Energy efficiency options in core networks

NOKIA

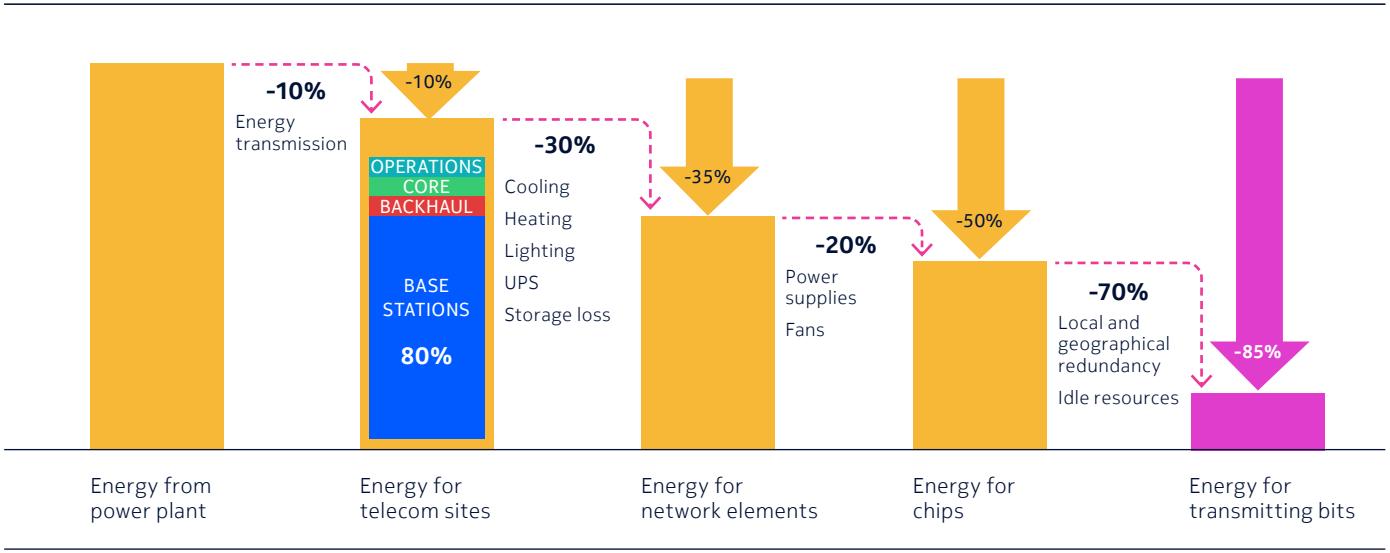
Boosting energy efficiency in core networks

Rising energy costs and the need to address climate change, sustainability and energy efficiency have never been more important.

Nokia has a long history of introducing innovative energy efficiency features in its radio network products. However, the core network has primarily implemented power saving functions provided by underlaying hardware. This is changing as Nokia focuses more sharply also on the application code to help meet rising communications service provider (CSP) demands for energy efficient core solutions.

Nokia and the GSMA have estimated that 80% of total mobile network energy is consumed by the radio access, with the rest accounted for by transport, core, and OSS networks.

Where does the energy go?



UPS: Uninteruptable Power Supplies
Source: Nokia calculations based on published operator figures

Nokia has estimated by information received from mobile operators that 10% of the energy consumed by networks is lost in transmission, while 25% is used by cooling/heating and other systems.

Fans and power supplies consume another 15%. The power needed for redundant components and elements to cover worst case scenarios and achieve desired levels of network availability account for 35% therefore a key to energy saving is to reduce the power, or to shut down, unused resources, which also leads to a reduced demand from fans, UPS, heating, lighting, and cooling.

Potential ways to save power in core networks

1. Power saving driven by the CPU chipset

New chip generations support higher performance and better energy efficiency. Nokia Network Functions and Platform products support the latest hardware generations and technologies with higher performance and more efficient processing with better performance per Watt, to consume less energy.

Enhanced fast CPU C- and P-state transitions. As a reference, the maximum power budget for a single rack mount hardware server can be around 1,200W, while typical power consumption could be much less. Nokia 5G Core Networks often use dual socket CPU servers which together consume 400W, with the rest used by non-core resources.

Several technologies are available from CPU chip vendors to manage CPU power consumption, such as P-states to adjust the CPU frequency per core and C-states to put the CPU core into different sleep modes. These methods with lower frequency and mini sleep states of CPU cores can introduce power savings for the two CPU sockets consuming 400W from the total power budget of a single HW server. However, when the CPU Cores consume less power it means also cumulative power savings for the other components on HW server like for uncore resources, memory, fans, power supplies, etc.

The CPU chip vendors have recently enhanced the transitions between any CPU Core C- and P-states. The fast CPU Core frequency change is supported between any current and any target frequency without delay to the processing. The exit times of CPU Core C-states' (sleep states) are also significantly reduced. Nokia Core Network products can use the enhanced CPU Core frequency and sleep control with appropriate application specific tuning and thresholds.

The Linux operating system kernel can manage the CPU Core C- and P-state transitions. Although these transitions have been available, they could not previously be used by telco grade

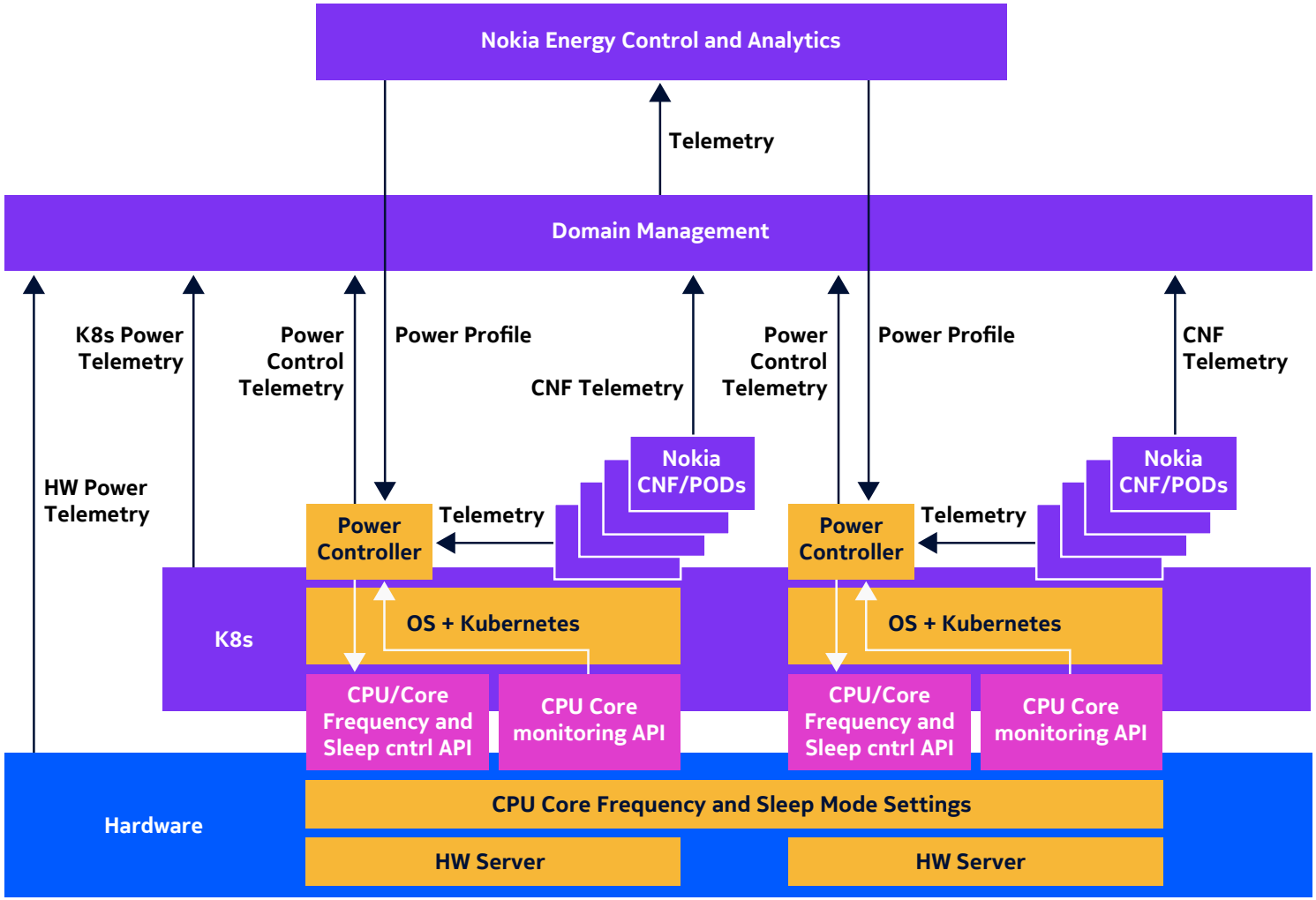
applications due to the too long processing delays and lag involved in returning from sleep mode.

DPDK power saving for network functions with high network throughput. The Data Plane Development Kit (DPDK) is used for high performance network IO applications like user plane network functions.

Applications using DPDK cause the CPU core to continuously poll new received packets. The DPDK library allows nowadays CPU cores to enter C- and P-states directly from the application user space, that was previously only available for the Operating System. The DPDK library now has also enhanced power monitoring APIs and power saving capabilities that support the micro sleep states while waiting for new networking events.

The Power Telemetries obtained from cloud stack are aggregated in Domain Management to get visible for the energy consumption for each platform and application component. The aggregated Power Telemetry provides

Nokia Energy Control Architecture



means to optimize application specific Energy Control and Power Profile. The Power Controllers on Kubernetes Nodes use the application specific Telemetry and Power Profile to change the CPU Core frequency and sleep states.

Intel® Infrastructure Power Manager is dynamically able to control the power per core at runtime to correlate the energy consumption of high performance applications using DPDK to traffic volume.

2. Cluster-level power control

The Kubernetes Power Controller can be used to command Kubernetes nodes to move to a to a high performance profile during peak hours and to a power saving profile during times of low traffic. Each application can request a specific power profile from the Kubernetes nodes used.

Frequency tuning allows individual cores on the system to speed up or slow down to optimize power consumption.

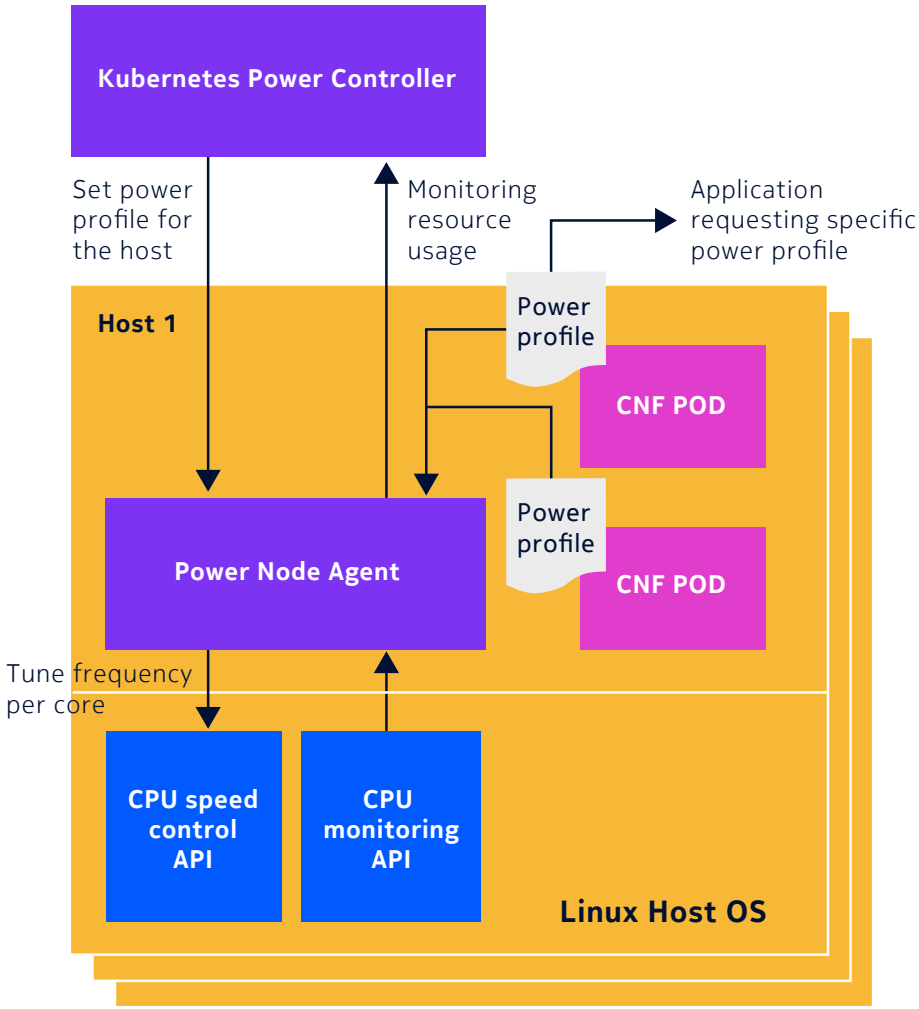
Automated scaling to avoid energy consumption of unnecessary hardware components. Currently all available hardware servers are usually powered on and allocated for workloads. Scale-in and power-off for any unused hardware servers can provide power savings.

3. Core network function power control and architecture enhancements

Network functions with optimized footprint to avoid energy consumption of unnecessary components. Enhancements made to optimize the footprint of network functions will lower the energy consumption. The footprints of Nokia Core Network Functions are optimized continuously.

Network functions that support cloud native automated scaling can avoid energy consumption by unnecessary software components. Nokia Core Network Functions support granular automated and manual scaling to many different needed capacity levels.

Kubernetes Power Manager



4. AI/ML-controlled power savings

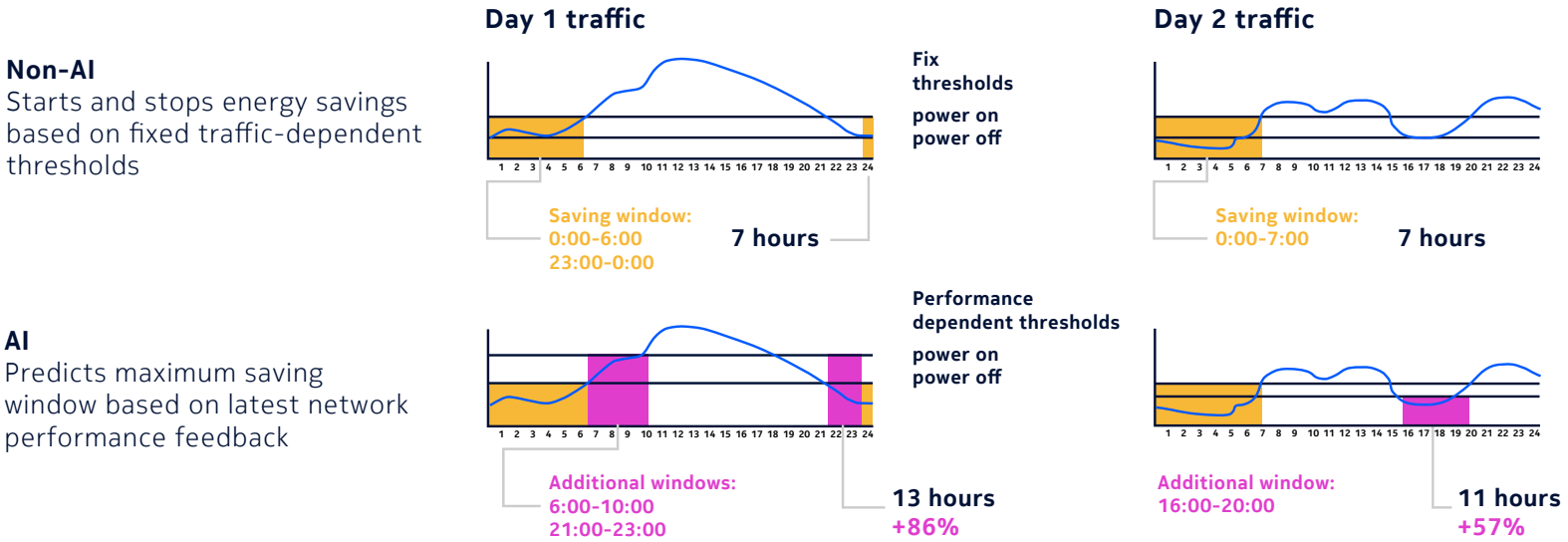
The next leap in energy saving is the use of AI. Artificial Intelligence and Machine Learning (AI/ML) could save power and energy by providing the required network performance and using different power APIs. AI/ML could also control the scaling of application PODs and worker nodes in the Kubernetes Cluster to match the resource allocation to the present traffic volume, maximizing the energy saving

Nokia has already introduced AI/ML on its Cloud Packet Core using using computational system to learn and predict patterns on the network. It rapidly improves processes in areas such as network optimization, demand prediction and overload prevention.

Nokia implemented its solution in the form of a pod known as MLIS (Machine Learning Intelligence Service). Data is collected from various PODs inside the Packet Core and forwarded to MLIS. It is then processed into custom metrics and streamed northbound to a Data Lake. Finally, based on a Traffic Load Prediction Model, adjustments are performed on the network.

Specifically for power savings, the Prediction Model scales the pod up or down using Kubernetes Horizontal Pod AutoScaler. This allows the capacity to be perfectly adjusted to the demand, saving energy in the processing units. After this action is taken, the system returns to the “Learn and Adapt” mode.

Energy saving window without and with AI



5. Power consumption monitoring and reporting

Power consumption monitoring and reporting APIs and tools are needed for both Network Function and Infrastructure products. These are used to improve the power consumption of less efficient software and hardware.

Conclusion

Several technologies can be used to enhance energy efficiency in Nokia core networks. Several of the energy efficiency features introduced above will be adopted by Nokia core network CNFs in both the short- and mid-term.

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Through networks that sense, think and act, we work with our customers and partners to create the digital services and applications of the future.