# TRIZ Innovation Principle of The Operating System Development

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## Abstract

**Although modern operating systems can provide us with convenient interacts with the system, the operating system is in the process of people using computer, in order to satisfy the two requirements: computer system performance and improve resource utilization and increase along with the increasing development of computer technology itself and its application, and gradually formed and perfected. In the development of the operating system, there is also the embodiment of the principle of innovation.**

## Keywords

**Operating system; contradiction analysis; innovation principle.**

## 1.　A brief description of the operating system

An operating system is a computer program that manages computer hardware and software resources. It is also the kernel and cornerstone of a computer system. The operating system needs to handle such basic tasks as managing and configuring memory, prioritizing the supply and demand of system resources, controlling input and output devices, and operating networks and managing file systems. The operating system also provides an interface for users to interact with the system.

Operating systems can range from simple to complex, from embedded systems on mobile phones to large operating systems on supercomputers. Many operating system makers also have different definitions of what it covers. For example, some operating systems integrate a graphical user interface (GUI), while others use only a command-line interface, treating the GUI as a non-essential application.

Although modern operating systems can provide us with convenient interacts with the system, but the operating system is not born with computer hardware, it is in the process of people to use computers, computer systems in order to improve resource utilization and enhance performance these two requirements, along with the increasing development of computer technology itself and its application, and gradually formed and perfected. In the development of the operating system, there is also the embodiment of the principle of innovation.

## 2.　Manual operation mode and contradiction analysis

The world's first general-purpose computer, ENIAC, was created at the university of Pennsylvania on February 14, 1946. The defense department uses it for ballistic calculations. ENIAC took the electron tube as the component, so it was also called the electron tube computer, which was the first generation of computer. There was no concept of an operating system, and computers were still working by hand.

The programmer loads the perforated paper tape corresponding to the program and data into the input machine, and then starts the input machine to input the program and data into the computer memory, and then starts the program to run against the data through the console switch. After the calculation is completed, the printer outputs the calculation results. After the user takes the result and unloads the paper tape, the next user can get on the machine.

In the late 1950s, there was a sharp contradiction between the slow manual operation and the high computer speed. The manual operation mode has seriously damaged the utilization rate of system resources and reduced the utilization rate of resources to several percent or even lower, which could not be tolerated.

At the beginning, in order to improve the efficiency of data processing, the computer was applied to data processing. However, after the adoption of the computer, the manual operation of paper tape loading and removing speed was much slower than the computing speed of the computer, which restricted the efficiency of problem processing and reduced the utilization rate of resources.

The effective solution is to add a system software to the computer, and under its control, the computer can automatically and batch the work of one or more users. In other words, a system software is designed to preprocess the input and output of data, and then the system software is incorporated into the computer to form a set of periodic comprehensive processing problems.

## 3.  Batch system description and contradiction analysis

With the analysis of the contradictions in the previous stage and the relevant solutions, the batch operating system came into being. Batch system: system software loaded on a computer under whose control the computer can automatically and batch the jobs of one or more users (including programs, data, and commands).

Add a storage device between the host and the input machine -- magnetic tape, under the automatic control of the supervision program running on the host machine, the computer can complete automatically: batch the user jobs on the input machine read into magnetic tape, and then read the user jobs on magnetic tape into the host memory and execute and output the calculation results to the output machine. After the last batch of jobs is completed, the supervisor inputs another batch of jobs from the input machine, saves them on tape, and repeats the steps above.

The supervisory program continuously processes each job, thus realizes the automatic transfer from job to job, reduces the time of job establishment and manual operation, effectively overcomes the man-machine contradiction, and improves the utilization rate of the computer.

By increasing the batch system has effectively solved the contradiction between human, improve the efficiency of the use of the computer, but the further processing problem makes the application of computer, people found in the assignments when input and output, high speed CPU host is still in the idle state, waiting for slow input/output devices to complete work, therefore, and further improve the utilization efficiency of space.

Although a batch system is applied, it waits for a slow input/output device to complete its work: the host is in a "busy wait" state. Therefore, the utilization efficiency has room for further improvement.

Through the merger, dimension change, the continuity of effective action and feedback invention after comprehensive application of the principle of effective solution for the problem is that the operating system design from a one-dimensional single channel of single point operation mode to develop multiple channel of multidimensional operation mode, and in the operating system to join the feedback mechanism, when a channel running through the process of or not to use a variety of software and hardware resources, feedback signal to CPU, this is the process of CPU and then call the other channels to use free software and hardware resources, so as to realize effective, continuous use of various kinds of resources.

## 4.  multiprogramming system description and contradictions analysis

Multiprogramming technology allows multiple programs to enter memory and run simultaneously. That is to put multiple programs into memory at the same time, and allow them to run alternately in the CPU, they share a variety of hardware and software resources in the system. When a program is suspended because of an I/O request, the CPU immediately goes to run another program.

Multi-programming technology not only makes full use of CPU, but also improves the utilization rate of I/O equipment and memory, thus improving the resource utilization rate and system throughput of the whole system (the number of processing jobs (programs) per unit time), and finally improves the efficiency of the whole system.

The appearance of multi-program system marks the gradually mature stage of the operating system, which has the functions of job scheduling management, processor management, memory management, external equipment management, file system management and so on.

Since multiple programs are running in the computer at the same time, the concept of space isolation has begun. Only the isolation of memory space can make data more secure and stable.

In addition to spatial isolation, multi-channel technology also embodies the characteristics of time-space reuse for the first time. Switching programs in case of IO operation improves the utilization rate of CPU and the working efficiency of computer.

One of the important disadvantages of batch processing system is that it does not provide human-computer interaction, which brings inconvenience to users. Although the user monopolizes the whole machine resources, and directly controls the operation of the program, and can know the running situation of the program at any time, this working mode is very inefficient because of monopolizing the whole machine resources. Therefore, a new requirement is put forward, which can not only ensure the efficiency of the computer, but also make it convenient for users to use the computer.

Although various technologies have been used in the past to improve the efficiency of operating system calls and computer resources to deal with problems, what has been improved is only the speed of the computer, which ignores the ability of human-computer interaction and brings inconvenience to users.

By local quality, pre operation, dynamic segmentation, and the continuity of effective invention after comprehensive application of the principle of effective solution to the problem is the new operating system is divided into parts, each part has added the corresponding pretreatment, can implement some functions, add a time feedback mechanism at the same time, through the feedback of time to make the CPU can according to the feedback signal to the process of dynamic adjustment of each user.

Due to the continuous improvement of CPU speed and time-sharing technology, a computer can be connected to multiple user terminals at the same time, and each user can use the computer online on his own terminal, as if he monopolized the machine.

Time-sharing technology is to divide the running time of the processor into very short time slices, and allocate the processor to each online job in turn according to the time slices.

If a job cannot complete its calculations within the time slice allocated to it, the job is temporarily interrupted, leaving the processor in the hands of another job until the next round. Because computers are fast, jobs run in circles so fast that each user is given the impression that he has a computer to himself. Each user can issue various operation control commands to the system through his terminal, and complete the operation of the job under the full human-computer interaction.

Although the multi-channel batch processing system and time-sharing system can achieve satisfactory resource utilization and system response time, they cannot meet the needs of real-time control and real-time information processing.

The three stages of manual operation, batch system and multi-program system all emphasize the improvement of speed and utilization rate, but ignore the real-time requirements of some process responses.

After the comprehensive application of the principle of pre-compensation and feedback invention, the effective solution to the problem is the feedback mechanism of the time slice added in the previous operating system, so the sensitivity of the feedback time is further adjusted and the feedback time is strictly limited.

## 5.  Real-time system description and contradiction analysis

Real-time system, that is, the system can timely respond to random external events, and complete the processing of the event in a strict time range. Real-time systems are often used as control devices in a particular application.

The real-time system can be divided into two categories: one is the real-time control system. When it is used for the automatic control of aircraft flight and missile launch, the computer is required to process the data measured by the measurement system as soon as possible, control the aircraft or missile in a timely manner, or provide relevant information to decision makers through the display terminal. When used for steel rolling, petrochemical and other industrial production process control, also requires the computer can be timely processing data sent by all kinds of sensors, and then control the corresponding actuator. Second, the real-time information processing system, when used for booking air tickets, inquiries about flights, routes, fares and other matters, or when used in the banking system, information retrieval system, all require the computer to be able to terminal equipment sent to the service request in a timely and correct answer. This kind of requirement for response timeliness is slightly weaker than the first kind.

Each of the previous phases produced an operating system that had its own set of disadvantages, but also its own unique advantages. But in some cases, because of the specific needs of the problem, each operating system alone is not enough to meet the requirements, so now a unified common operating system is needed to deal with a variety of different environments, different requirements of the problem.

Previously developed operating systems are limited to the immediate contradictions to improve, so that each operating system has its own advantages, each has its own shortcomings, so the need for a unified universal operating system.

Through the comprehensive application of the combination and the multi-function invention principle, the effective solution to the problem is to develop the operating system generated in the previous stages and achieve the appropriate combination, so that the operating system can perform multiple functions.

## 6. General operating system analysis

There are three basic types of operating systems: multi-channel batch systems, time-sharing systems, and real-time systems.

General operating system is an operating system with multiple types of operating characteristics, which can simultaneously have multi-channel batch processing, time-sharing, real-time processing or two or more functions.

For example, real-time processing + batch processing = real-time batch system. First, make sure that real-time tasks are prioritized and batch jobs are inserted. Real-time tasks are often referred to as foreground jobs and batch jobs as background jobs.

For another example, time-sharing + batch = time-sharing batch system. That is, jobs with weak time requirements are put into the "background" (batch processing), and jobs requiring frequent interaction are processed in the "foreground" (time-sharing). The processor has priority to run the "foreground" job.

Since the mid 1960s, some large universal operating systems have been developed internationally. These systems attempt to achieve the goal of being fully functional, adaptable to a variety of applications and operating in a variety of environments. However, these systems are too complex and large, not only at great cost, but also at great difficulty in addressing their reliability, maintainability and understandability.

UNIX, by contrast, is an exception. This is a universal multi-user time-sharing interactive operating system. It starts with a lean core that can function as well as many large operating systems, supporting large software systems outside the core layer. It was quickly applied and popularized, and constantly improved, with a significant impact on modern operating systems.

At this point, the basic concept of the operating system, functions, basic structure and composition have been formed and gradually improved.

## 7. Further development of the operating system

In the 1980s, the rapid development of large-scale integrated circuit technology and the emergence and development of microprocessors set off a wave of great development and popularization of computers. On the one hand, it ushered in the era of personal computers, and at the same time, it developed towards computer networks, distributed processing, giant computers and intelligence. Thus, the operating system has a further development, such as personal computer operating system, network operating system.

An analysis of the use of innovative principles in PC operating systems

PC operating system is a single-user operating system on a PC, which provides online interactive functions similar to those provided by the universal time-sharing system. Some features are much simpler because they are personal. However, with the popularity of personal computers, the need for file systems that provide a more user-friendly interface and rich functionality will become more and more urgent.

Personal computer operating system development embodies the innovation principle of pre operation, namely: although now computer has been very rapid development, but for some technology application, in addition to the personnel engaged in the computer industry or technology enthusiasts, most of the users either don't have the time to understand, or don't know how to use directly, so it need us in the development of the operating system time to do enough to dispose of the pre-processing, the greatest degree of optimization of human-computer interaction, so as to make the personal computer can maximum convenience for the users.

Analyze the innovation principle of network operating system

Network operating system is the original computer operating system, according to the network architecture of each protocol standard to increase the network management module, including communication, resource sharing, system security and various network application services.

The development of the network operating system embodies the innovation principle of suit, that is: will the related technology of computer network communications, for example, transfer of resources, collaborative operation and so on, set into the into the current operating system, makes the operating system can give full play of the computer network of various advantages, thereby the optimal development of wider operating system.

## 8. The future of operating systems

Through the history of the various stages of the development of the operating system, the various stages of the contradiction,the analysis of potential and the application of the two innovative principles of package and pre-operation are more sufficient. Therefore, it is believed that the development trend of future operating systems is to embed the operating system into any realistic object that can be optimized to greatly promote the connection between people, Internet and everything.

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