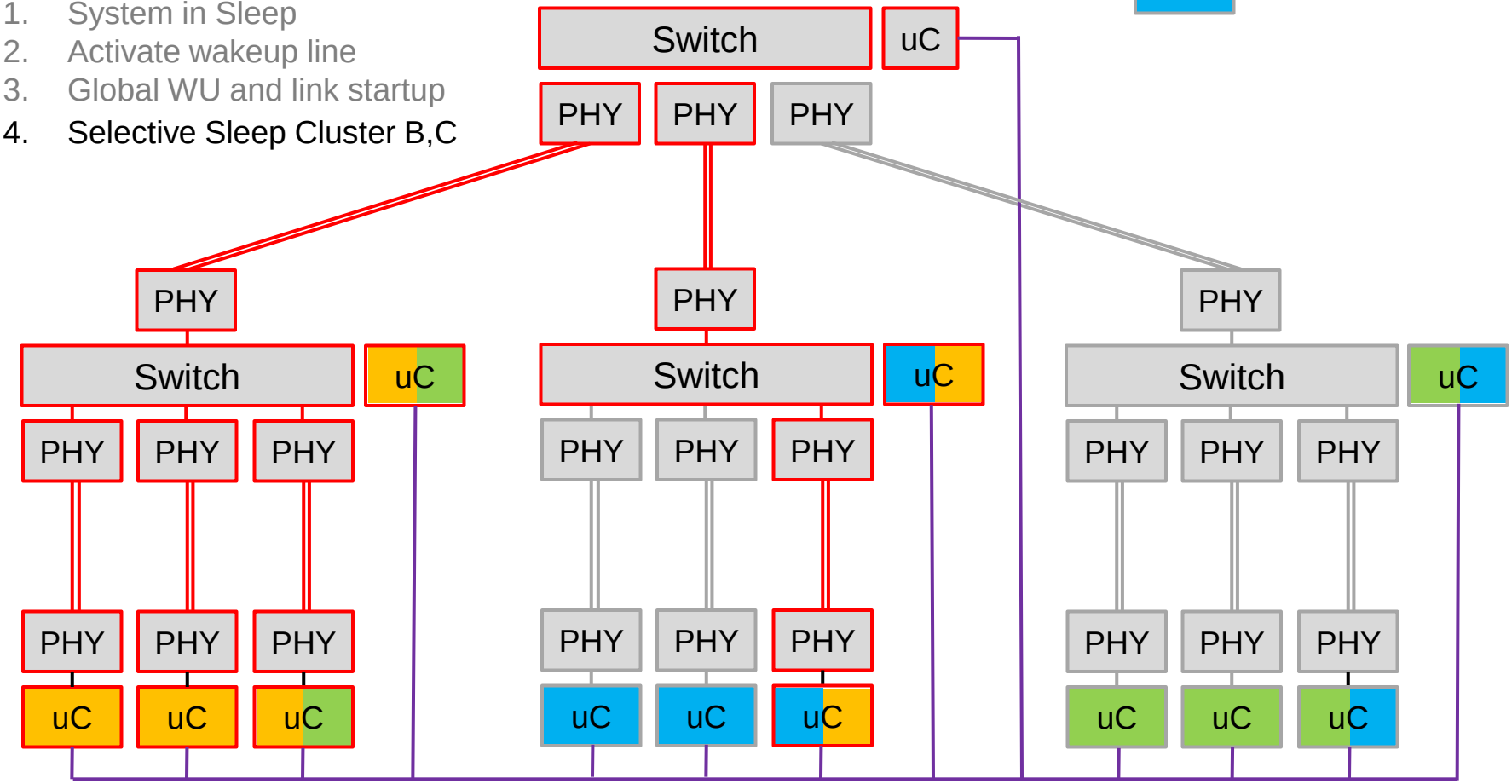
1. System in Sleep
2. Activate wakeup line
3. Global WU and link startup



Network Wake-up Concepts

2. Global wakeup with activation line

1. System in Sleep
2. Activate wakeup line
3. Global WU and link startup
4. Selective Sleep Cluster B,C



Network Wake-up Concepts

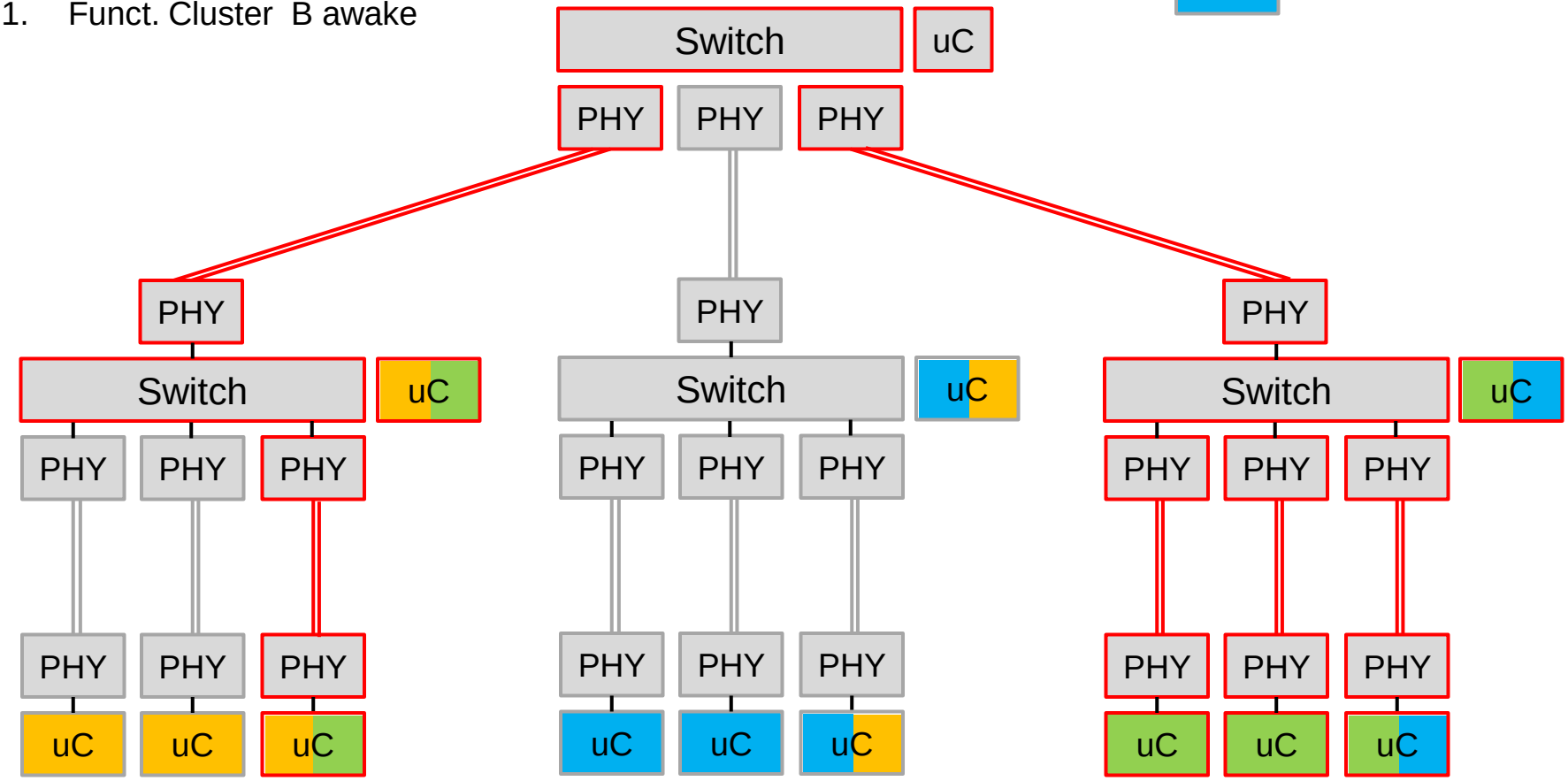
3. Global wakeup via Ethernet line

uC Funct. Cluster A

uC Funct. Cluster B

uC Funct. Cluster C

1. Funct. Cluster B awake



Network Wake-up Concepts

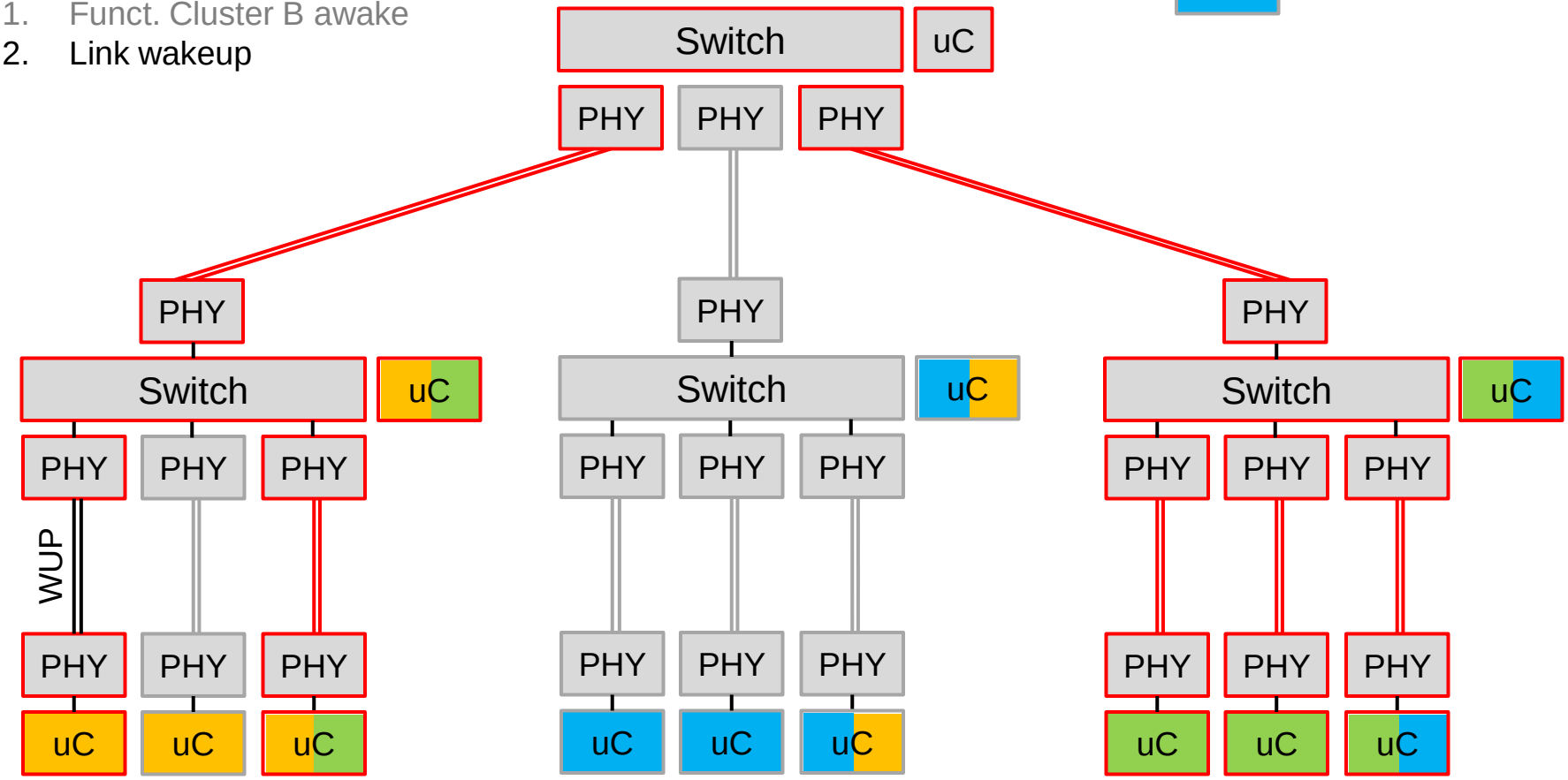
3. Global wakeup via Ethernet line

uC Funct. Cluster A

uC Funct. Cluster B

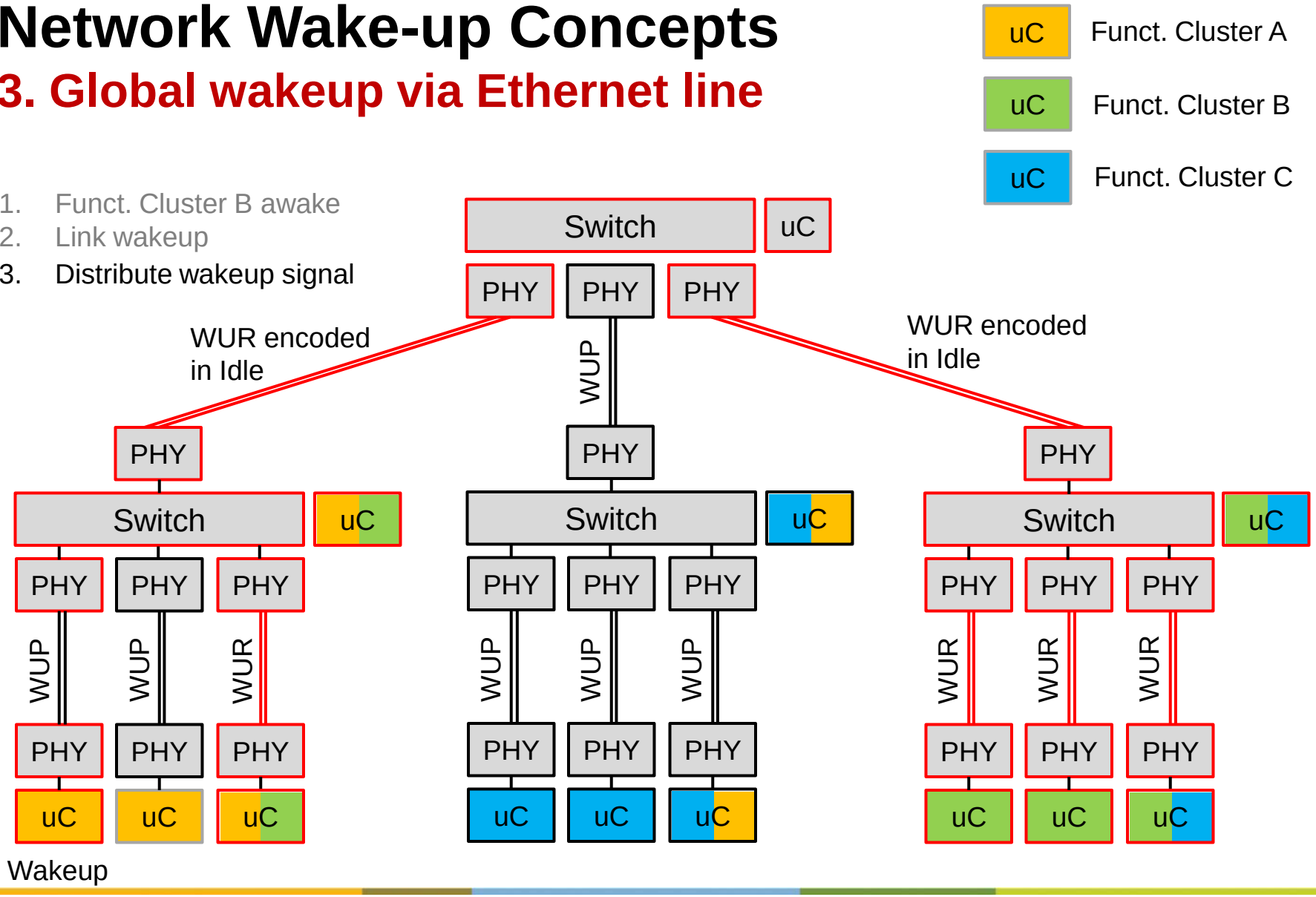
uC Funct. Cluster C

1. Funct. Cluster B awake
2. Link wakeup



Network Wake-up Concepts

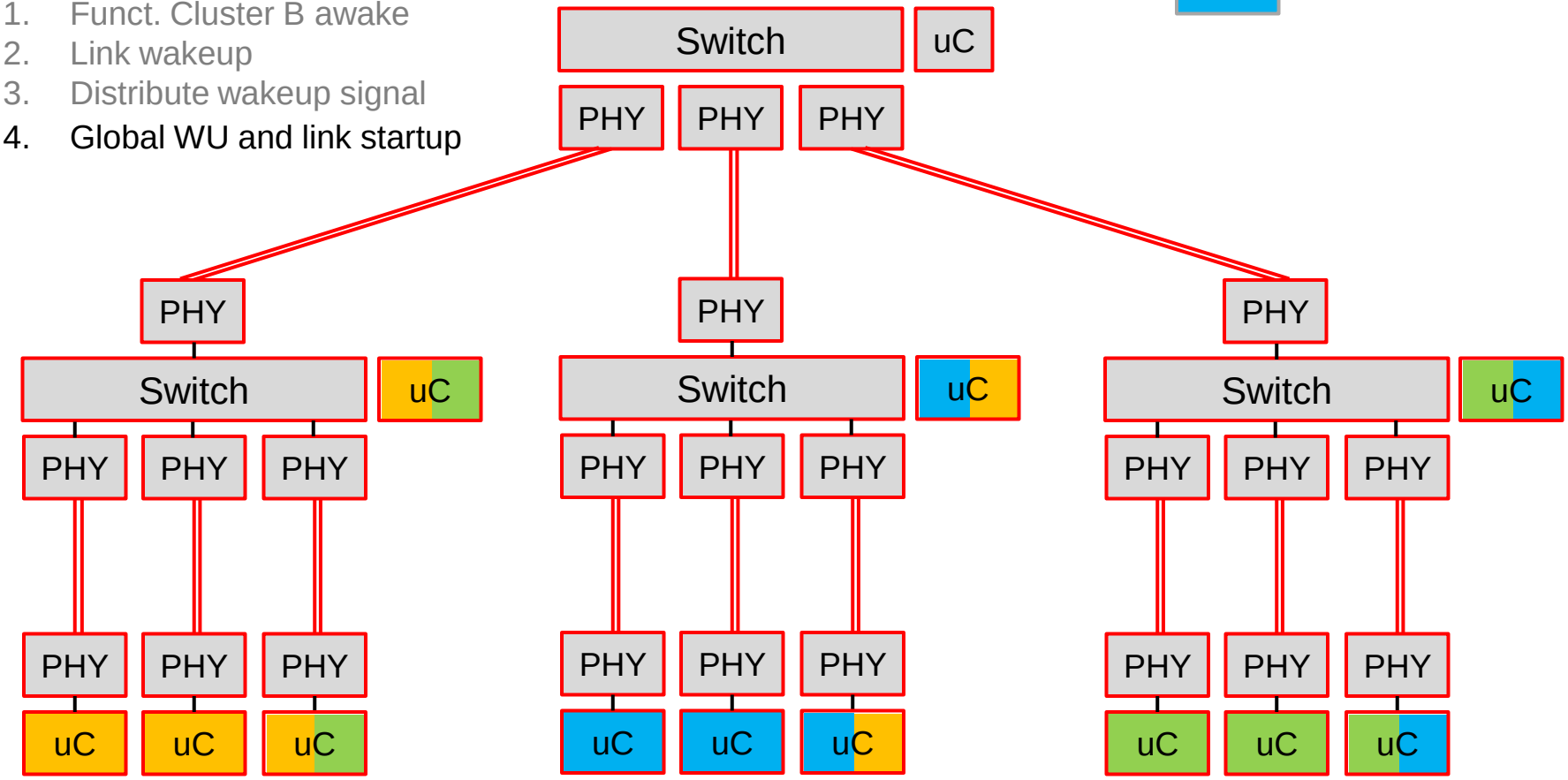
3. Global wakeup via Ethernet line



Network Wake-up Concepts

3. Global wakeup via Ethernet line

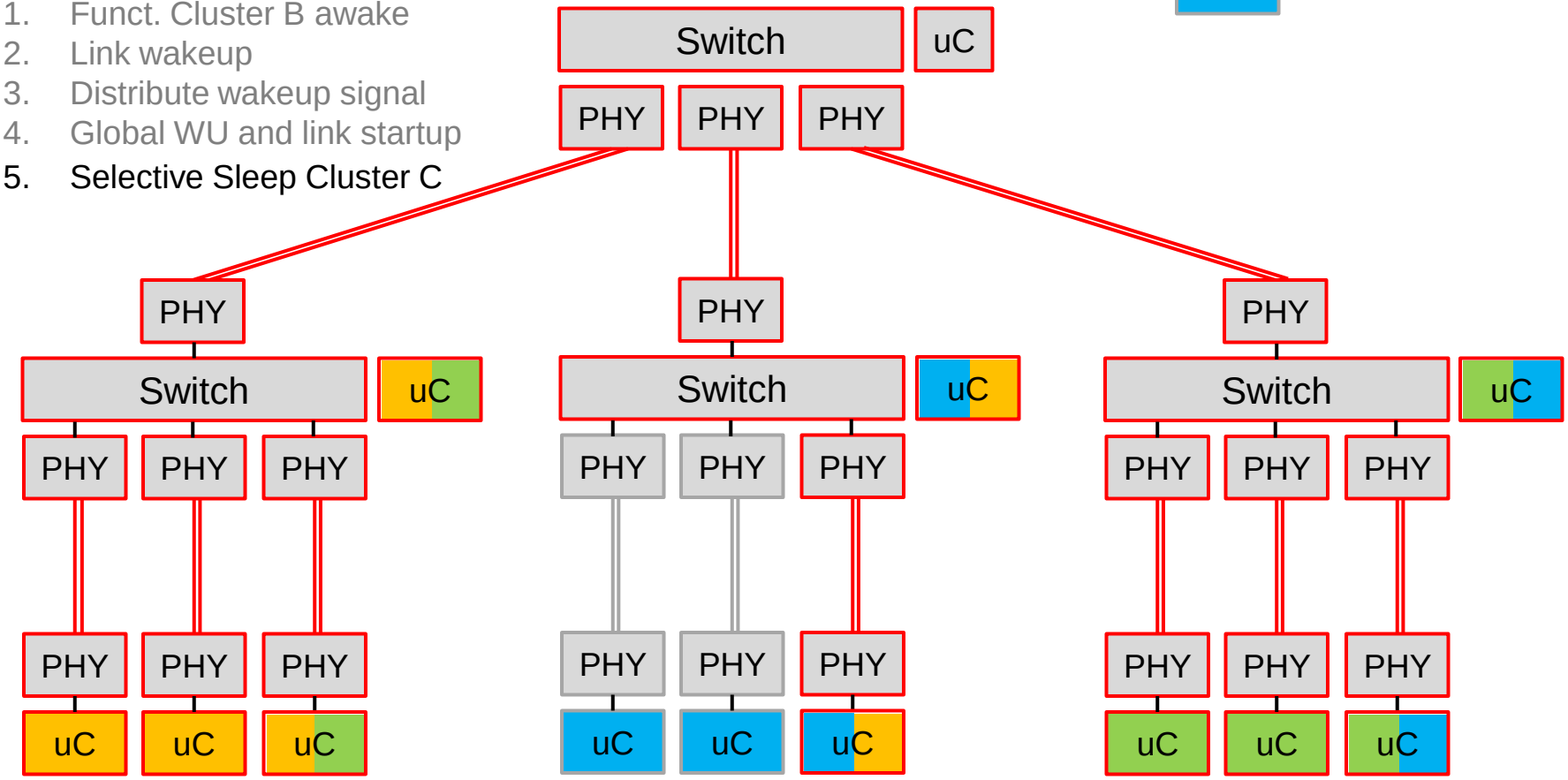
1. Funct. Cluster B awake
2. Link wakeup
3. Distribute wakeup signal
4. Global WU and link startup



Network Wake-up Concepts

3. Global wakeup via Ethernet line

1. Funct. Cluster B awake
2. Link wakeup
3. Distribute wakeup signal
4. Global WU and link startup
5. Selective Sleep Cluster C



Conclusion

- **Global wake-up via Ethernet fulfils all essential requirements**
  - Minimum transition time sleep → wake
  - Network and Switch device unchanged
  - PHY: sourced by 12V + bus activity detector + new services (WUR code)
- **Power consumption in network in quiescent state**
  - P = (# of PHY in network) x (PHY device quiescent power)

    … when remaining node functionality is completely switched off
- **Mechanism is well known and used in AUTOSAR**

Power Saving is Vital for the Success of Automotive Ethernet

Secure Connections for a Smarter World

Thank you!