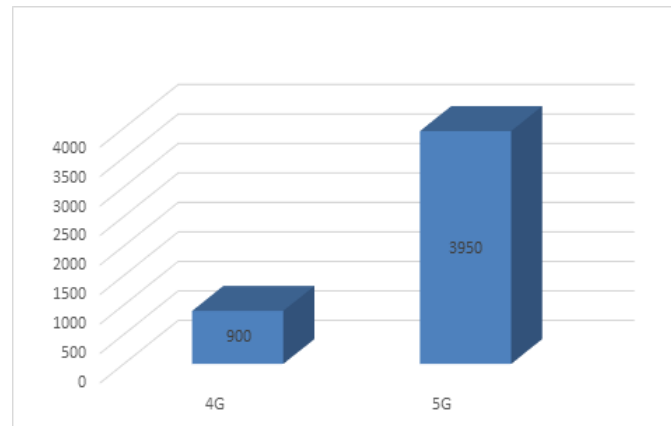
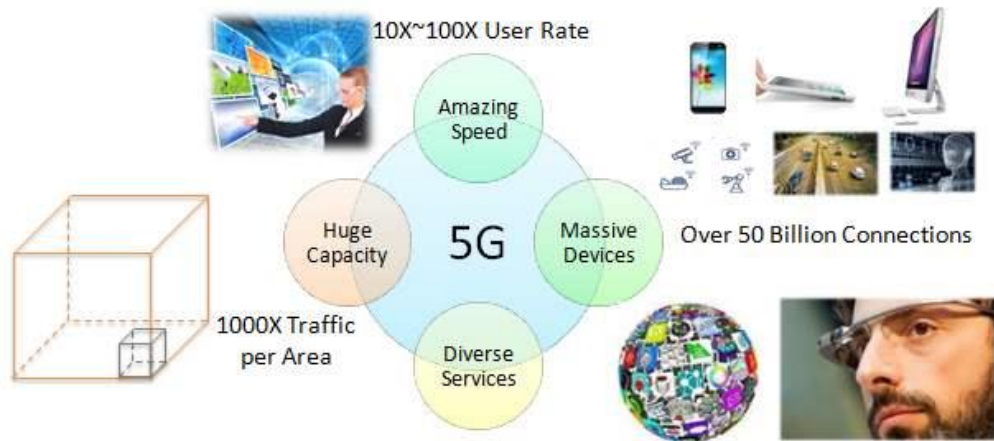


Application of AI technology in 5G base station to Improve Energy efficiency ——Practices of China Telecom

Ying Shi

China Telecom

Background



Energy Consumption of 5G Base Stations in comparison to 4G with a full load

Introduction of energy saving of 5g

There are mainly two method of base station energy saving, which are hardware power saving and software energy saving.

1

Hardware Energy

It is based on lowering the basic energy consumption of the base station. By modifying the hardware architecture design, improving the product craft and enlarging the core chip integrity of base band processing, digital IF and radio frequency. For example, using 10nm/7nm and corresponding high integrity chipset craft to minimize the chipset area, improve system performance and the usage of Gallium nitride and similar new materials to improve the efficiency of AAU power amplifier.

2

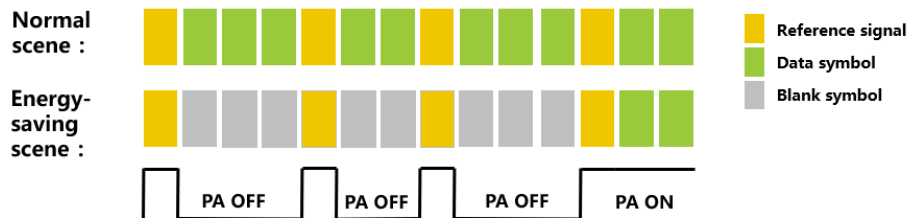
Software Energy

It is based on the software to schedule base station resource according to the service load to keep the base station to run effectively. According to the different characteristics of communication services in time and space distribution and the change of network load, under the premise of ensuring the user's perception experience, the software energy saving adopts dynamical scheduling strategy to different shut down energy saving strategy to base station carrier frequency, channel, symbol or whole machine sleep, so as to increase the working time of equipment in low-power consumption mode and maximize the base station equipment resource utilization efficiency.

Energy saving functions of 4G base station

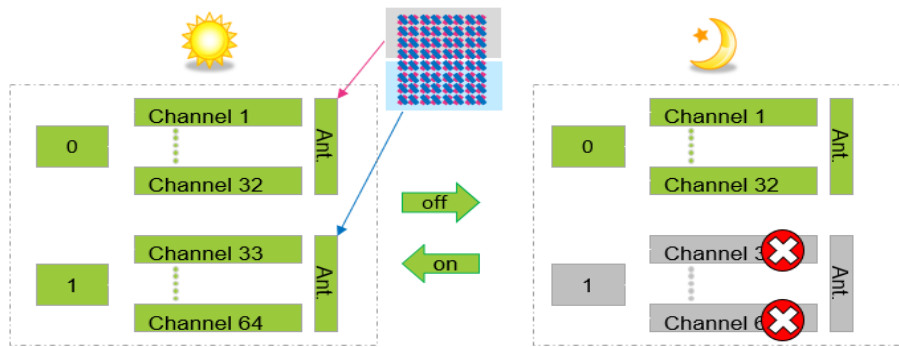
- Energy saving functions of 4G base station equipment includes symbol shut down, channel shut down, carrier frequency shut down, cell sleep, carrier frequency block, etc.

Symbol shutdown

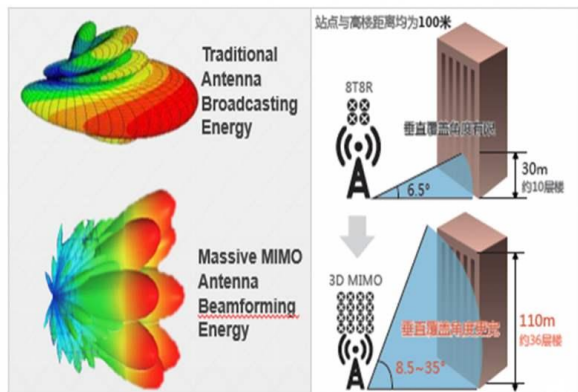


Timeslot shutdown (Enhanced symbol shutdown)

Channel shutdown



Energy saving functions of 5G base station



- Compared with 4G, 5G base station energy-saving function has more clear specifications. Based on 4G symbol turn off, channel turn off and cell sleep functions, 5G base station is upgraded based on 5G characteristics, and new functions such as L-NR carrier cooperative turn off and power control are added. The system can adjust the number of channels, turn on and off of the end power amplifier, and use of carrier frequency independently and regularly.

Energy Saving Functions of 5G base station equipment

symbol shut down



channel shut down



inactivation / blocking

cell sleep



L-NR carrier cooperative shutdown



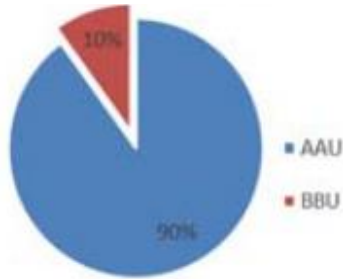
power control



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Proportion of energy consumption of 5G Base Station

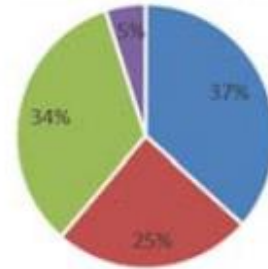
Proportion of energy consumption of 5G Base Station



Proportion of energy consumption of AAU



Full Load



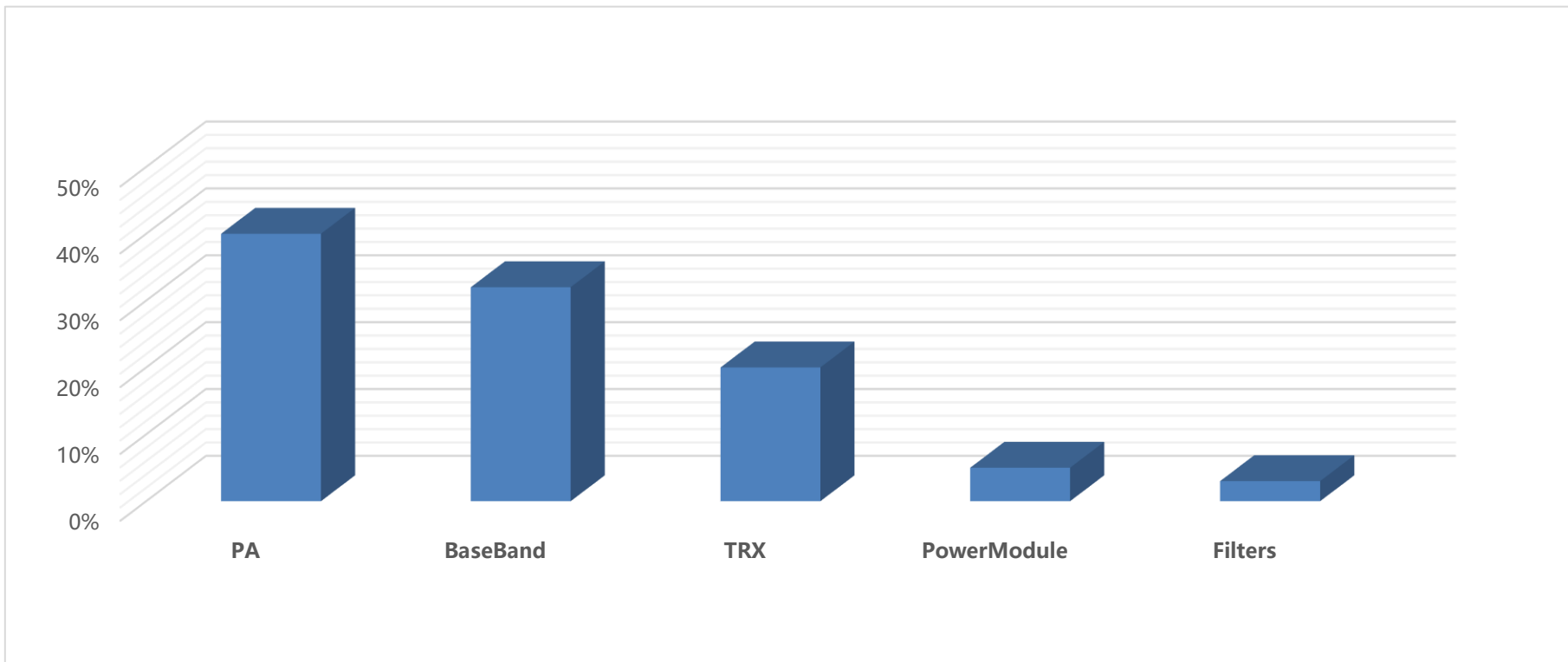
30% of Full Load



No-load

- Power Amplifier
- Small-signal
- Intermediate Frequency
- Power Module

Proportion of energy consumption of AAU



Base station shut down strategy for power saving

- The normally used basic power saving shut down strategy is as following:

1

Symbol shut down

- The symbol shut down function reduces the total power consumed by the power amplifier module through discontinuous transmission when the network is under low load. When the symbol shut down function is turned on, when there is no user data transmission in the downlink symbol, the base station equipment can achieve the purpose of energy saving by actively turning off the transmission power of the power amplifier module in the RF part.

2

Carrier shut down

- For network scenarios with multi-layer coverage, one carrier is used for basic coverage, and the other carrier is used for capacity complementary. According to the periodic monitoring of pRB and other KPIs, the capacity complementary carrier is turned off in the idle period of service to save energy.

3

Channel

- The 5G standard introduces massive MIMO technology. In low base station service load scenarios, such as idle hours at night and non-capacity cell scenarios, it can be considered to turn off the transmission power of some RF channels to achieve energy-saving effect.

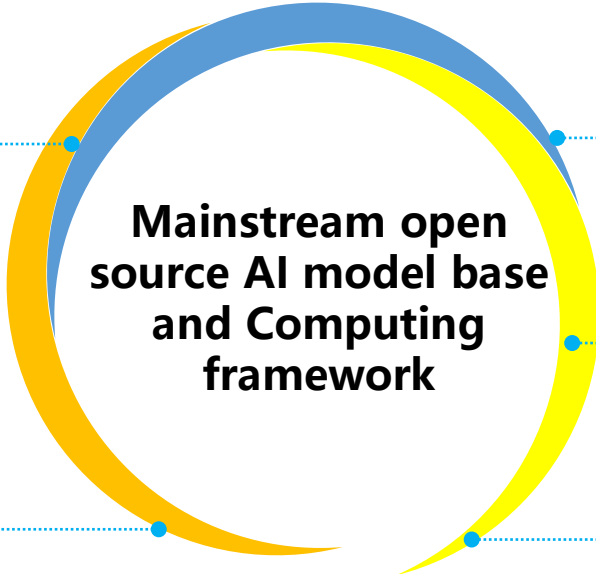
Energy saving technology and solution of 5G base station based on AI

ML/MLlib (Spark)

ML/MLlib (Spark) is spark machine learning library, which can integrate machine learning with spark in a simple, scalable and seamless way (ML mainly operates on dataframe, while MLlib operates on RDD). These libraries can also be used in Python through PySpark.

TensorFlow

TensorFlow is an open source machine learning framework created by Google to support its research and product goals, which is easy to use and deploy on various platforms. The framework allows the development of neural networks and even other computational models using flowcharts. It can be encoded in C++ or Python and run on the CPU or GPU device.



Mainstream open source AI model base and Computing framework

Scikit learn

Scikit learn is an open source library developed for machine learning. It is based on Python and designed on three other open source projects Matplotlib, numpy and SciPy. It focuses on data mining and data analysis, and contains a variety of tools for machine learning tasks.

Keras

Keras is an open source software library designed to simplify the creation of deep learning modeling. It is written in Python and can be deployed on top of other AI technologies, such as TensorFlow.

PyTorch

PyTorch is a machine learning library that provides a wide range of deep learning algorithms. Torch is based on Lua and provides flexibility and speed for optimization.

Energy saving technology and solution of 5G base station based on AI

- Artificial intelligence (AI) technology has been widely used in computer vision, information retrieval, natural language processing, expert systems and other fields.
- Base station energy-saving is a complex system engineering.
- The intelligent energy-saving of base station using AI technology should be combined with the professional understanding, divided into different types of problems, study the characteristics of telecommunication data, and determine the idea of analysis and modeling.
- Through data mining and Feature Engineering, we try to select the appropriate model algorithm and parameter adjustment optimization, through repeatedly training and verification, finally get the model algorithm code with the best balance of recall rate, accuracy and operation performance.
- Because different problems may have different models and algorithms, it is necessary to integrate them effectively to serve subsequent intelligent decision-making.
- In addition, some professional problems may need self-developed algorithms when there is no general model algorithm suitable for solving

Application of AI technology in 5G base stations



- Artificial intelligence (AI) technology has natural advantages in solving high computational data analysis, cross domain feature mining, dynamic strategy generation and so on, which will give new mode and ability of network operation and maintenance in 5G.

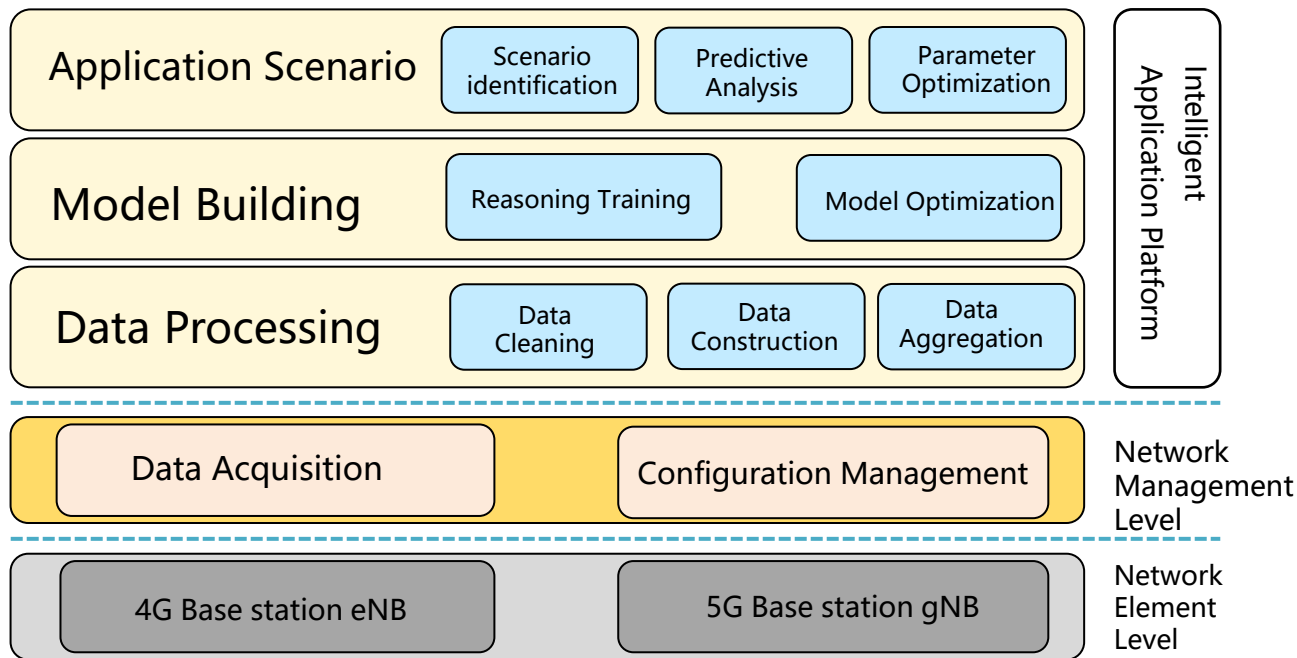


- There is obvious tidal effect in network traffic, and the fluctuation is very large in different periods. However, most of the traditional base station equipment is in 24-hour continuous operation state or shut down according to fixed strategy, which can not be intelligently regulated according to traffic load, which leads to additional energy consumption cost. Therefore, how to improve the utilization of wireless resources has become the general goal of operators.



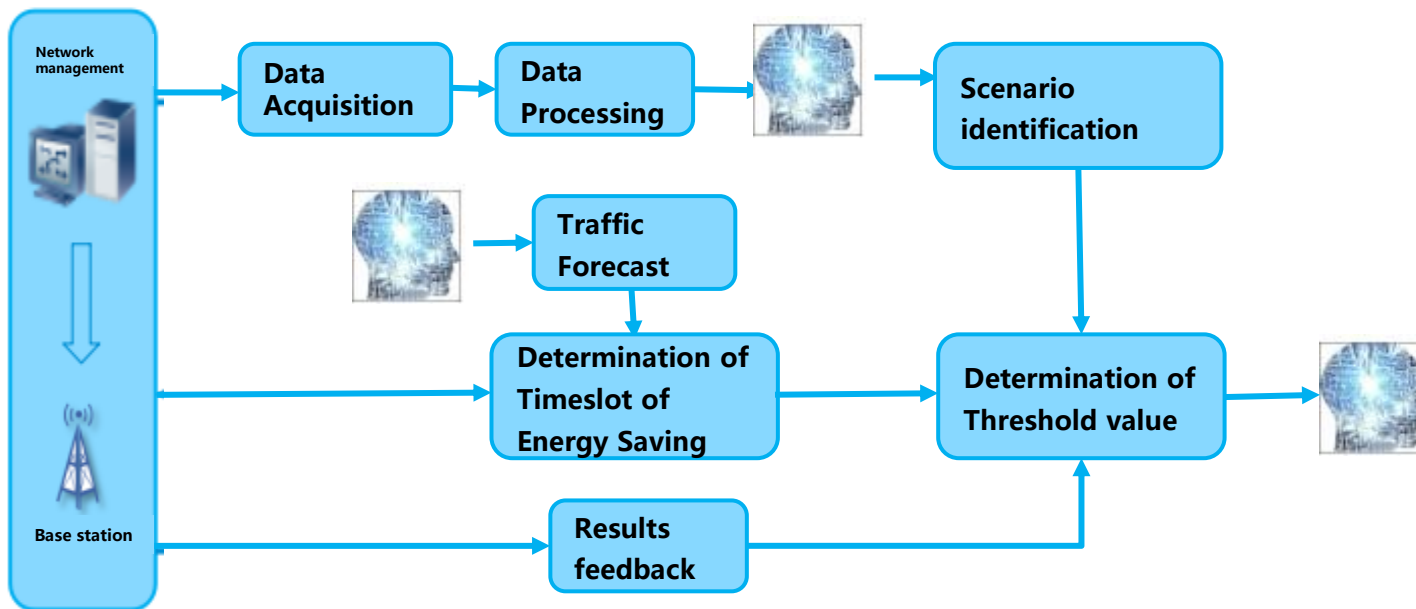
- By collecting historical spatiotemporal characteristic data, analyzing the change law of wireless resource utilization rate, monitoring and evaluating the KPI of the coverage cell, fully considering the network coverage, user distribution and scene characteristics by using artificial intelligence technology, and predicting and evaluating the radio resource utilization rate according to the historical data and real-time data, and giving appropriate suggestions and measures according to the operator's strategy and user's will (such as shutdown strategy, shutdown time and duration, etc.) to ensure network performance and reduce energy consumption.

Energy-saving Scheme of 5G base station Based on AI



Overall architecture of the intelligent energy-saving network

Energy-saving workflow of 5G base station based on AI



Intelligent energy-saving workflow of 5G base station

Outlook of Future Development

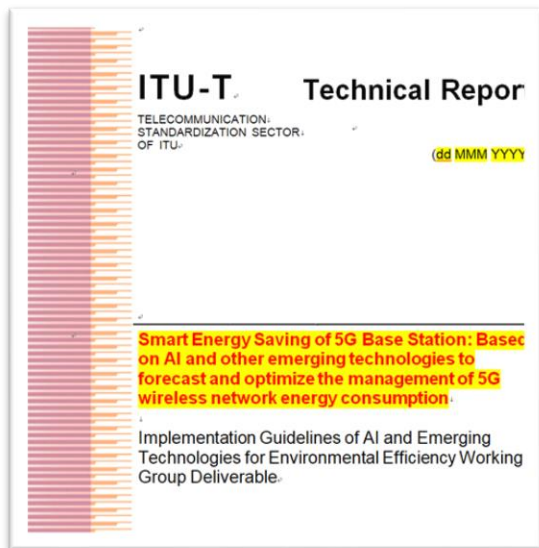


- Energy saving of 5G base station is a long-term systematic work
 - » cooperation of software and hardware
 - » continuous technological innovation
 - new architecture
 - new technology
 - new materials
 - new schemes
 - new designs



- Artificial intelligence technology plays an important role in 5G base station energy-saving and will effectively reduce the OPEX cost of operators and improve the market competitiveness and sustainable development ability of operators.

D.WG3-01 of FG AI4EE



Want to know more about how AI help saving energy of 5G Base station?

Please follow the work of D.WG3-01 of FG AI4EE!



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THANKS !

