IZMIR KATIP CELEBI UNIVERSITY

Faculty: “Information Technologies and Management”

Department: “Software Engineering”

Graduation work

"Development system for forecasting of supercomputer performance"

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ABSTRACT

Subject: “Development system for forecasting of supercomputer performance” .

The research purpose:–The purpose of the graduation work is to create a system for forecasting the performance of supercomputers in Python. Forecasting is one of the most important topics in modern times and Python is one of the best programs used to create forecasting systems with the help of the different libraries. A system for forecasting the performance of supercomputers has been created here.

The research result: The graduation work is devoted to forecasting the performance of modern supercomputers. The main stages of forecasting in the graduation work were as follows: Selection of modern supercomputers; Review of forecasting methods; Using the Stats models library in Python.

Keywords: supercomputer, forecasting, Machine learning techniques, Python

Content

Introduction

The purpose of the graduation work is development a performance estimation system of supercomputers. Forecasting is a scientific discipline that studies the general principles of forecasting, the laws of forecasting. There are various types that are used for forecasting systems, but I prefer Python because it has different type of libraries especially for forecasting which we conduct it with the help of the previous years' results for the next years. Today, Python is one of the best programs used to create forecasting systems with the help of its different libraries. The graduation work consists of three chapters.

CHAPTER 1 RESEARCH OF A SUBJECT AREA

This chapter provides common information on the history of supercomputers, their classification and architecture .Nowadays supercomputers are most used utilities according to their convenient use. As you know a supercomputer consists of a large number of multicore systems integrated into a common system for high performance.

CHAPTER 2 BASIC OF FORECASTING

This chapter provides information on the concepts of forecasting and major methods. Here you can get various information about forecasting with the help of these methods. Different forecasting methods, which are many today, must be used for production, but in practice we use only some of them. We'll focus on the most popular forecasting methods.Also there are several steps to properly assessing the forecasting process.

CHAPTER 3 ISSUES OF PRACTICAL IMPLEMENTATION

In this last chapter, we analyze the features of Python for programming forecasting problem, practice problem was solved and analyzed . Time sequence problems can be classified and estimated through machine learning techniques. There are a lot of libraries in Python which can help us for predicting for the subsequent years with the help of the previous years' results. I've showen all examples in Python and use Stats models library.

CHAPTER 1. RESEARCH OF A SUBJECT AREA

1.1. Review of supercomputers

Supercomputer is a specialized computer with excellent characteristics and speed of computing, common in the world of computers. Modern supercomputers are commonly made up of a large number of high-performance server computers linked by a local high-speed backbone in order to ensure optimum performance whenever parallelizing a computing task. A supercomputer consists of a large number of multicore systems integrated into a common system for high performance. Another difference from conventional PCs is the large size. The equipment is located in several rooms, occupying entire floors and buildings. Supercomputers solve a variety of problems - from complex mathematical calculations and processing huge data arrays to modeling artificial intelligence. There are models that reproduce the "architecture" of the human brain. Supercomputers design industrial equipment and electronics, synthesize new materials and make scientific discoveries. The definition / 1 / of "supercomputer" has been the subject of much debate and discussion more than once. Most often, the authorship of the term is attributed to George Michael (George Anthony Michael) and Sidney Fernbach (Sidney Fernbach), who worked in the Livermore National Laboratory in the late 60s of the XX century, and the company CDC. Nevertheless, the fact is known that in 1920 the New York World newspaper talked about "super-computations" carried out using the IBM tabulator, commissioned by Columbia University. The term “supercomputer” has entered the common vocabulary due to the prevalence of Seymour Cray computer systems, such as CDC 6600, CDC 7600, Cray-1, Cray-2, Cray-3 (English) and Cray-4 (English). Seymour Cray developed computing machines, which essentially became the main computing tools of US government, industrial, and academic science and technology projects from the mid-60s to 1996. It was no coincidence that at that time one of the most popular definitions of a supercomputer was the following: - "any computer that Seymour Cray created." Cray himself never called his offspring supercomputers, preferring to use the usual name "computer" instead.

The Top500 / 2 / list was released in June. Top500 is a project that aims to compile a list of the world's 500 most powerful publicly recognized computing systems, along with ratings and descriptions. The project is celebrating its 25th anniversary, and while it cannot be happy, the list was revised in contrast to previous editions, with 133 new systems and new favorites taking the top spots.The performance of a supercomputer is usually restrained in floating point operations (FLOPS) per second instead of millions of instructions (MIPS) per second. Since 2017, there are supercomputers that can accomplish 1017 FLOPS (one hundred quadrillion FLOPS, a hundred peta FLOPS or a hundred PFLOPS). Since Nov 2017, all of the world's five hundred quickest supercomputers lane on Linux-based operative systems. further analysis is afoot within the us, the Union, Taiwan, Japan and China to form quicker, additional powerful and technologically advanced superior supercomputers.

LINPACK is a digital line algebra software reference library for digital computers. Written by Jack Dongarra, Jim Bunch, Cleve Moler and Gilbert Stewart at Fortran, it was established for usage in supercomputers in the 1970s and primary 1980s. It has been largely replaced by LAPACK, which works more efficiently in modern architecture. Basic vector and matrix operations are performed by LINPACK using BLAS (Basic Linear Algebra Subprograms) libraries. LINPACK indicators first appeared as part of the LINPACK user guide.

1.Summit - IBM (USA):

IBM and the US Department of Energy's Oak Ridge National Laboratory collaborated on the computing complex (ORNL) / 3 /. The world leader has declared a productivity of 200 petaflops, which is equivalent to 200 thousand trillion calculations per second. For contrast, the Chinese Sunway TaihuLighto supercomputer has an output of 93 petaflops. Summit - IBM is made up of 4,608 servers, with a total RAM capacity of 10 petabytes and a footprint of two tennis courts.

Figure1.1. Summit components

2.Sunway TaihuLight - NCRPC (China):

Sunway TaihuLight is a Chinese supercomputer which, from June 2016 to June 2018 ,was the highest performing supercomputer in the world with a 93 petaflops production system, according to LINPACK tests. This speed is calculated more than 2.5 times faster than the previous world record holder Tianhe-2, which has a processing power of almost 34 petaflops. Peak characteristics of Sunway TaihuLight - 125.43 petaflops against 54.9 petaflops for Tianhe-2.In addition, as of June 2016, Sunway TaihuLight is ranked third in the Green500 list of the most efficient energy efficient supercomputers with a score of 6 gigaflops / watt (measured by Linpack).The cost of this system is approximately US $ 1.8 billion, funded in equal shares by the central government of Jiangsu province and Wuxi city. To parallelize the code, the system offers a number of programming interfaces: its own implementation of OpenACC 0.5, a limited implementation of OpenMP, and a simplified a threads threading library. The total number of processors in the system is 40,960, each processor contains 4 general-purpose control cores and 256 specialized RISC computing cores, which in total gives 10,649,600 cores Processor cores contain 64KB of internal memory for data and an additional 16KB for instructions . The previous most productive Chinese supercomputers Tianhe-1A and Tianhe-2 were built on the processors of the American company Intel.

Figure1.2. Sunway TaihuLight - NCRPC (China) supercomputer

3. Sierra (ATS-2)

Sierra (ATS-2) is a supercomputer created for the Livermore National Laboratory. Lawrence. The US National Nuclear Safety Administration employs the second Advanced Technology System. Used to assist in the management of the US nuclear arsenal, improve the security, effectiveness, and usefulness of US nuclear weapons. The theoretical performance of Sierra is estimated at 125 PFlops, almost achieved on the LINPACK 94.6 PFlops performance test. Sierra, a summit set at Oak Ridge National Laboratory. Sierra is powered by IBM POWER9 CPUs as well as Nvidia Tesla V100 GPUs. These nodes are interconnected using the EDR InfiniBand network. There is a system similar in power to the Sierra Lassen supercomputer system, with a production system of about 18 PFlops on the LINPACK test.

Figure1.3. Sierra (ATS-2) supercomputer

4. Tianhe - 2A - NUDT (China):

Tianhe-2 is a supercomputer designed by the People's Republic of China Defense Science and Technology University and Inspur. Although the supercomputer is currently housed at the PLA University Defense Science and Technology Center, it will eventually be relocated to Guangzhou's National Supercomputer Center. At first it was planned to finish the project in 2015, but it was possible to launch it ahead of schedule.Tianhe-2 took first place in the TOP500 supercomputers in the world in June 2013, but lost the championship after the launch of Sunway TaihuLight. The supercomputer achieves more than 33.8 Pflops in the HPL Linpack benchmark (33.8 * 1015 operations per second), its theoretical peak performance is about 54.9 Pflops.

Figure1.4. Tianhe - 2A - NUDT (China) supercomputer

5. Piz Daint - Cray (Switzerland):

The newcomer to the Top 10 list is called "Piz Daint", unlike most other supercomputers located in America or Asia, it is in Europe, namely Switzerland. To be honest, "Piz Daint" is not a newbie, but after the update it got a new round of performance. The supercomputer originally consisted of 12 racks (Cray XC30 with Intel Xeon E5 processors) and ranked 42nd in the ranking. In recent weeks, the supercomputer at the Swiss National Supercomputing Center (CSCS) has received 16 more racks with five thousand NVIDIA graphics cards. In total, the supercomputer uses 5.272 Tesla K20X graphics cards and consists of 28 racks. The system can achieve computational performance up to 6.27 petaflops (Rmax) in the Linpack benchmark. Possible short-term peak load up to 7.8 petaflops (Rpeak).In addition, the Swiss supercomputer emphasizes efficiency. "Piz Daint" boasts a ratio of about 3.110 megaflops per watt, making it the most energy efficient of 31 petaflop supercomputers in the world. The competitor "Stampede" delivers an efficiency of just 1.146 megaflops per watt. The Piz Daint task will be to calculate the weather forecast for seven weather services in Europe. So far, no shifts in the Top 10 ranking are expected. The Chinese supercomputer "Tianhe 2" continues to lead with a performance of 33.86 petaflops, it consists of more than 3.1 million x86 cores, a significant gap from second place with 17.59 petaflops.

Figure1.5. Piz Daint - Cray (Switzerland) supercomputer

6. Trinity - Cray (USA): In December 2013, NERSC and ACES announced a joint RFP for Trinity that would include technical specifications. Formation: Cray XC40, Memory Volume: 2.07 PiB, Number of Calculating Nodes: 19,420, Parallel File System Capacity: 78 PB, Cray XC40, Cray XC40, Cray XC40, Cray XC40, Cray XC40, Cray XC40, Cray X Trinity was constructed in two phases . The Intel Xeon Haswell processor was used in the first stage, while the Intel Xeon Phi Knights processor was used in the second stage to provide a major performance boost. The shared computer has a combined peak capacity of over 40 PF/s, with 301,952 Haswell and 678,912 Knights Landing processors. There are 5 primary storage levels: Burst Buffer,Memory, Campaign Storage, Parallel File System, and Archive.

Figure1.6. Trinity - Cray (USA) supercomputer

5 MOST AUTHORITATIVE SUPERCOMPUTERS:

1.Summit:

Supercomputer Summit / 4 /, created by the American company IBM for the National Laboratory in Oakridge. The equipment was put into operation in the summer of 2018, replacing the Titan model, which was considered the most productive American Supercomputer. The development of the best modern supercomputer cost the US government $ 200 million. The device consumes about 15 MW of electricity - as much as a small hydroelectric power station produces. To cool the computing system, 15.1 cubic meters of water circulating through the tubes are used. IBM servers are located on an area of about 930 square meters - the territory occupied by 2 basketball courts. Computer performance is provided by 9216 processors of the IBM POWER9 model and 27648 Tesla V100 graphics chips from Nvidia. The system received as much as 512 GB of RAM and 250 PB of read-only memory (2.5 TB / s interface). The maximum calculation speed is 200 Pflops, and the nominal performance is 143.5 Pflops. According to American scientists, the launch of the Summit model has increased the computing power in the energy sector, economic competitiveness and national security. Among the tasks that will be solved with the help of a supercomputer, they note the search for a connection between cancers and genes of a living organism, a study of the causes of drug dependence and climate modeling to make accurate weather forecasts.

2. Sierra

The second American supercomputer Sierra (ATS-2) was also released in 2018 and cost the United States about $ 125 million. In terms of performance, it is considered the second, although in terms of average and maximum levels of computation speed it is comparable to the Chinese model Sunway TaihuLight. The Supercomputer is located on the territory of the E. Lawrence National Laboratory in Livermore. The total area occupied by the equipment is about 600 sq.m. The power consumption of the computing system is 12 MW. And by the ratio of productivity to electricity consumption, the computer noticeably overtook a competitor from China. The system uses 2 types of processors - server CPUs IBM Power 9 and graphic Nvidia Volta. It was possible to improve both energy efficiency and productivity using these chips. 125.712 Pflops (or 125 quadrillion floating point operations per second) is the maximum performance. The new device would specifically be used for scientific research. First of all, for calculations in the field of nuclear weapons, replacing underground tests with calculations. Engineering calculations using Sierra will allow you to understand key issues in the field of physics, knowledge of which will make a number of scientific discoveries.

3. Sunway Taihulight

The Chinese Supercomputer held a leading position in the TOP500 ranking from 2016 to 2018. According to LINPACK tests, it was considered the most productive supercomputer, at least one and a half times superior to its closest competitor and three times ahead of the most powerful American model Titan. The development and construction of a computer system cost 1.8 billion yuan or $ 270 million. The investors of the project were the government of China, the administration of the Chinese province of Jiangsu and the city of Wuxi. It is headquartered in the central supercomputer center in Wuxi, China. The name of the model was given in honor of the nearby Taihu Lake, the third largest freshwater reservoir in China. The presence of 41,000 SW26010 processors and 10.6 million cores in the design of the computer allows it to carry out calculations at a speed of 93 Pflops. Maximum performance - 125 Pflops. The transition to Chinese-made chips required developers to create a completely new system. Prior to this, it was supposed to increase the performance of another Chinese Tianhe-2 Supercomputer by 2 times, but these intentions had to be changed due to problems with the supply of Intel processors from the USA. The Sunway TaihuLight model is used to perform complex calculations in the fields of medicine, mining and manufacturing. With the help of a computer, weather is predicted, new drugs are researched, and “big data” is analyzed - data arrays that cannot be processed even by the most powerful serial computer.

4. Tianhe 2

The Tianhe-2 supercomputer (“Milky Way”), or rather, the already supplemented and modernized version 2A, was developed by employees of Inspur and the University of Science and Technology of the People's Liberation Army of China. In July 2013, the model was considered the most productive in the world and lost the palm only to another Chinese TaihuLight computer. About 200 million dollars were spent on computer assembly. At first, the computer system was located on the territory of the university, and then was moved to a supercomputer center in Guangzhou. The total area it occupies is about 720 square meters. The equipment is based on 80 thousand Intel Xeon and Xeon Phi CPUs. The amount of RAM is 1400 GB, the number of computing cores is more than 3 million. The first performance indicators of the system are 33.8 Pflops, the modern modification reaches a calculation speed of 61.4 Pflops, the maximum - 100.679 Pflops. The supercomputers were created at the request of the Chinese government, its main tasks are calculations for projects on a national scale.

5. Piz Daint

For a long time (from 2013 to 2018), the Piz Daint supercomputer ranks third in the ranking of the most powerful computing systems in the world. Simultaneously time, it continues to be Europe's most productive device. The project was estimated to have cost about 40 million Swiss francs. The model was named after the territory of the same name in the Swiss Alps and is located in the national supercomputer center. The equipment that the Supercomputer consists of is located in 28 racks. For the operation of the equipment, 2.3 MW of electricity is required, and according to this indicator Piz Daint provides the best specific productivity - 9.2 Pflops / MW. The computer includes another Piz Dora supercomputer, which first worked separately. After combining the capacities, the Swiss developers received a computing system with 362 thousand cores (Xeon E5-2690v3 processors) with a nominal capacity of 21.23 Pflops. Maximum speed - 27 Pflops.

The main tasks of the supercomputer are calculations for research in the field of geophysics, meteorology, physics and climatology. One of the computer applications, COSMO, is a meteorological model and is used by the weather services of Germany and Switzerland to obtain highly accurate weather forecasts. Supercomputers are used in all areas where numerical modeling is used to solve the problem; where a huge amount of complex calculations is required, processing a large amount of data in real time, or solving a problem can be found by simply enumerating the set of values of the set of initial parameters (see Monte Carlo Method).

1.2. Architecture of supercomputers

Tactics to architecture of supercomputers were orientated within the sixties have taken dramatic chances since the original systems. Early mainframe architectures relied on compact innovative styles and native correspondence to achieve superior procedure peak performance based by queen Cray. However, as the age of massively parallel systems approached, the need for increased procedure power grew. Whereas supercomputers of the Seventies used solely some processors, within the Nineteen Nineties devices with thousands of processors began to appear as if by the top of the twentieth period there have been selfsame parallel supercomputers.21st century supercomputers will use quite a hundred,000 processors (some of that square measure graphics modules) that square measure connected by poor connections. / 5 / Throughout the periods, the management of warmth density has endured a motivating issue for many unified supercomputers. the big quantity of warmth generated by the system also can produce other effects, like shortening the lifetime of different system devices. There are numerous methods to heat supervision, from pumping Fluorinert over the system, air cooling with traditional air-con temperatures or to a hybrid liquid-air cooling system. Systems with an enormous vary of processors usually take one in each of two paths: in one approach, e.g., For grid computing, the procedure energy of a large number of distributed computers is opportunistically used whenever a computer is available, across a range of body domains.In another maneuver, an oversized range of processors square measure utilized in shut immediacy to every different, e.g., in an exceedingly pc cluster. In such a unified massively parallel system the pliability and speed of the interconnect becomes terribly important, and up to date supercomputers have used varied approaches starting from heightened Infiniband systems to three-dimensional torus interconnects. InfiniBand (IB) is a computer networking infrastructures standard that used in high-performance computation that features very low inexpression and very high throughout . It is used for data interrelate both among and within computers. InfiniBand is similarly used as either a direct or substituted interconnect between storage systems and servers, as well as an interrelate between storage systems.

Figure1.7.A torus interconnect

A torus interconnect / 9 / is a switch-less network topology for concerning processing nodes in a parallel computer system.

The strength and proliferation of supercomputers has exploded since the late 1960s, and the key architectural lines of these devices have changed dramatically. As the first supercomputers used a small number of closely coupled processors that shared memory, today's supercomputers employ over 100,000 processors connected by fast networks. The density of warmth generated by a mainframe is directly associated with the sort of processor utilized in the system, with additional powerful processors usually generating additional heat given similar underlying semiconductor technologies. whereas early supercomputers used many quick, densely packed processors that took advantage of native correspondence (such as pipelining and vector processing), over time the quantity of processors grew and work out nodes may well be situated more away, like in a very laptop cluster, or will be geographically spread in grid computing. because the range of processors in a very mainframe grows, "component failure rates" become a serious concern. If a mainframe uses thousands of nodes, every of which may fail on the average once a year, then the system can expertise multiple node failures on a daily basis. because the performance / worth proportion of all-purpose illustrations dispensation units (GPGPU) increased, variety of petaflop supercomputers like Tianhe-I and Nebulae commenced to have faith in them. However, different systems, like the K laptop, tolerate the employment of conservative processors like SPARC-based styles, and also the universal relevancy of GPGPU in all-purpose superior computing applications may be a matter of dispute, because the GPGPU will be tuned for analysis on specific tests, its general relevancy to everyday algorithms will be restricted if important effort isn't spent on customizing the appliance to try to to thus. However, GPUs are gaining momentum, and in 2012, Jaguar's supercomputer was altered into a Titan by substituting processors with GPUs. As the variety of independent processors in a very mainframe computer cultivates, it becomes apparent however they access knowledge within the classification system and the way they share and make contact with memory device resources. variety of distributed file management systems are industrial over the years, like IBM General Parallel classification system, BeeGFS, Parallel Virtual classification system, Hadoop, etc. variety of TOP100 supercomputers like Tianhe-I use Linux's Lustre classification system additionally as lustre could be a form of parallel distributed classification system, typically used for large-scale cluster hard.

Early systems:

The CDC 6600 range machines were early attempts towards supercomputers that acquired an advantage over conventional systems by offloading work to peripherals, allowing the CPU (central processing unit) to focus on data processing./ 6 /

Figure1.8. The CDC 6600

Other early supercomputers, like the Cray one and Cray a pair of, that came later, used a little variety of quick processors that operated systematically and were consistently connected to the main quantity of collective memory that would be achieved at the time. These early architectures presented multiprocessing at the processor level, with inventions like vector process, within which the processor will perform multiple operations during a single clock cycle rather than looking ahead to sequential cycles. numerous study issues arose. The 2 problems that require to be self-addressed because the variety of processors will increase square measure memory allocation and process. within the distributed memory approach, every processor is physically packed along side some native memory. Memory certain to alternative processors is then "farther away" supported information measure and latency parameters for non-uniform memory accesses. within the Nineteen Sixties, pipelining was thought of associate innovation, and by the Nineteen Seventies the utilization of vector processors was well established. By the Nineteen Eighties, several supercomputers were mistreatment parallel vector processors. The comparatively tiny variety of processors in early systems permitted them to simply use the shared memory design, that permits processors to access a shared pool of memory. Within the period of time, a typical approach was to use unified operation (UMA), within which the time interval to a section of memory was constant for various processors. The employment of non-uniform operation (NUMA) allowed the processor to access its own native memory quicker than alternative memory locations, whereas cache-only memory architectures (COMA) allowed every processor's native memory to be used as a cache, therefore requiring matching once dynamic memory values. Because the variety of processors upsurges, well-organized interprocessor communication and synchronization on a mainframe computer converts to a challenge. many approaches will be wont to deliver the goods this goal. During this approach, all processors had admittance to collective registers, that failed to move information back and forth, however were solely used for interprocessor communication and synchronization.

Figure1.9. Cylindrical shape of early Cray computers with centralized access to reduce distances and uniformity.

Massive centralized parallelism:

During the 1980s, as the request for calculating power increased, shared memory architectures could not expand to as many processors, and there was a tendency for more processors to enter the era of mass-distributed memory and distributed file systems. Hybrid approaches, such as shared memory, also emerged after early systems. Computer clustering incorporates a number of computing nodes (personal computers that act as servers) that can be easily reached over a fast dedicated local area network. The actions of compute nodes are controlled by a "clustered medium program" that sits on top of the nodes and allows users to visualize an entire cluster with an interconnected computing unit, such as a single system image concept. Computer grouping is based on a centralized management approach that presents nodes as sequentially shared servers. It also differs from other methods, such as peer-peer or grid computing, which use many nodes but are more common in nature. For the 21st century, the semi-annual lean of the 500 fastest supercomputers often includes numerous groups, such as memory and cluster architecture, which were distributed in 2011 as the world's fastest computers. Contemporary supercomputers take various approaches to solving this issue, such as Infiniband's own high-speed network based on Infiniband QDR, which is supported by Tianhe-1 and FeiTeng-1000 processors.

Figure1.10. A Blue Gene / L cabinet with stacked blades, each with multiple processors.

Massive distributed parallelism:

Network computing is used by a large number of computers in various administrative areas. This is an opportunistic approach that is used when resources are available. An example of this is BOINC, a flexible, voluntary-based network system. Contemporary supercomputers take various approaches to solving this issue, such as Infiniband's own high-speed network based on Infiniband QDR, which is supported by Tianhe-1 and FeiTeng-1000 processors. However, these types of results are generally not included in the TOP500 rankings because they do not meet the Linpack standard. Although network computing is successful when tasks are performed in parallel, supercomputer applications such as air modeling or computing fluid dynamics (CFD) are partly hindering the reliable distribution of a large number of tasks and at the same time resources. Semi-opportunistic supercomputers.The crashed computer is arranged with internal security features. The kazi-opportunistic approach allows for unobtrusive access to multiple computing groups in programs available in such languages, with the average software going beyond voluntary computing in highly distributed systems such as BOINC or global computing in a system such as Globus. It can be spread to many computing sources such as Fortran or C. Quasi-opportunistic supercomputers strive to provide a higher quality service than flexible resource sharing. The quasi-opportunistic approach allows complex applications to work on computer networks by concluding supply-side distribution agreements; and to deliver some tolerance while delivering tolerant messages to defects to protect abstractly from the frustration of key sources and thus provide a higher level of control. Cluster features:

1. Heterogeneous connection - slow between nodes (latency from micro milliseconds) and fast (nanoseconds) between processors on the same node.
2. Reasonably priced - the price is comparable to that of industrial equipment.
3. Sizeable deployments are possible, with the largest existing installations containing up to 10,000 nodes.
4. Fault Tolerance - If a single node fails, the cluster does not come to a halt.
5. Green - Inactive nodes can be shut down.

Figure1.11.Clusters

21st century architectural trends

The cool IBM Blue sequence mainframe style combines processor speed with low power consumption to make sure that additional processors run at temperature mistreatment typical air-con. Processors with integrated communication logic between nodes are used in the second generation Blue sequence / P method. Its energy economical and reaches 371 MFLOPS / Watt.

Computer K may be a homogenous cluster design with distributed memory and water cooling. It uses quite eighty,000 SPARC64 VIII processors, every with eight cores, for a complete of quite 700,000 cores - concerning doubly the quantity of alternative systems. It includes quite 800 cupboards with ninety six cipher nodes (each with sixteen GB of memory) and half dozen G / C nodes. It's 112 pc cupboards and two62 terabytes of spread recollection; 2 computer memory unit disk loading was applied mistreatment Luster clustered records. Tianhe-1 uses a special high-speed communication network to attach the processors. The dedicated network was supported the Infiniband QDR, complete with Chinese-made FeiTeng-1000 processors. The machine is times as quick as Infiniband in terms of communications, but slower than certain connections on other supercomputers. Figure1.12.Cray XE6.

CHAPTER 2. BASIC OF FORECASTING

2.1. Fundamentals of forecasting

Man's need to foresee the future stems from the nature of his mind and his desire to know and explain the alleged events, phenomena and processes. At different stages of the development of civilization, the prediction of the future was expressed in different forms. / 14 / They were based on the level of human thought and cognition, as well as social situations arising from a number of objective and subjective reasons. However, in all periods of society's development, man's ability to foresee the future was inextricably linked with his ability to evaluate the past correctly. Their reluctance or deliberate distortion of the regularities of past events led to a misinterpretation of the course of history and contributed to the development of mystical ideas. This is especially true of some religious teachings based on the belief in supernatural, courageous forces that determine the development of nature and society. The next stage in the development of future knowledge was the emergence of Marxism, which organically combined dialectical-materialist philosophy and political economy. Unlike utopian and religious teachings, Marxism did not aim to accurately describe the future, but laid down the basic laws of social development and defined the objective conditions for the transition to communist society. He proved the ability to scientifically predict, influence and manage the development of social processes. It should be noted that in all periods of human development, many social, weather, climatic and general geographical predictions were sometimes completely fulfilled, although scientific methods were not used to build them. Many events in modern life have been predicted using a whole arsenal of scientific predictions. For example, according to the 1960 forecast, a person's descent to the moon was dated 1970 (actually 1969); most of the elementary particles found in practice (neutrons, neutrinos, mu-mesons, etc.) were theoretically predicted 5-15 years before their discovery; even the discovery of the islands was predicted. Thus, in both the first and second cases, despite the different degrees of scientific reliability, we have a positive prognosis. It is important to remember some principles from probability theory in order to understand this situation. An event is an occurrence that could or could not occur. Each result of a random event is given a certain probability. The more results an event has, the less likely a result is. With an unknown result - an unscientific forecast of events. Probability theory, on the other hand, incorporates the concept of the distribution law of random variables. However, in addition to probability theory, there are other laws on which forecasting is based. All of those are, first and foremost, the laws of natural, social, and intellectual creation. These are just the three pillars upon which all of our global knowledge is built. The forecast is focused on objective laws that make the forecast easier to understand. It's crucial to understand the difference among "model" and "copy". A copy is the only level of closeness of the copied object to the original - an exact repetition of the identity. When simulating, there may be different levels of proximity depending on the targets. We pass a similar example to man, that is. tries to predict (predict) all life situations. This is theoretically possible. By examining all situations related to mental abilities, character traits, knowledge resources, living conditions, and other factors that determine a person's individual, social, home, and work status, for example, between the ages of 20 and 30, you can: situations, etc. However, many sciences, especially those related to man himself, his biological and physiological psychoanalysis, require a special approach. Here the problem of moral acceptability of the legality of the court decision is important, and it is connected with possible consequences. This is a field of forecasting in which science has no right to err. Review the key concepts and definitions recommended by the Committee.

Forecasting is a scientific discipline that studies the general principles of forecasting, the laws of forecasting. The subject of his research is the laws, principles and methods of forecasting, the main tasks are the development of problems of forecasting theory, the principles of typology and classification of forecasts, as well as the methodological basis of forecasting. According to I.V. Bestuzhev-Lada (1990), in the structure of forecasting, it is necessary to develop specific forecasting theories with double subordination: along general forecasting lines and along certain lines of scientific discipline. The production of all private forecasts must be based on a single forecasting theory. As a result, independent "predictions" should not be developed in individual scientific disciplines, but rather the principles and laws of general, unified forecasting should be used.

Forecasting is the process of preparing (producing) forecasts, special scientific research aimed at determining the future state of objects, events, happenings, etc. Forecasting is a scientifically based decision about the possible conditions of a predicted object in the future. Often in the form of synonyms for forecasting are "foresight", "forecast", "foresight" and so on. Terms are used. Meeting is the acquisition of information about the future. It can be both scientific and non-scientific. Non-scientific foresight is the result of human foresight (intuitive foresight), belief in unconscious forces (religion), and at the same time, everyday experience, signs, and so on. Based on (daily or daily). Scientific foresight is based on knowing the laws of development of nature and society. In cases where foresight is related to the present or past state of the projected object, it can be imitated - an assessment of the dynamics of the object from the past to the present; presenter - assessment of mineral deposits; reconstructive mental reconstruction of ancient monuments. Forecasting - obtaining possible or desirable perspective situations of a predicted object whose quantitative characterization is impossible or difficult. This is a descriptive form of foresight. Thinking in advance is a judgment about intuition. The term "forecasting" refers to the acquisition of information about the future based on life experience or unscientific assumptions about it.

Along with forecasting, future events can be planned, planned, programmed. Unlike a forecast, a plan contains certain terms and conditions for the realization of a predicted event. Reflects the order, sequence and methods of implementation of the system of measures. Planning is an activity aimed at achieving the intended purpose by certain means, the directive use of information about the future. It is the main forecast for the development of multidimensional models of the plan, in some cases the forecast and the plan can be prepared independently of each other. Comparative features of the essence of the concepts of "forecasting" and "planning".

Forecasting:

- related to the objective course of life; income from the dialectical understanding of life, in which necessity is emphasized in a number of other accidents;
- the probable occurrence of certain events is characteristic;
- there are alternative ways and time to achieve certain events;
- act at will.

Plan:

- covers the decision, will and responsibility of those who plan to change reality;
- events - permission to move;
- is characterized by a decision on a system of measures to ensure the sequence, order, timing and means of achieving any event;
- is considered by a responsibility to act.

forecasts and plans are prepared separately, but must be adjusted to reflect the ever-changing external environment for the plan to be effective. Forecasting is the first step to validating your plan and increasing the reliability and accuracy of your solution.

A forecast is a scientifically based decision about the possible future conditions and / or development conditions and alternative conditions of an object. The process of making forecasts is called forecasting, a scientific discipline, and forecasting patterns of development. Basic forecasting concepts:

- forecast variant - one of the forecasts consisting of several variants of forecasts of possible objects;

-Prediction methodology - a set of methods and rules for forecasting;

- forecasting method - the study of an object to prepare a forecast;

- object of forecasting - events, happenings and processes to which the activity of the object is directed. Depending on:

1) opportunities to influence the object of forecasting - uncontrolled, control;

2) to distinguish the nature of the object - scientific, technical, economic, ecological, social;

- forecasting model - a model of a forecasting object, the study of which allows to obtain information about the future conditions of the object and / and the duration and methods of their implementation. The forecast model graph is called a "forecast object graph model" or "graph model";

- forecasting technique - several logical or mathematical operations to obtain a result when preparing a forecast;

- forecasting system - a system of forecasting approaches and incomes of their application;

- forecast background - many external conditions that affect the solution of the problem.

To understand the nature of forecasting in procurement, it should be noted that forecasting is one of the leading management functions in the current context. Moreover, forecasting is one of the key processes of effective management. Forecasting increases the efficiency of procurement planning, creating a database for management decisions. Analysis of the scientific literature shows that forecasting performs the following functions:

-Look for different ways to influence the development of an object as a result of decision-making, evaluate the consequences of these decisions

-Prediction of trends in the field of activity;

-Evaluation of the results and progress of the decision, unexpected changes in the external environment to respond in a timely manner, if necessary.

These functions are interrelated, are elements of management activity and are implemented in the forecasting process. These features:

- analysis of social, technical and economic processes;
- comparison, analysis and justification of options for further development of the researched process.

The first function is related to the forecasting function, the second function is related to the management function, and the third function is related to planning and management. The first role should be examined in greater depth. The most acceptable version of the list is L.P. Given by Vladimirskaya:

-Evaluation of future trends, forecasting economic problems and conditions;

-analysis of scientific, technical and socio-economic trends, the relationship of these events under certain conditions;

- identification of different ways of the company's development; collect information and make an ideal decision based on the information collected.

2.2. Methods of forecasting

Forecasting predicts the future based on accumulated experience and existing assumptions. / 15 / Forecasting is a difficult process that necessitates the resolution of several issues. Different forecasting methods, which are many today, must be used for production, but in practice only 15-20 are used. Let's focus on the most popular ones. The most popular forecasting methods:

Expert evaluation method. The prediction is based on an expert's or a group of experts' opinions, which are based on technical, realistic, and scientific knowledge. Distinguish between collective and individual expert assessments, which are often used in individual assessments.

Extrapolation method. Extrapolation's main goal is to examine and extrapolate into the future the continuous developments in the growth of businesses, both in the past and present. Recognize the difference between extrapolation that is predictive and extrapolation that is formal. Formal - based on the assumption that past and current trends in the enterprise's development will continue in the future; informal - based on the assumption that past and current trends in the enterprise's development will continue in the future. Linear extrapolation is the process of drawing a point at the end of existing data and extending this beyond it. Linear extrapolation will only work well if it is used to expand an area with an approximate linear function, or if it is too far beyond known data. If two data points closest to a point x_* to be extrapolated are (x_{k-1},y_{k-1}) and (x_k,y_k) linear extrapolation gives the function:

$$Y(x_*)=y_{k-1}+\frac{x_*-x_{k-1}}{x_k-x_{k-1}}(y_k-y_k-1)$$

You can enter more than two points using regression-like methods for the data points you choose to include, and add the inclination of the linear interpolation on average.

Modeling methods. Modeling is the construction of a model based on the initial study of an object and process, emphasizing its main features and characteristics. The creation, experimental analysis, comparison of the results of initial forecast calculations with factual knowledge about the state of the process or entity, and optimization and adjustment of the model are all part of forecasting using a model.

Method of balancing. This approach is focused on the production of balances, the first part of which defines the sources of income and a set of indicators that represents income distribution in all directions.

The balance approach enacts the proportionality and equilibrium principles that are used in forecasting. Its purpose is to connect an enterprise's requirements for various types of raw materials, materials, financial, and labor resources with manufacturing budget and expertise. As a result, the financial, material, and labor balances are all part of the forecasting mechanism. There are many balances in each of these classes.

Any economic process or phenomenon that occurs in the enterprise is divided into parts, then the effect and relationship of these parts on the direction and development of the process, as well as on each other, is calculated using the economic forecasting (economic analysis) system. You can use the analysis to uncover the nature of a process, as well as identify potential change trends and determine the various options for achieving your objectives. Economic analysis is an integral part and element of forecasting logic and should be conducted at the macro and micro levels. Used when planning production in an enterprise.

The stages of economic analysis are as follows:

- issue disclosure;
- specification of assessment criteria and objectives;
- preparation of data for analysis;
- policy analysis following data research; compilation of suggestions on alternative ways to accomplish the objective;
- discussion of data.

Target programmed method (PCM). Compared to other methods, this method is relatively new and less developed. It has only recently become widely used. PCM is strongly connected to the approaches already discussed, and it involves forecasting in the identification and quest for appropriate means and ways to accomplish, beginning with an evaluation of current needs based on the enterprise's growth goals.

The essence of PMC is to define the main goals of enterprise development, to develop interrelated measures to achieve them with a balanced supply of resources over a period of time, as well as taking into account their efficient use.

In addition to forecasting, PUE is used to create complex target programs that are a document that outlines production, organizational, economic, social, and other activities and executives-related responsibilities, deadlines, and sources.

One of the classifications of forecasting methods.

Official methods:

-Trend extrapolation method;

-Methods of correlation and regression analysis;

-Mathematical modeling methods.

Expert forecasting methods:

1. Individual methods

-Script writing method;

- "reportage" method;

- Method of analytical notes.

Collective methods:

-Demand method;

-Commission method;

- "brainstorming" method;

-Delphi method.

An overview of the categories of forecasting methods.

Forecasting is a forecast for the future based on historical data, available data (current situation) and trend analysis. Risk and uncertainty are key factors in forecasting, so it is a good practice to show the degree of uncertainty in forecasts.

There are several steps to properly assessing the forecasting process. The following are five crucial steps to remember:

- clarification of initial data to identify errors;

- development of forecasts and assessment of reliability of results;

- use (interpretation) of results and, if necessary, clarification and addition of forecasts.

Quantitative and quantitative approaches are the two types of forecasting methods.

Qualitative forecasting methods are arbitrary, relying on customer and expert views and decisions. In the absence of historical data, quality methods are appropriate. These methods are generally used for medium and long-term solutions. Examples of quality forecasting methods: market research, Delphi method, historical life cycle analogue, etc.

On the basis of historical data, quantitative forecasting models are used to predict upcoming data. Suitable for use when there is historical numerical data and when information trends are expected to continue in the future. Such techniques are commonly used for forecasting in the immediate future. Moving averages, exponential visibility, exponential seasonal indices, and other quantitative forecasting approaches are examples.

The average method assumes that all future values will be the same as the average values of the historical results. Any type of historical data can be used for this tool. The averaging method allows you to make a forecast based on the average value of past observations.

The "naive" approach

The naive method is based on the assumption that the future is characterized by the latest changes. The method is based on the assumption that the forecasted indicators in the future are equal to the indicators of the previous period. Even if you don't have any historical proof, you can work with a naive prediction. A naive forecast is understandable, easy to prepare, quick to implement, and virtually cost-effective. The main drawback of naive forecasting is the likely low forecast accuracy. Naive predictions area unit the foremost efficient prediction model and function a benchmark for scrutiny additional various models. This prediction technique is barely appropriate for statistic information. employing a naive approach, forecasts area unit given adequate the last determined price. This technique works glowing enough for economic and monetary statistic, which often have patterns that area unit problematic to forecast faithfully and accurately. If the statistic is assumed to be seasonal, a seasonally naive approach is also additional applicable once the forecasts area unit adequate the values of the previous season. Time series record:

$$\hat{y}_{T+h/T} = y_T$$

Drift method: A variation of the naive method is to allow forecasts to increase or decrease in a completed time, with the quantity of change over time (called drift) set equivalent to the middling change observed in antique data. Consequently the forecast for time T+h is assumed by this formulation:

$$\hat{y}_{T+h/T} = y_T + \frac{h}{T-1}\sum_{t=2}^{T}(y_t - y_{t-1}) = y_T + h\left(\frac{y_T - y_1}{T-1}\right)$$

This is similar to drawing the boundary between the primary and last observation and extrapolating it to the longer term.

Seasonal naïve approach:

The seasonal naive way takes into account the seasonality by setting each prediction equal to the latter experiential cost for the same season. For example, the forecast value for all following months of April will be identical to the preceding value experiential in April. The forecast of T + h time is given by the subsequent formula:

$$\hat{y}_{T+h/T} = y_{T+h-km}$$

Where m=seasonal period and k is the least integer greater than (h-1)/m.

Forecast accuracy: The forecast error (also called residual) is that the distinction between the particular price and also the forecast price for the relevant period:

E_t=Y_t-F_t

where E t is the forecast error for the period, Y is the true value for the period, and F t t is the forecast for the period. A good forecasting method creates related balances. If there is a relationship between the balances, the balances contain information that should be used to calculate the forecasts. Calculating the estimated residual value as a function of known past balances and modifying the forecast to the degree by which this expected value differs from zero is one way to accomplish this. A good forecasting process will also have a callous of zero. If the balances have a non-zero average, the forecasts are biased and might be improved by adjusting the prediction technique with an extra constant adequate to the typical of the uncorrected balances.

Scaled-dependent errors:

The forecast error E is on a similar scale because the information, as such, these measures of accuracy area unit scale dependent and can't be wont to compare series at totally different scales.

Mean absolute error or mean absolute deviation:

$$\text{MAE}=\text{MAD}=\frac{\sum_{t=1}^{N}|Et|}{N}$$

Mean squared error or mean squared prediction error:

$$\text{MSE}=\text{MSPE}=\frac{\sum_{t=1}^{N}E_t^2}{N}$$

Root mean squared error:

RMSE= $\sqrt{\frac{\sum_{t=1}^{N} E_t^2}{N}}$

Average of errors(E):

E= $\frac{\sum_{i=1}^{N} E_i}{N}$

Percentage errors:

They are additional usually accustomed compare forecast performance between totally different datasets as a result of they're scale freelance. However, they need a drawback: they're terribly giant or undefinable if Y is about to or adequate zero.

Mean absolute percentage error:

MAPE=100* $\frac{\sum_{t=1}^{N} |\frac{E_t}{Y_t}|}{N}$

Mean absolute percentage deviation(MAPD):

MAPD= $\frac{\sum_{t=1}^{N} |E_t|}{\sum_{t=1}^{N} |Y_t|}$

CHAPTER 3. ISSUES OF PRACTICAL IMPLEMENTATION

3.1. Forecasting in Python

In python there are a lot of libraries especially for forecasting. Time sequence problems can be classified and estimated through machine learning techniques.

Previously exploring machine learning approaches for time series, it is a respectable impression to make sure you have fatigued traditional linear time series forecasting approaches. Classic time series forecasting methods can focus on linear dependencies, however, they are complex and work well for a wide range of problems if you assume that your data is properly prepared and the method is well configured. I'll show all examples in Python and use Stats models library. Here are demonstrated 11 dissimilar classical time series forecasting approaches. They are:

- Autoregression
- Moving Average
- Autoregressive Moving Average
- Autoregressive Integrated Moving Average
- Seasonal Autoregressive Integrated Moving-Average
- Seasonal Autoregressive Integrated Moving-Average with Exogenous Regressors
- Vector Autoregression
- Vector Autoregression Moving-Average
- Vector Autoregression Moving-Average with Exogenous Regressors
- Simple Exponential Smoothing
- Holt Winter's Exponential Smoothing

Each method is presented in the same way. This includes:

- Description. Brief and accurate explanation of the method.
- Python code. A brief working example of fitting and predicting a model in Python.

Let's look through some of them.

-Auto regression:

Autoregressive (AR) method models the following step in a sequence as a linear function of observations at preceding time steps.

Model symbolization includes stipulating the command of the model p as a parameter to an AR function, for example AR (p).

The method is appropriate for unilabiate time series without trend and periodic components.

Python code of the Autoregressive (AR) method:

-Moving average

The moving average (MA) method models the following step in a sequence as a linear function of remaining errors from the procedure mean at preceding period stages.

A moving average method is not the same as calculating a time series' moving average. Let’s look at an example, MA (1) is a primary command moving average model. This method is appropriate for unilabiate time series without trend and periodic components.

We can use the ARIMA class to make an MA model and set up a zeroth-order AR model. We must postulate the command of the MA model in the command argument.

Python code of the moving average (MA) method:

-Autoregressive Moving Average

The Autoregressive Moving Average method represents the following step in a sequence as a linear function of clarifications and remaining mistakes at preceding time ladders.

It combines autoregressive (AR) and moving average (MA) models.

Model notation comprises stipulating the command for the AR (p) and MA (q) models as limitations to an ARMA function, such as ARMA (p, q).

The method is appropriate for unilabiate time series without movement and seasonal mechanisms.

- Autoregressive Integrated Moving Average :The Autoregressive Moving Average method models the following step in a sequence as a linear function of observations and remaining errors at preceding time steps. It combines autoregressive (AR) and moving average (MA) models.

Model notation involves defining ordering for models AR (p) and MA (q) as parameters to an ARMA function such as ARMA (p, q). The ARIMA model can be used for progressing AR or MA models.

The method is appropriate for unilabiate time series without tendency and cyclical components.

Python code of the Autoregressive Moving Average (ARMA) method:

-Seasonal Autoregressive Integrated Moving Average

The Integrated Seasonal Autoregressive Moving Average with Exogenous Regressors is a postponement of the SARIMA model that also encompasses modeling of exogenous inconsistent.

Exogenous inconsistent are also named covariates, can be thought of as parallel input preparations that have explanations at the same time stages as the unique series. The main series may be stated to as endogenous data to discriminate it from the exogenous order. Descriptions of exogenous variables are encompassed in the model directly at each time period and are not modeled in the alike way as the main endogenous order.

Python code of Seasonal Autoregressive Integrated Moving-Average with Exogenous Regressors (SARIMAX) method:

3.2 Solving of practice problem

As practical problem we consider the forecasting of Rmax (max performance of supercomputers). As known there is an international organization https://www.top500.org/ C:\Users\HP\Downloads\www.top500.com which organizes benchmarking of supercomputers and keep all statistics about them. Below present fragment of **Rmax** statistics since 1993 up to 2020 (28 points).

Figure 3.1 Supercomters performance statistics

For convenient processing rationally are used logarithmic scaling (log10(x)). On the figure 3.2 is presented scatter of performance in log scale.

Figure 3.2. Scatter of supercomputer performance

As we see the graph has linear like shape. Python has several libraries with forecasting functions, particularly SClearn-machine learning methods library. We can use Linear regression function, which calculate parameters of linear regression equation **y=a+bx**. Second it is auto regression models y(t+1)=f(y(t)), which are presented in STAT library. We developed 2 Python script , let’s consider these codes and their results. Traditionally Python scripts are considered by blocks. First blocks are presented code for include all necessary libraries.

```
import numpy as np
import matplotlib.pyplot as plt
from sklearn.linear_model import LinearRegression
```

In next block is presented code for entering statistical data

```
x=np.array([1993,1994,1995,1996,1997,1998,1999,2000,2001,2002,2003,2004,2005,
        2006,2007,2008,2009,2010,2011,2012,2013,2014,2015,2016,2017,
        2018,2019,2020])
X=x.reshape(-1,1)
y=np.array([11.09,11.23,11.23,11.57,12.11,12.11,12.38,12.69,12.86,13.56,13.56,
        13.85,14.45,14.45,14.68,15.04,15.26,15.41,16.02,16.25,16.53,16.53,
        16.53,16.97,16.97,17.16,17.17,17.65])
Y=y.reshape(-1,1)
```

Next is presented block for building linear regression model.In next block we organize.

```
Y=y.reshape(-1,1)
lr=LinearRegression()
lr.fit(X,Y)
m=lr.coef_
c=lr.intercept_
```

output of results:

```
print("slope= %8.3f" % float(m))
print ("Intercept=%8.3f" % float(c))
y_pred=lr.predict(X)
#print(X,y_pred)
for i in range(0,28):
   uu=float(X[[i]])
   vv=float(y_pred[i])
   tt=float(y[i])
   print("%8.2f %8.2f %8.2f"%(uu,tt,vv))
   y_pred1=lr.predict([[2021]])
print("Predict value when x is %5d %8.3f" %(2021,float(y_pred1)))
plt.scatter(X,y)
plt.xlabel("Years")
plt.ylabel("Performance")
plt.plot(X,y_pred)
plt.show()
```

Here we use functions from matplotlib library.
Below are presented results: coefficients of regression equation
y=0.256x -499.774 ,
comparative performance data (statistical and model) and prediction for 2021 year:

```
slope=   0.256
Intercept=-499.774
 1993.00   11.09   11.02
 1994.00   11.23   11.27
 1995.00   11.23   11.53
 1996.00   11.57   11.78
 1997.00   12.11   12.04
```

Predict value when x is 2021 **18.192** and graph is presented below:

Figure 3.3 Comparative graph of model and scatter

Let's consider application for this problem auto regression model **AR**

X(t+1) = b0 + b1*X(t-1) + b2*X(t-2)

In first block we present import of necessary libraries:

```
# AR example
from statsmodels.tsa.ar_model import AutoReg
```

Next we organize entering data

```
data = [11.09,11.23,11.23,11.57,12.11,12.11,12.38,12.69,12.86,13.56,13.56,
        13.85,14.45,14.45,14.68,15.04,15.26,15.41,16.02,16.25,16.53,16.53,
        16.53,16.97,16.97,17.16,17.17,17.65]
```

And in next block are presented building auto regression model and output results:

```
# fit model
model = AutoReg(data, lags=5)
model_fit = model.fit()
# make prediction
yhat = model_fit.predict(len(data), len(data)+1)
print(yhat)
```

We have prediction for 2021=**17.73**

CONCLUSION

The main purpose of this graduation work is creating a forecasting to develop performance estimation of supercomputers on bases on Machine Learning techniques. For this purpose Python was chosen for working.

Today forecasting is so important issue. To predict supercomputer performance product's productivity in advance is applicable for companies. In our work , with the help of different libraries of Python I've created a program which you can get performance of any supercomputers with parameters , regardless its existing.

Our work gives us following results:

-development and features of supercomputers have been researched

-basic forecasting methods were analyzed

-information about Stats models libraries have been analyzed
-forecasting in Python have been learned
-implementation of supercomputer performance prediction program was realized

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Figure1.1. Summit components

Figure1.2. Sunway TaihuLight - NCRPC (China) supercomputer

Figure1.3. Sierra (ATS-2) supercomputer

Figure1.4. Tianhe - 2A - NUDT (China) supercomputer

Figure1.5. Piz Daint - Cray (Switzerland) supercomputer

Figure1.6. Trinity - Cray (USA) supercomputer

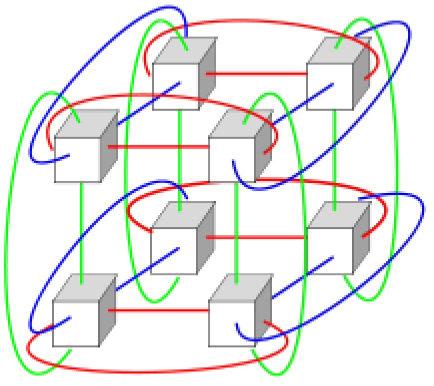

Figure1.7.A torus interconnect

Figure1.8. The CDC 6600

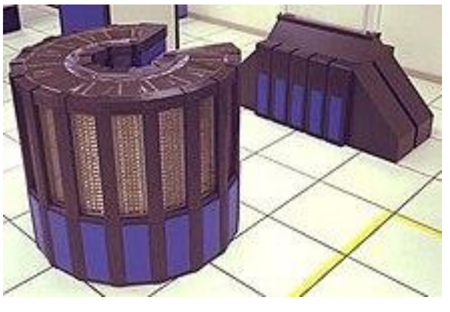

Figure1.9. Cylindrical shape of early Cray computers with centralized access to reduce distances and uniformity.

Figure1.10. A Blue Gene / L cabinet with stacked blades, each with multiple processors.

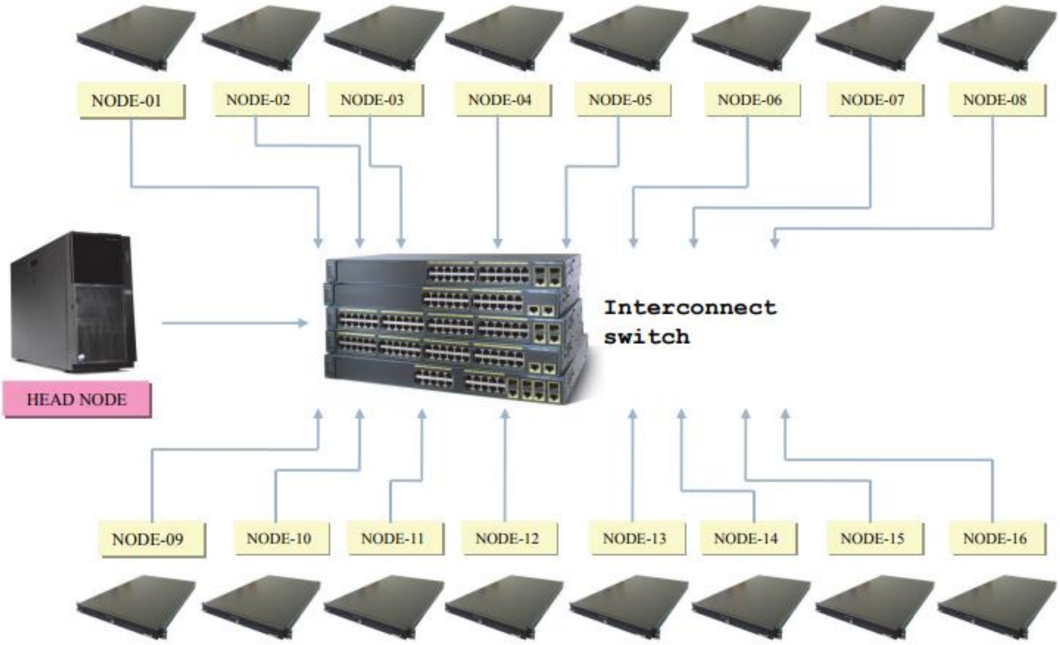

Figure1.11.Clusters

Figure1.12.Cray XE6

Python code of the Autoregressive (AR) method:

```
# AR example
from statsmodels.tsa.ar_model import AutoReg
from random import random
# contrived dataset
data = [x + random() for x in range(1, 100)]
# fit model
model = AutoReg(data, lags=1)
model_fit = model.fit()
# make prediction
yhat = model_fit.predict(len(data), len(data))
print(yhat)
```

Python code of the moving average (MA) method:

```
# MA example
from statsmodels.tsa.arima.model import ARIMA
from random import random
# contrived dataset
data = [x + random() for x in range(1, 100)]
# fit model
model = ARIMA(data, order=(0, 0, 1))
model_fit = model.fit()
# make prediction
yhat = model_fit.predict(len(data), len(data))
print(yhat)
```

Python code of the Autoregressive Moving Average (ARMA) method:

```
# ARMA example
from statsmodels.tsa.arima.model import ARIMA
from random import random
# contrived dataset
data = [random() for x in range(1, 100)]
# fit model
model = ARIMA(data, order=(2, 0, 1))
model_fit = model.fit()
# make prediction
yhat = model_fit.predict(len(data), len(data))
print(yhat)
```

Python code of the Autoregressive Moving Average (ARMA) method:

```
# ARMA example
from statsmodels.tsa.arima.model import ARIMA
from random import random
# contrived dataset
data = [random() for x in range(1, 100)]
# fit model
model = ARIMA(data, order=(2, 0, 1))
model_fit = model.fit()
# make prediction
yhat = model_fit.predict(len(data), len(data))
print(yhat)
```

Python code of Seasonal Autoregressive Integrated Moving-Average with Exogenous Regressors (SARIMAX) method:

```
# SARIMAX example
from statsmodels.tsa.statespace.sarimax import SARIMAX
from random import random
# contrived dataset
data1 = [x + random() for x in range(1, 100)]
data2 = [x + random() for x in range(101, 200)]
# fit model
model = SARIMAX(data1, exog=data2, order=(1, 1, 1), seasonal_order=(0, 0, 0, 0))
model_fit = model.fit(disp=False)
# make prediction
exog2 = [200 + random()]
yhat = model_fit.predict(len(data1), len(data1), exog=[exog2])
print(yhat)
```

Year	FLOPS	Petaflops	Exaflops	log10(FLOPS)
1993	1.24E+11	0.000124	0.000000124	11.09
1994	1.7E+11	0.00017	0.00000017	11.23
1995	1.7E+11	0.00017	0.00000017	11.23
1996	3.68E+11	0.000368	0.000000368	11.57
1997	1.3E+12	0.0013	0.0000013	12.11
1998	1.3E+12	0.0013	0.0000013	12.11
1999	2.4E+12	0.0024	0.0000024	12.38
2000	4.9E+12	0.0049	0.0000049	12.69

Figure 3.1 Supercomters performance statistics

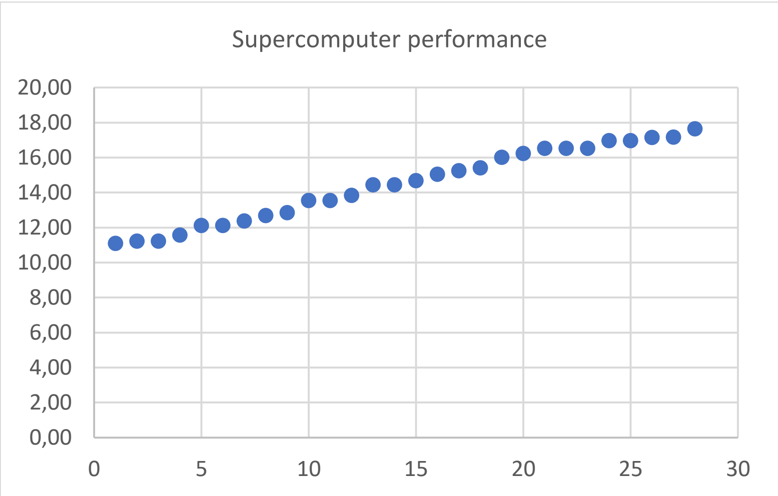

Figure 3.2. Scatter of supercomputer performance

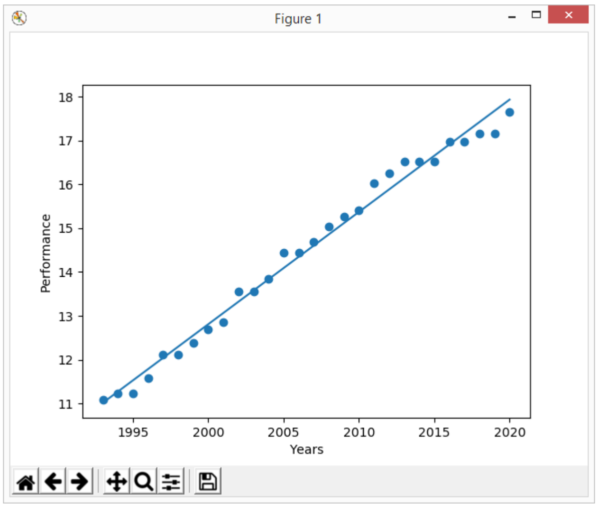

Figure 3.3 Comparative graph of model and scatter