Smart Education Scenarios White Paper

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Preface

With growing investment, education informatization is advancing and improving education quality around the world. Fair, quality, innovative, personalized, and competence-oriented education is a common goal. Technologies such as the Internet, IoT, cloud computing, big data, and artificial intelligence (AI) are promising solutions to creating intelligent, intuitive, and ubiquitous education.

This white paper describes the industry landscape, values, and service transmission requirements with reference of schools, integrators, operators, and education application companies. In particular it identifies the following four smart education scenarios:

Smart Classroom

As a primary scenario for smart education, smart classrooms use VR/AR and hologram technologies to provide interactive, individual, and immersive teaching experience.

Smart Campus

As a fundamental smart education solution, smart campus provides broadband access to ensure that schools are fully connected and under security surveillance.

Smart Analysis

As the "brain" of smart education, smart analysis uses big data and AI to analyze and provide visualized education management of teaching, learning, and sports activities.

Smart Management

As a service platform for smart education, smart management allows for communication between schools, faculties, students, and parents.

Smart education advances will drive demand for education applications, network resources, and smart devices, bringing huge opportunities to the education market. This white paper helps cloud, pipe, and device vendors seize market opportunities and grow their businesses.

Contents

01
Evolution of Education

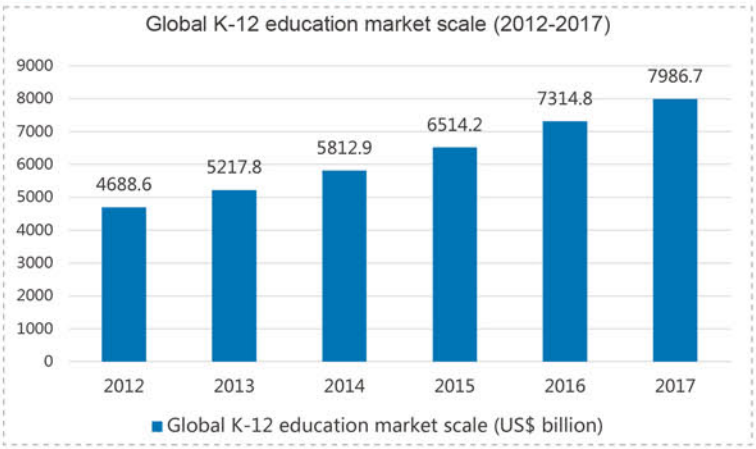
1.1 Global Education Market

Huge Market Space and Fast Growth

Education can be divided into early childhood education, basic education (K-12 education), higher education, vocational education, extracurricular tutoring, language training, and vocational training. The 2016 Edtech Trends report released by Edtech Europe, an education and technology organization, finds that global education spending exceeded US$5 trillion in 2016, eight times that of the software industry and three times that of the media and entertainment industries. The report also predicts that global education spending will grow at 8% year-on-year and reach over US$8 trillion by 2020, higher than the average annual GDP growth rate (4%).

The global K-12 education market continues to grow rapidly. The Intelligent Research Group found that the global K-12 education market reached nearly US$800 billion in 2017, with North America, Europe, and Asia Pacific being the top three markets. The K-12 education market as a whole had a compound annual growth rate (CAGR) of 11.2% since 2012.

Figure 1-1 Scale and landscape of global K-12 education market

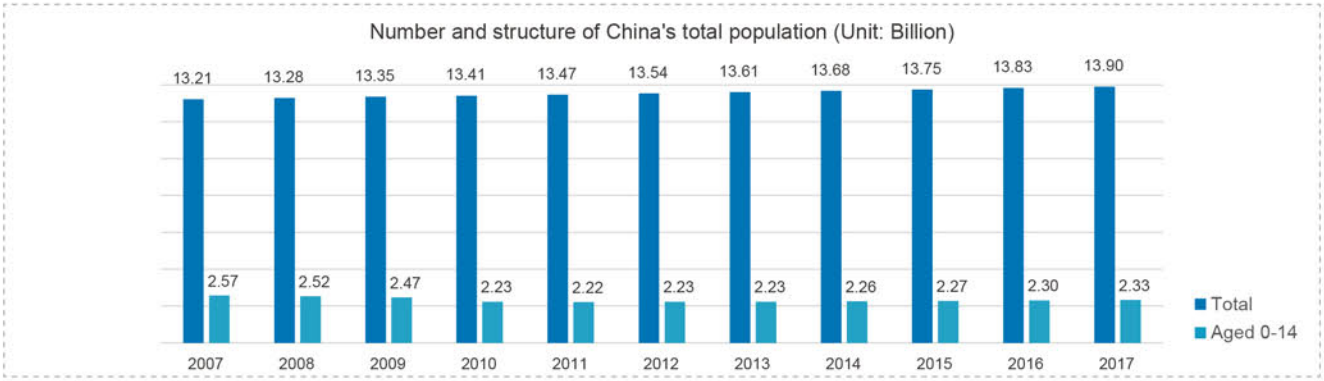


Source: Intelligent Research Group

Steady Growth of China's Education Investment

China has a large population, providing demand for growth in the education sector. Chinese fertility rates have been increasing steadily since 2007, particularly with the relaxation of China's former one-child policy. The population aged 0-14 remains above 200 million. According to China's national plan on population development (2016-2030) released by the State Council, the total population of China will reach 1.42 billion in 2020 and 1.45 billion by 2030, and the total fertility rate will increase from 1.55 in 2015 to 1.80 in 2020 and maintain at this level.

Figure 1-2 Number and structure of China's total population

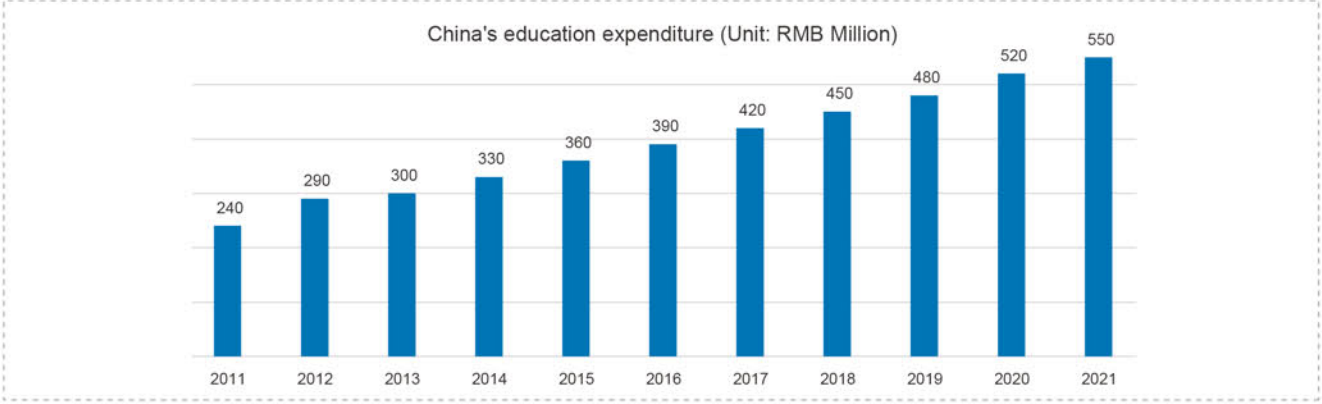


Sources: Ministry of Education, National Bureau of Statistics, and Bexcel Management Consultants

Education has always been a strategic priority of China's government since the Eighteenth National Congress. China's education sector has made historic progress and attained above-average level in the world. Chinese government spending in education has exceeded 4% of GDP for five consecutive years since 2012. In 2016, total investment in education in China was RMB 3.9 trillion, and government expenditure was RMB 3.1 trillion, comprising 4.22% of the GDP. There are a total of 512,000 schools of various levels in the country, with a total of 265 million academic students (53 million students are registered students in non-academic education).

Compared with the proportion of education expenditures to GDP in typical developed countries (6.0% in the US, 5.5% in France, and 5.3% in the UK), China's education expenditure should still increase. It is estimated that China's education expenditure will reach RMB 5.2 trillion by 2020.

Figure 1-3 Forecasts on China's education expenditure



Sources: Ministry of Education, National Bureau of Statistics, and Bexcel Management Consultants

In addition to government expenditure, Chinese parents spend heavily on education, creating huge market potential of the education sector in China. According to China Statistical Yearbook 2017, the total value of China's education market reached RMB 9 trillion, spread among 190 million K-12 students. Markets of this scale have great promise for capital investment.

1.2 Evolution of Education

1.2.1 Evolution of Global Education

Since the 1980s, education informatization has been an important aspect of global education policy. All countries have set development goals of education informatization. By the 1990s, many developed countries recognized that the application of information technologies in education helped promote regional education and sharing of high-quality resources, and promoted large-scale education informatization plans, such as the U.S. National Education Technology Plans, Australia's Digital Education Revolution, Korea's Smart Education Advancement Strategy, Singapore's Masterplan for ICT in Education, and Japan's Future School Advancement Undertaking.

Many countries are increasing their investment in education, improving overall quality and competing for science and technology talent. According to the Education Development Research Center of China's Ministry of Education, the trends in the development of education in other countries are as follows:

- **Steady Increase in Education Investment**

  Developed countries recognize the important role of education in economic, social, and talent development, and actively increase education expenditure. Education investment therefore accounts for a rising proportion of their GDP.

- **Fair and Quality Education**

  Fairness is a key education goal in many countries. For example, the UK government advocates results-based education fairness and balance. Australia has overhauled its basic education system to ensure quality and fairness.

- **Education Quality Improvement and Standard**

  Quality is a basic requirement of education, common to most countries around the world. For example, the Australian government has introduced quality standards in higher education. The French government has made efforts to promote quality standards of higher education in alignment with international standards to expand influence and reputation.

- **International Exchanges at All Levels**

  Governments recognize the importance of internationalization in politics, culture, and education, and promote international exchanges from traditional higher education to lower levels. For example, the U.S. government helps young students, teachers, and scholars to reach out and learn from the world. The U.S. government works with civil societies and schools to facilitate the internationalization of education.

- **Education Informatization As a Key in Global Education Modernization**

  Education informatization is an important indicator of a country's education level and even their overall strength. Many countries are actively promoting education informatization investment. For example, the U.S. government has invested heavily in education informatization; the UK government is strengthening informatization, such as hardware, network connectivity, and software; and the Korean government has actively strengthened teacher and student IT capabilities.

- **Education Decentralization, Evaluation and Performance Responsibility**

  Many countries have adjusted education governance policies to decentralize education regulation and give schools more power. Government supervision is strengthened, importance is attached to the evaluation system and performance responsibility, and a market competition mechanism improves efficiency and performance. For example, the U.S. has been increasing support for charter schools. The British government contributes to the establishment of free schools and establishes the education accountability system as an important measure of the reform of the educational management system. The Indian government has transformed the management model of higher education, shifting from command-and-control to guide-and-evaluate.

- **Improved Teacher Training and Qualification Standards**

  The improvement of teachers' proficiency is a strategic task in many countries, which have formulated policies for this purpose. For example, the U.S. has developed the "Our Future, Our Teachers" teacher education reform strategy. France has increased teachers' salaries to attract more talent. Finland requires that primary and secondary school teachers have masters' degrees. Germany promotes the flow of teachers between states by strengthening the mutual recognition of the state teachers' qualification certificates.

- **Increased Investment in STEM Education**

  Science, technology, engineering, and mathematics (STEM) education has become a focal point of many countries in their quest for next-generation talents. For example, the U.S. has developed the STEM education goal in the basic education phase. The U.S. government's budget for STEM education in 2015 was US$ 2.9 billion, an increase of 3.7% compared to its 2014 budget. Japan has taken measures to strengthen the development of STEM teachers, especially by supporting and encouraging female STEM teachers.

- **Increased Investment in Innovation and Entrepreneurship Education**
  A lack of innovation and entrepreneurship education limits entrepreneurial success in many countries. Nowadays, there is a global push toward innovation and entrepreneurship education from top to bottom and increasing investment. For example, the EU has increased investment in innovation and entrepreneurship education, and in the U.S., innovation and entrepreneurship education is a lifelong endeavor reflected throughout the national education system.

- **Education for Sustainable Development**
  International organizations have begun to actively promote education for sustainable development. The UNESCO Roadmap for Implementing the Global Action Programme on Education for Sustainable Development was released in November 2014, providing an overall design and deployment guide for the next five years. Ireland released its first National Strategy on Education for Sustainable Development (ESD) (2014-2020) in July 2014. Likewise, Scotland has incorporated the concept of sustainable development education into its basic curriculum.

1.2.2 Evolution of Education in China

Significant Progress of Education Informatization 1.0

To implement China's *National Plan for Medium- and Long-term Education Reform and Development (2010-2020)*, the Ministry of Education released the *Ten-Year Development Plan on ICT in Education (2011-2020)* in March 2012, marking the beginning of what can be referred to as Education Informatization 1.0. In September 2012, the China's State Council further clarified that a goal in the 12th Five-Year Plan is to provide broadband access for each school, premium resources for each class, and online learning space for each student. Moreover, building an education resource platform and an education management platform were priorities. The *Education Informatization Plan during the Thirteenth Five-Year Plan* released by the Ministry of Education in June 2016, further cemented this education informatization strategy.

Education informatization 1.0 has made significant progress. The network environment of schools has been improved significantly. Internet penetration in small- and medium-sized schools has increased to 92%, the penetration rate of multimedia classrooms has reached 85%, and there are now 71 million network learning spaces. More than 10 million primary and secondary school teachers, 100,000 primary and secondary school principals, and 200,000 vocational college teachers have received special training on applying ICT to their work. By the end of 2017, China's education informatization market reached RMB 160 billion, a YoY increase of 16.4%. The investment in education informatization continues to increase and is expected to reach RMB 380 billion by 2020.

Although China's education informatization has made great progress, it varies by area according to socioeconomic development, education heritage, local mindset, and geographical environment. Education quality varies by area and school, the gap between urban and rural quality is large, and uneven distribution of educational resources is a major concern. The gap between China and developed countries in education informatization remains wide in terms of applications and innovation.

Education Informatization 2.0

In April 2018, the Ministry of Education released the *Education Informatization 2.0 Action Plan* to accelerate educational modernization and promote nationwide education. Education informatization 2.0 emphasizes universal promotion of education modernization through informatization. By 2022, the education application should cover all teachers, learning applications should cover all students, and digital campuses should be implemented in all schools. The ICT literacy of teachers and students should be improved. The platform joining the Internet with education should transform dedicated education resources to widely-shared resources and build a new model of talent cultivation.

In the 2018 Government Work Report, Premier Li Keqiang emphasized the development and application of next-generation AI technologies, promoting Internet applications in healthcare, elderly nursing, education, culture, and sports. His report also attached importance to fair and quality education.

The *Education Informatization 2.0 Action Plan* and the *2018 Government Work Report* emphasize the application of new technologies such as cloud computing, big data, Internet of Things (IoT), mobile Internet, and AI in all aspects of education, laying an important roadmap for China's educational advancement.

- **Intelligent, Automated, and Digitalized Education**
  Information technologies will be widely used in education in China. Massive Open Online Courses (MOOCs), blended learning, and flipped classroom have been widely deployed. The intelligent teaching system (ITS), intelligent decision making support system, and intelligent computer-aided instruction (CAI) systems have developed rapidly. IoT has been applied in classroom teaching, extracurricular learning, and education management.

- **Competence Becoming a New Target for Educational**
  Traditional education is based on knowledge transfer and understanding. However, in the future workplace, tasks requiring simple memorization of knowledge and basic understanding will be performed by AI. Therefore, the focus of education must shift from knowledge acquisition to competence building, such as independent thinking, creativity, innovation, and entrepreneurship.

- **Blended Learning Becoming Popular**
  Blended learning is an education program that combines face-to-face learning and online learning. It combines multiple teaching devices, teaching methods, learning strategies, evaluation methods, and courses and learning resources to improve school teaching quality. Blended learning has significant advantages in learning planning, methodology design, effect evaluation, and record keeping. It has been widely used in many developed countries and is an important trend in education.

- **Individualized Education**
  Traditional education is not personalized and cannot inspire individual students to strive for their full potential. Using big data, individualized education can push the right learning resources to the right students based on their preferences, purposes, styles, and hobbies.

- **Shift from Teacher-centered to Student-centered**
  Traditional teacher-centered education does not promote self-motivation among students. Future society will need people who are willing and able to commit to lifelong learning. Therefore, teaching must be shifted from teacher-centered to student-centered. Moreover, a wide variety of educational resources are available on the Internet. AI will help students identify learning resources inside and outside of classrooms.

- **Lifelong Learning Becoming a Way of Life**
  Everyone needs to update their knowledge and skills to keep up with societal and economic development. Lifelong learning will be popularized and made possible by information technologies, such as the Internet and AI.

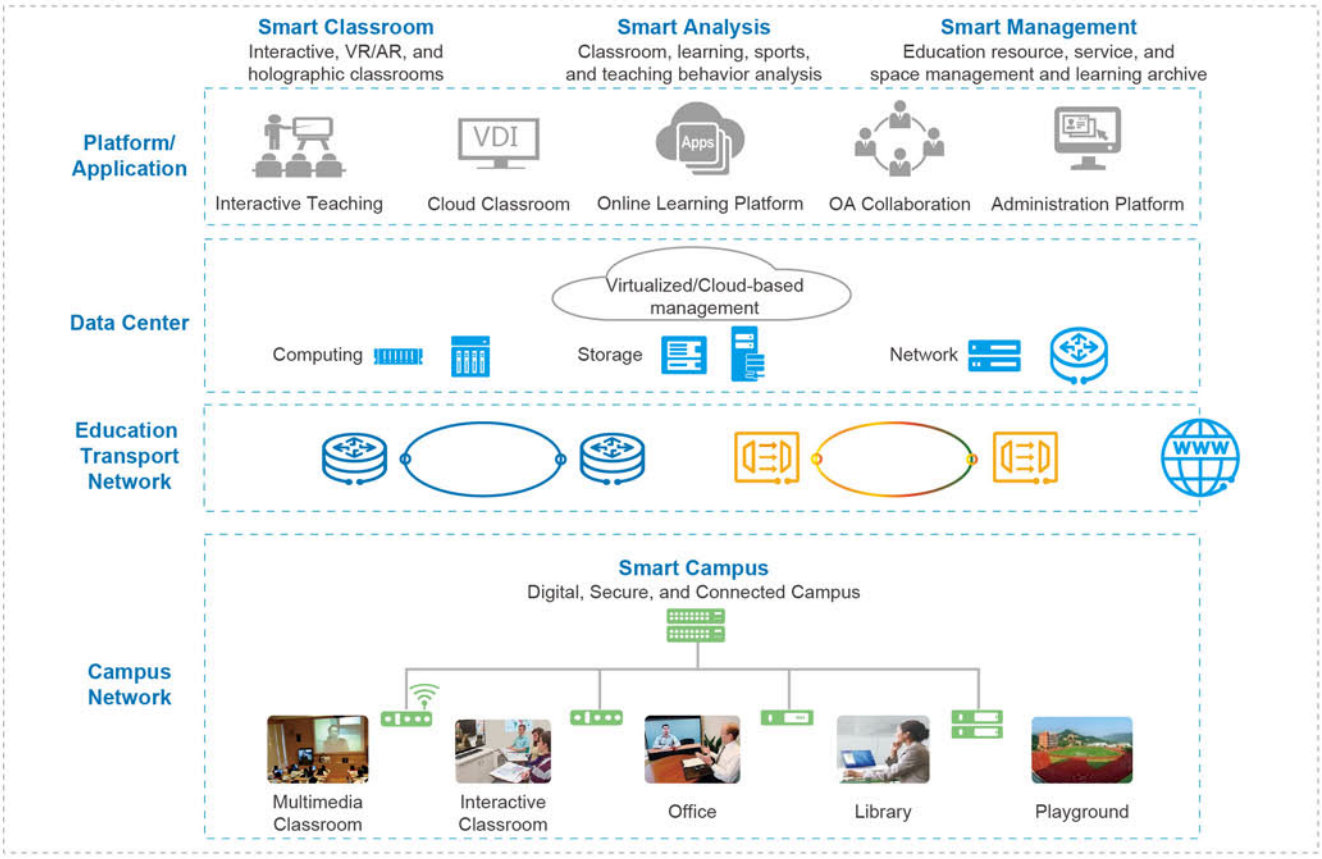
- **Teachers' Role Becoming Planning and Guiding**
  The major traditional role of teachers was to lead and teach. However, with the application of information technologies, especially AI, and the popularity of blended learning, education is increasingly student-centered, and the role of teachers must change accordingly. Teachers can be divided into two categories: Instructors and tutors. Teachers who are good at lecturing will become instructors, teaching students face-to-face or online. Other teachers will become tutors, helping students according to their individual needs.

- **Individualized Schooling**
  Schooling must be individualized to adapt to changing needs and wide application of information technologies. People prefer individualized schools that respect the personal traits and needs of students. Schools need to be more flexible in teaching activities.

1.2.3 New Stage of Education: Smart Education

With the development of the Internet and application of technologies such as cloud computing, big data, and AI, education is becoming intelligent, intuitive, and ubiquitous. It will provide individualized, refined, and immersive leaning experiences, making classroom teaching more effective, students more enthusiastic, and learning more efficient.

Figure 1-4 Architecture of smart education



Smart education covers multiple aspects, such as classroom, campus, analysis, and management. The preceding figure shows the campus network, transport network, data center, platforms, and applications providing E2E connectivity from device to pipe and cloud. This provides core smart education applications, such as smart classroom, campus, analysis, and management.

Smart Classroom: Interactive and Immersive Teaching Environment

As a main component of smart education, smart classrooms use VR/AR and hologram technologies to provide individual and immersive teaching experience.

- **Interactive Classroom**: Combining Internet and education provides interactive teaching environments in physical classrooms, online classes, and cloud classrooms, enabling interaction between teachers and students, teaching by group or level, discussion-based teaching, and flipped classroom.
- **VR/AR Classroom**: VR and AR provide students with immersive teaching environment and experience.
- **Holographic Classroom**: Hologram technologies provide intuitive, 3D, and immersive experience and support real-time and multi-point virtual interaction.

Smart Campus: Broadband, Safe, and Fully-Connected Campus

- **Broadband campus**: Wired and wireless ultra-broadband networks provide integrated transmission of multiple services, such as Internet access, video, office application, and IoT.
- **Safe campus**: 360° HD video surveillance and intelligent identification of risky behavior ensures safety of faculty and students on campus.
- **Intelligently Connected Campus**: Intelligent collection and analysis of information about IoT terminals facilitates the management of school assets, entry and exit of students, and faculty attendance. It supports services such as smart card and campus vehicle navigation and location.

Smart analysis: Analyzing Classroom, Learning, Sports, and Teaching Activities Using Big Data and AI

- **Classroom behavior analysis**: Students behavior in classrooms can be analyzed for subsequent teaching and guidance.
- **Student behavior analysis**: Student learning and behavior data is dynamically collected and analyzed so that teachers can optimize teaching design and guide students to improve learning results.
- **Sports analysis**: The sports activities of students are monitored and analyzed to determine whether students are cutting corners, exercising excessively, or have unusual physical conditions. This function also supports automatic measurement of some activities.
- **Teaching behavior analysis**: The behavior of teachers is analyzed to objectively evaluate the quality of classroom teaching.

Smart Management: Services for Teachers, Students, and Parents

Smart management of educational resources, administration, spaces, and development archives is provided for faculty, students, and parents.

1.3 Summary

- The education market space in China and worldwide is huge, and education investment as a proportion of GDP continues to grow.
- As global education informatization advances, providing fair, quality, innovative, individualized, and competence-oriented education has become a common goal.
- The smart education enabled by information technologies such as the Internet, big data, and AI is well-aligned with the global education evolution and will improve the classroom, campus, analysis, and management.

02 Smart Classroom

As an important part of smart education, smart classroom digitalizes education applications and runs them in smart classroom terminals to implement interactive and immersive teaching.

2.1 Interactive Classroom

2.1.1 Application Scenario

Interactive classroom is a new teaching model enabled by combining Internet and education, facilitating interaction between teachers and students and between students. The classrooms focus on achieving better results for students and developing their potentials.

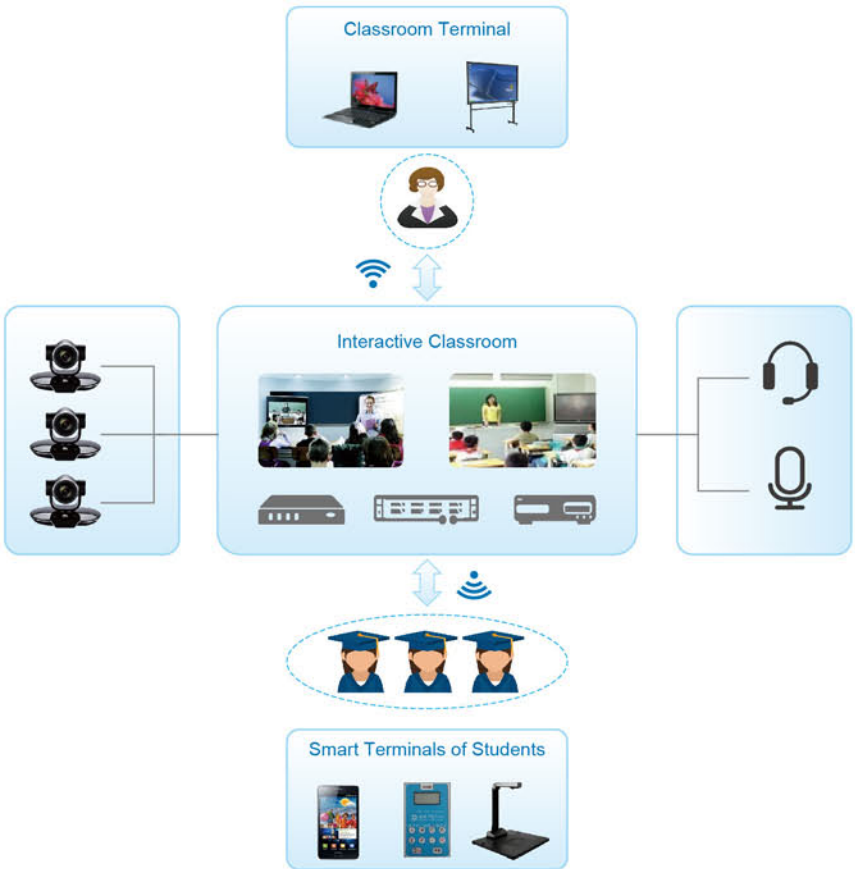
Interactive classrooms apply to offline physical classes, online classrooms, and cloud classrooms, which combine the former two types.

Physical Interactive Classroom

Teachers and students are in a physical classroom. However, new interaction methods, such as video systems, voice systems, and smart devices facilitate interaction and discussions classroom to improve results.

An interactive classroom uses classroom terminals (such as computers/tablets and electronic whiteboards), smart devices (such as tablets, responders, and smart projection terminals) of students, video and audio devices (such as cameras and microphones), and classroom interaction systems. The classroom interaction system is the core. It provides interaction management and intelligent interaction scheduling, and can be deployed locally or remotely.

Figure 2-1 Physical interactive class



Interactive classrooms may involve the following:

- **Interactive video**
  The intelligent video system automatically identifies and switches video images, and displays the images of teachers and students on the electronic whiteboard. For example, when the teacher walks down the platform, the student sees the front image of the teacher, and the teacher sees the front image of the students. When a student answers a question, the video automatically zooms in on the student.

- **Teaching desktop activities**
  In classroom teaching, smart devices, such as tablets, projectors, and projection terminals, transfer content to the interaction system for automatic projection or interaction. For example, when the teacher is explaining a subject, the electronic whiteboard automatically displays the corresponding courseware content. When students share their notes or classroom exercises, the notes or exercises are automatically projected on the electronic whiteboard.

- **Material sharing**
  The interaction system can distribute materials and homework assignments and projects. For example, when classroom teaching has finished, the teacher can share materials with students or add them to the homework or assigned learning materials.

Physical interactive classroom significantly improves teaching quality using features such as recorded broadcast, open classes, and sharing of class video between schools. However, due to physical space limitations, this form of class is not suitable for large audiences. With the development of interaction methods, these physical restrictions will abate so that classes can be presented to a larger audience and go online.

Online Interactive Classroom

Online interactive classes are not limited by time, space, or location. Real-time online interaction systems transmit video, voice, and images in real time. Text, voice, and video feeds can be exchanged, papers can be projected to whiteboards, and the whiteboards can be commented and shared just as in a physical classroom.

An online interactive class involves an online teaching system, teacher side, and student side. An online classroom teaching system consists of the online classroom, recording, and management sub-systems. It provides functions such as teaching interaction, user management, courseware management, recording, and big data analysis. A teacher's terminals usually include high-performance computers, cameras, and microphones. Students usually use tablets, but may use computers for better performance.

Figure 2-2 Online interactive classroom

In online interactive classrooms, teachers and students are not in the same physical location. Therefore, the interaction methods differ.

- **Interaction during lecture**: The main interface of the interaction system can be switched between the teacher's interface, courseware interface, and student interface.
- **Interaction during tests**: The teacher can deliver test questions to the student interface through the interaction system. The students can complete and submit the test questions separately, and the teacher can see the answers and statistics of all students.
- **Q&A**: The teacher can ask questions on the interaction system, pick students to answer them, or ask students to "raise their hand," and switch the video feed to the student who is answering the question.
- **Group interaction**: A large class can be divided into small groups, and student can only interact with other members of their group.

Online interactive classes becoming increasingly accepted by parents and students because of their continuous enhancement of interaction and management. It is suitable not only for one-to-one teaching, but also for large-scale teaching. Students can access the resources over the Internet anytime, anywhere. This is very helpful for students in areas where local education resources are inadequate, and is suitable for on-the-job education and continuing education.

Cloud Classroom

Cloud class is an efficient, convenient, and real-time interactive teaching method. Classrooms are moved to the cloud and accessed online or from a physical classroom, achieving real-time teaching across regions.

Cloud class consists of the cloud class system, main classroom side, remote classroom side, and remote student or parent side. A cloud class system is deployed in the cloud to provide all teaching services, including the user management system, interaction system, courseware system, test question system, student bonus point system, recording system, video and scheduling system, and big data platform. Cloud classes can be accessed through private lines or the Internet. Private lines are often used on the classroom side to ensure high quality feeds, and the Internet is often used on the student side for convenience and cost. On the main classroom side, the configurations are the same as those of physical classrooms if the teacher is in the main classroom. If they are not, an independent teacher side is required. The difference between a remote classroom and the main classroom is that the system management is controlled in the main classroom. Tablets are used on the student side.

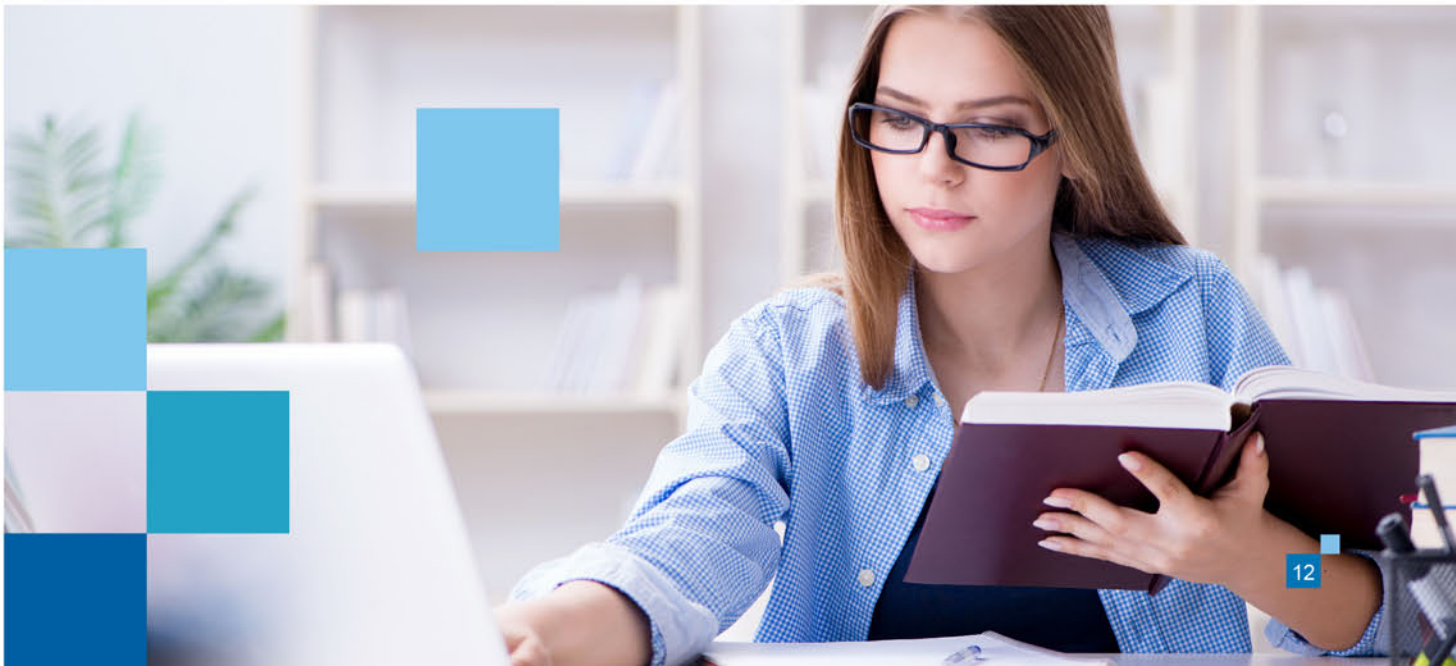
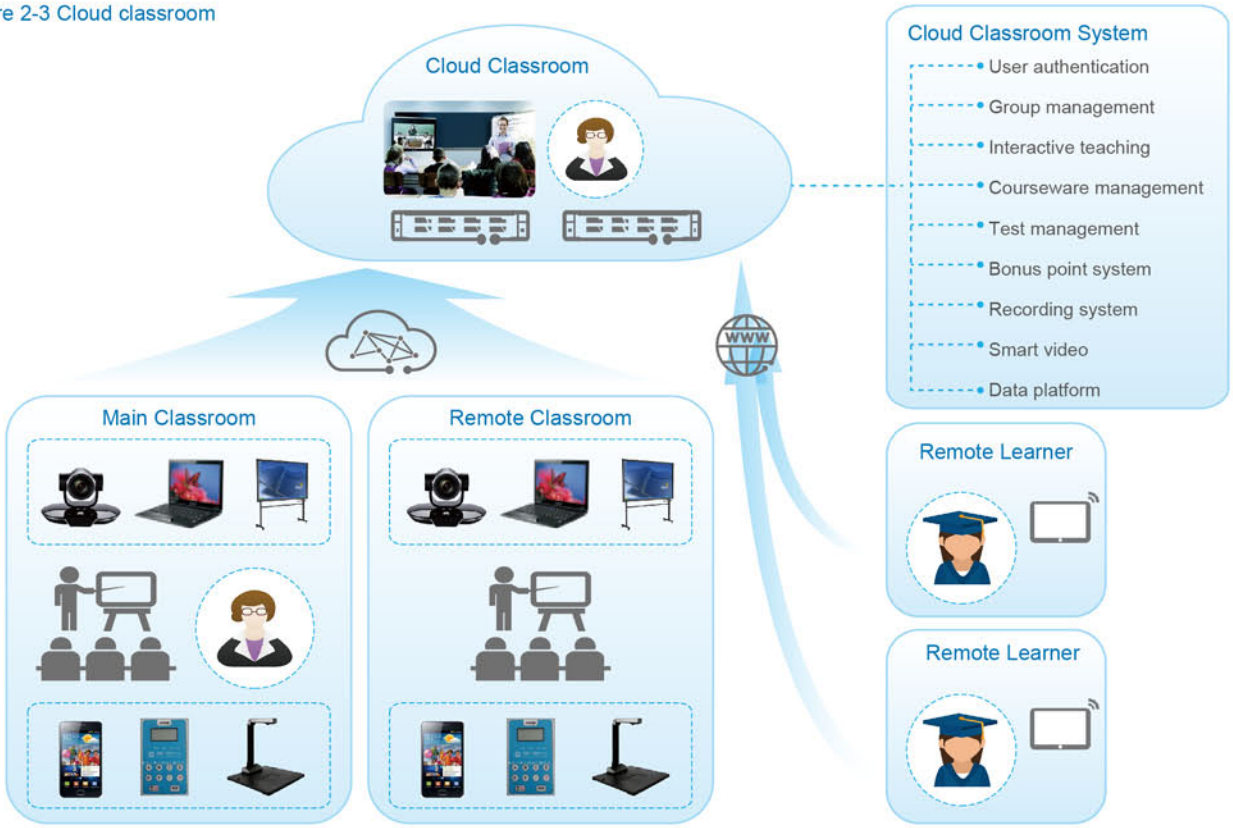


Figure 2-3 Cloud classroom



A cloud class involves multiple classrooms and remote students, both online or in physical classrooms. In addition to physical and online interaction, dual-teacher interaction is also supported.

- **Dual-teacher classroom interaction:** Two teachers are supported, which is useful if there are many students.

Cloud classes are helpful to students in areas where local resources are inadequate. The grouping and dual-teacher functions also helps improve teaching results. Therefore, cloud class is the trend, and online class will evolve to cloud class.

Ubiquitous Classroom

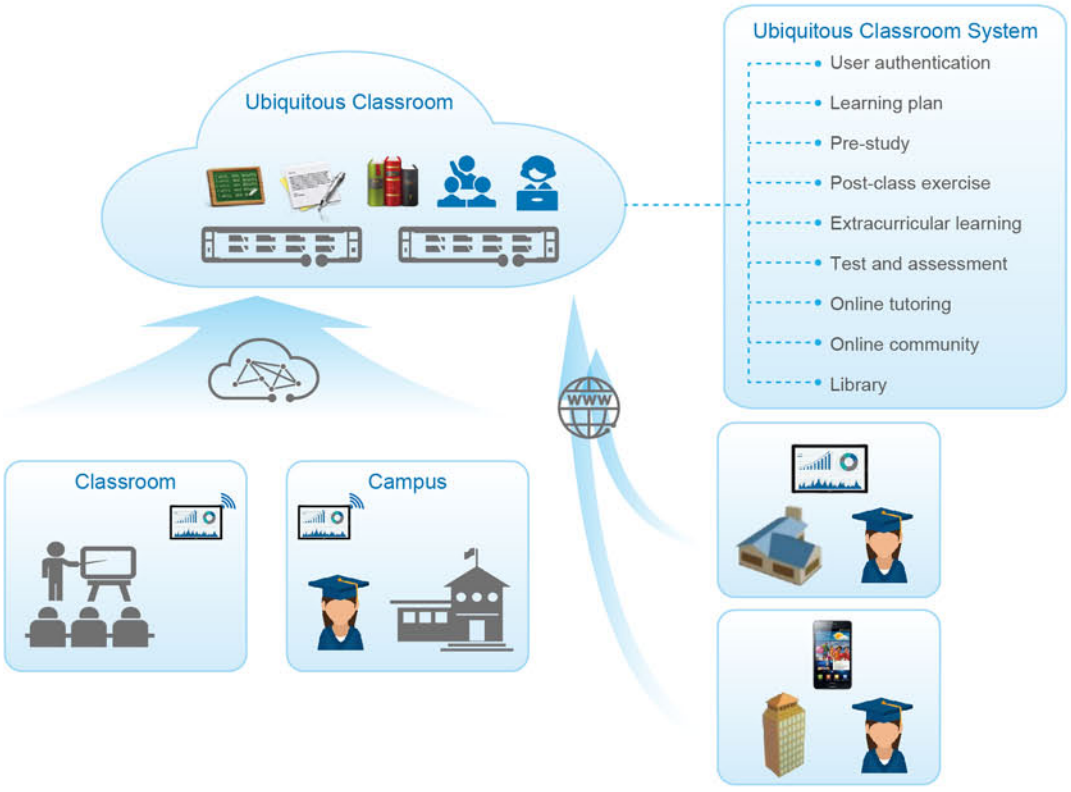
Ubiquitous classes refer to classes in the general sense, which are available anytime, anywhere. Ubiquitous classes incorporate the learning in physical classrooms, online classes, and cloud classes, as well as learning outside the classrooms, such as pre-study, post-class review, post-class exercises, extracurricular learning, and push of learning materials.

Ubiquitous class emphasizes system learning, and improves learning results if coupled with the learning in a physical classrooms, online classes, or cloud classes. A ubiquitous class system provides comprehensive learning services, including course selection, learning plan, learning model, intelligent sparring, learning materials, test questions, optional reading, exam assessment, and communication and interaction. Students can access the ubiquitous class system from applications running on their tablets or mobile phones. Then, they can perform system assessment, set goals, make learning plans, and select materials based on the capability assessment and learning model, then start systematic learning.

Ubiquitous class is intelligent. Learning tasks are generated based on individual learning capability assessment, learning goals, and time spent. During the learning process, the capability modeling and intelligent sparring continuously evaluate students and adjust their learning contents. For example, the system adjusts the contents of subsequent learning and exercises according to their performance in tests.

Ubiquitous class is virtual and accessible from smart devices over the Internet anytime, anywhere. It can interconnect with other resources and platforms, such as digital libraries, electronic schoolbags, external teaching resource platforms, and communication spaces to facilitate communication between teachers and students and between students.

Figure 2-4 Ubiquitous classroom



2.1.2 Industry Landscape

Interactive Teaching in Initial Stage, with Extracurricular Education Institutions the Early Adopters

Extracurricular education institutions are the early adopters of interactive teaching, and interactive teaching products and solutions emerge one after another. A wide variety of desktop interactions, classroom tests and interactions, group interactions, and dual-teacher class functions are used in educational institutions, such as TAL Education, New Oriental, and Gaosi Education. In K-12 education, multimedia-based and interactive teaching is provided in smart classroom. For example, interactive teaching using cloud classrooms is implemented in Longgang District, Shenzhen, to support routine teaching interaction, Q&A, interactive learning, and material sharing. However, some schools may still use recording systems, and some well-funded schools are introducing interactive teaching applications.

Interactive Teaching Has a Bright Future

With the popularization of applying Internet technologies to education, interactive teaching devices and solutions begin to emerge one after another. The success stories in educational institutions and unified deployment in school districts are good opportunities for the development of innovative and interactive class applications.

2.1.3 Scenario Value

Quality Education

Interactive teaching centered on students can better inspire them and improve teaching quality. Ubiquitous classes fill the gap between schools and homes, improving teaching and learning quality.

Fair Education

Information technologies enable cross-region teaching and interaction. For example, cloud and online classes make quality education resource accessible to students in areas where local resources are inadequate, facilitating fair education.

2.1.4 Transport Requirement

Interactive classes rely heavily on video and audio transmission.

The following table lists the requirements of interactive classroom for a teaching network.

Table 2-1 Network transport requirements of interactive classrooms

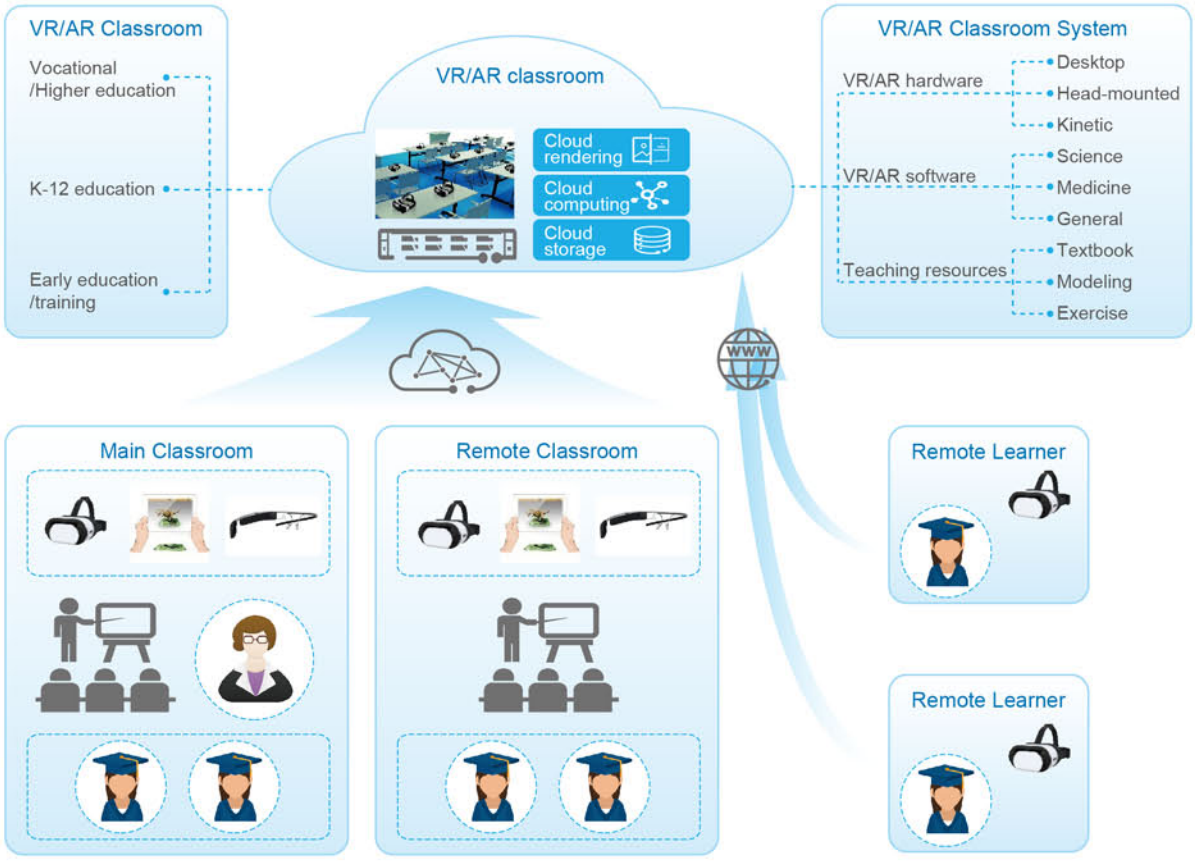
Service Type	Number of Terminals	Access Bandwidth	Latency	Packet Loss Rate
Video terminal	3–4 per classroom	≥ 8 Mbit/s per terminal	≤150ms	≤5%
Teaching terminal	30–50 per classroom	≥ 2 Mbit/s per terminal	≤200ms	≤5%
Classroom gateway	1 per classroom	≥50 Mbit/s		
Internet terminal		≥50 Mbit/s		≤5%
Cloud private line for interactive classroom access		≥ 50 Mbit/s, depending on the actual situation of the school	≤100ms	≤0.5%
Cloud service access		≥ 50 Mbit/s per class, supporting an audience of 100 or larger 4 Mbit/s per user, supporting up to 30,000 concurrent users		

2.2 VR/AR Classroom

2.2.1 Application Scenario

VR/AR technologies can create virtual classroom environments, allowing students and teachers equipped with VR glasses or AR terminals to enjoy a more intuitive teaching experience. VR/AR technologies provide courses and training that are difficult or even impossible in the real world. The immersive experience in education and training improves users' perception and retention of knowledge.

Figure 2-5 VR/AR classroom



There are many segmented scenarios in the education market. Currently, the VR/AR smart classroom has been applied to all areas of education.

VR/AR Classroom for Early Education

AR for early education often employs vivid and interesting 3D cartoon images, making it attractive to children and parents. The applications include:

- **AR cards**
  AR technologies can turn graphic images or cards into 3D images to attract children's attention.
- **AR books**
  An AR book can be regarded as a collection of multiple cards. However, it contains a large amount of closely related content, creating good stories and making children feel like they are present.
- **AR games**
  Combining games with education, children can improve their focus and knowledge absorption efficiency by playing games and learning simultaneously.

VR/AR Classroom for K-12 Education

VR/AR classes provide courses such as science, history, geography, biology, physics, chemistry, and art for K12 education. VR/AR courseware helps students experience all kinds of knowledge and participate in various experiments. For example, they can experience historical monuments, landforms, and movements of celestial bodies; comprehensively view human bones, joints, eyeballs, blood, heart structure, heartbeat, and respiration; and perform "hands-on" operations during biology and chemistry class experiments.

VR/AR Classroom for Vocational Training/Higher Education

For vocational training and higher education, VR/AR classes are mainly used in medical training, engineering training, and VR/AR talent development. The applications include:

- **"Hands-on" training in high-cost and high-risk scenarios**
  For example, VR/AR can be used for surgery simulation, automobile disassembling and maintenance training, and aircraft flight training.

- **Simulated teaching for disaster scenarios**
  For example, VR/AR can be used to simulate earthquakes and fires to practice escape drills.

2.2.2 Industry Landscape

VR/AR applications are increasingly used in training and education. However, experience needs to be improved and costs need to be reduced.

VR/AR technologies are increasingly used in training and education. According to Global Virtual Reality Market in Education Sector 2018-2022, a report released by Market Insights Reports, the global VR education market will grow at a compound annual growth rate of over 59% from 2018 to 2022, and almost half of educational institutions in the U.S. will use some form of VR by 2022.

However, VR/AR classes still face challenges, such as poor experience and high costs. According to the feedback from Strategy Analytics on VR HMD users, users often experience problems such as dizziness, complicated configuration, and smartphone overheating. Simultaneously, the popularization of VR/AR education also faces problems such as expensive hardware and content problems such as slow and difficult production, personalization requirements, and copyright protection issues.

In the future, VR/AR classrooms will use high-performance cloud computing and rendering to enrich and protect content and reduce costs.

Moving processing capabilities to the cloud reduces terminal requirements, and terminals can be lighter, more comfortable, and cheaper. In addition, content cloudification greatly enriches VR/AR application scenarios and drives the transformation from physical classrooms to online live broadcast and interactive classrooms.

2.2.3 Scenario Value

Intuitive and vivid immersive teaching inspires enthusiasm and improves knowledge absorption

The new teaching experience presented by VR/AR and education can greatly improve students' interest in learning and knowledge absorption speed. Immersive teaching scenarios and 3D images make education more intuitive and allow "hands-on" operations.

Useful for expensive, risky, or difficult-to-implement training

For example, VR/AR can be used for surgery simulation and aircraft flight training to reduce risks and costs. It is also able to simulate earthquakes and fires to practice escape drills.

2.2.4 Transport Requirement

VR/AR classes involve a large number of terminals and have strict requirements on network bandwidth and delay. The following table lists the requirements of VR/AR classrooms for a teaching network.

Table 2-2 Network transport requirements of VR/AR classrooms

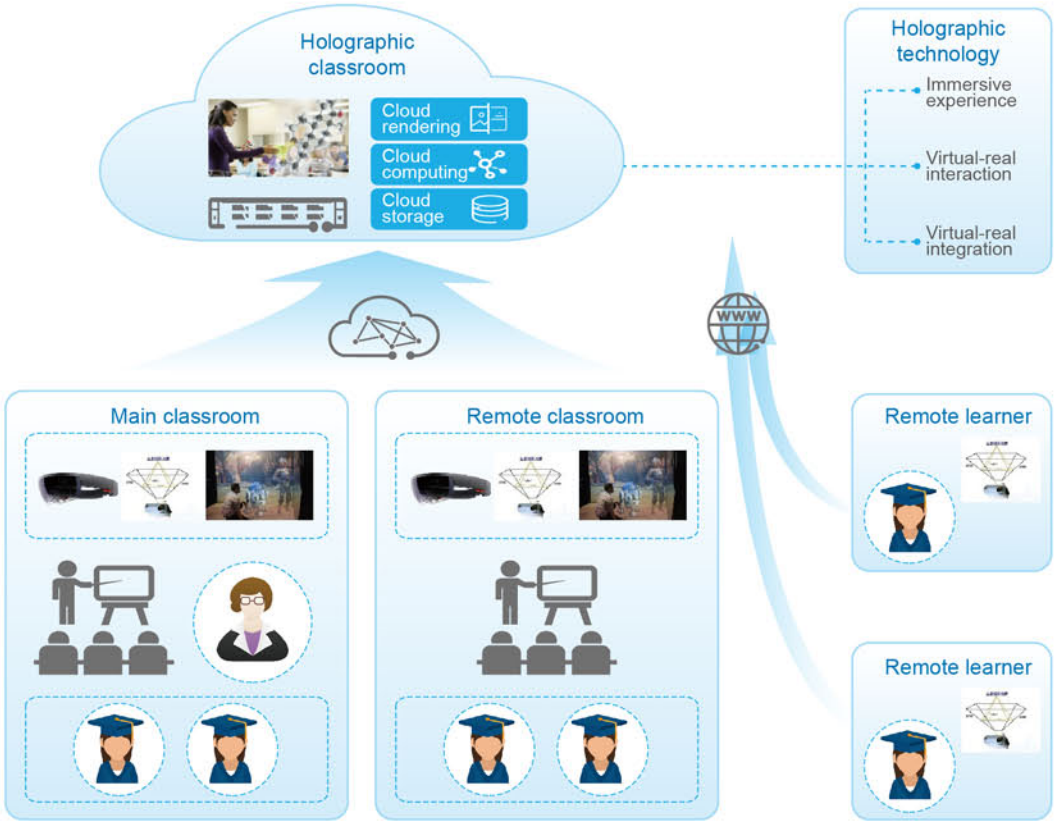
Service Type	Number of Terminals	Access Bandwidth per Terminal	Latency
Fair-experience VR/AR	30–50 per classroom	80 Mbit/s	20ms
Comfortable-experience VR/AR	30–50 per classroom	260 Mbit/s	15ms
Ideal-experience VR/AR	30–50 per classroom	1 Gbit/s	10ms

2.3 Holographic Classroom

2.3.1 Application Scenario

Holographic technologies are used for teaching in classrooms. Students and teachers use holographic screens, holographic glasses, and holographic 3D projection products to create a teaching scenario where 3D forms are synchronized with, correspond to, and interact with 2D parsing and even abstract information. This guides students to fully integrate 3D space and visual thinking with language, digital, and logical understanding, implementing an intuitive and immersive teaching experience.

Figure 2-6 Holographic classroom platform



Compared with the VR/AR classroom, holographic classroom is more intuitive, vivid, and convenient. In addition to its powerful immersive experience, it also provides powerful virtual-real interaction and integration.

- Holographic classroom does not need HMDs. Users can directly view 360-degree 3D images with the naked eye.
- Learners can associate holographic images with textbooks to view the static or dynamic 3D images corresponding to book content, and perceive the knowledge more vividly.
- Depth sensor and image analysis and tracking technologies enable teachers and students to interact with each other in real time and at multiple points, improving the educational experience.
- Holographic imaging technology enables teachers and teaching materials to be present on site. This improves students' participation and experience and provides the same education platform for all students, achieving fair education.

2.3.2 Industry Landscape

Holographic education is in its initial stage. It also faces problems such as technical bottlenecks, high cost, and incomplete industry chain.

Today's commercialized holographic products are displayed based on media. Holographic images that are directly displayed in the air are not mature. These are expensive, requisite industry chains are not mature, content resources are insufficient and production is challenging, there are no unified industry standards, manufacturing costs are high.

In the future, the holographic classroom will use high-performance cloud computing and rendering to enrich and protect content and reduce costs.

The cloud holographic technology is introduced to cloudify large-volume holographic processing capabilities (such as rendering processing), greatly enriching content services, protecting copyright, and reducing use costs. High-performance cloud computing also reduces terminal costs. In addition, content cloudification greatly enriches the application scenarios of holographic classroom and transfers physical classrooms to online live broadcast and interactive classrooms.

2.3.3 Scenario Value

Holographic classroom provides more vivid and immersive teaching experience than VR/AR classroom, and has powerful virtual-real interaction and integration capabilities. These benefits greatly improve students' learning interest and efficiency and enhance teaching quality.

2.3.4 Transport Requirements

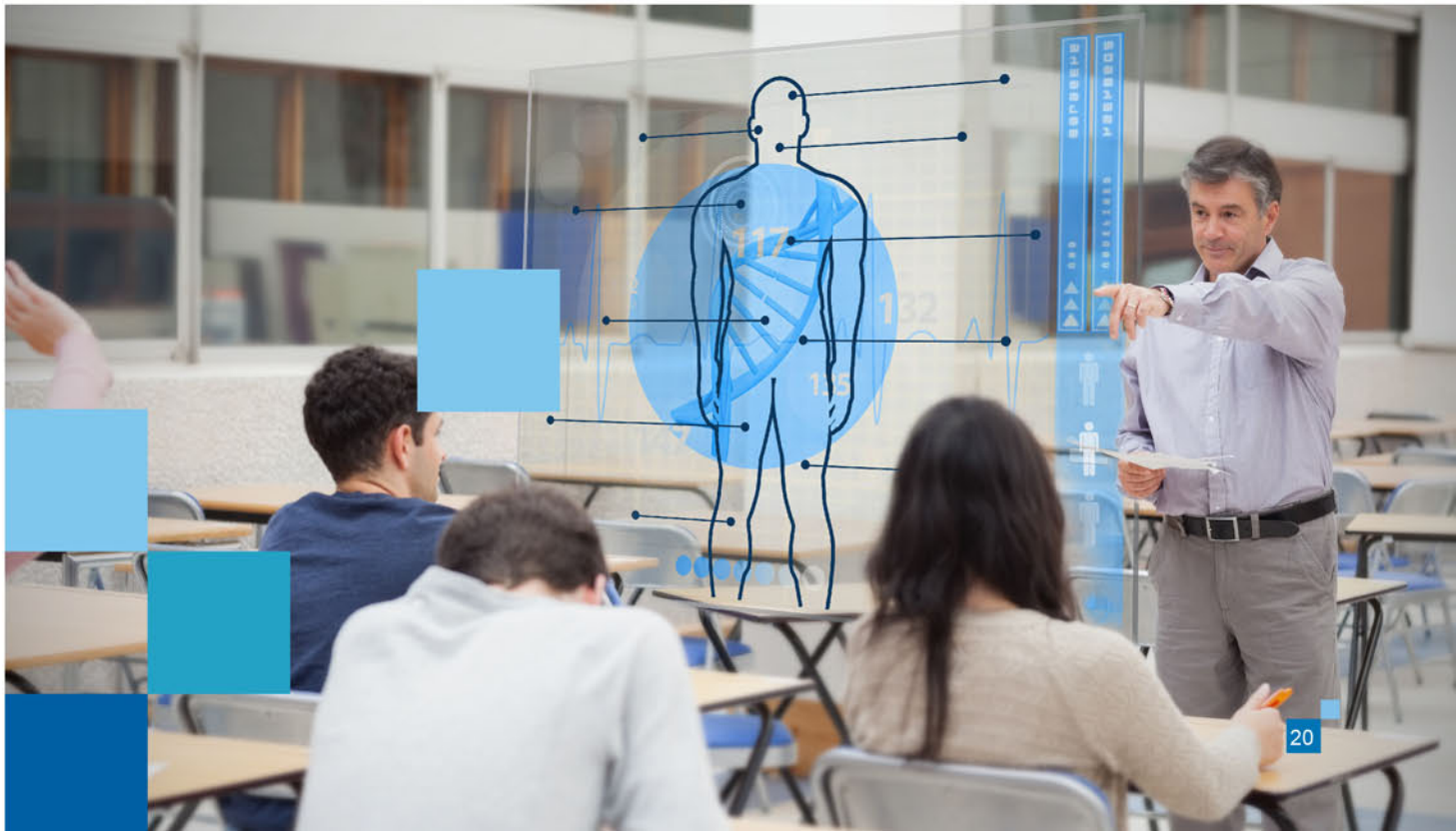
Compared with VR/AR classroom, holographic classroom involves access of 30 to 50 VR/AR terminals, increasing demands on network bandwidth and latency. The following table lists the requirements of the holographic classroom for the teaching network.

Table 2-3 Network transport requirements of the holographic classroom

Service Type	Technical Specifications	Access Bandwidth per Terminal	Latency
Immersive experience	8K (8 bits, 30 FPS)	100 Mbit/s	20ms
	16–32K (10–12 bits, 60–120 FPS)	100 Mbit/s–1 Gbit/s	10ms
Interaction experience	6 degrees of freedom (6DoF), real-time interaction	1 Gbit/s	5ms
Convergent experience	Light field, holographic	10 Gbit/s	1ms

2.4 Summary

- Smart classroom is an important application scenario of smart education. Using IoT, big data, and AI, teaching and informatization are deeply integrated, achieving a new approach to modern education.
- Smart classroom has scope, including physical classrooms and virtual teaching classrooms. With the continuous integration of STEAM and Maker education concepts and models, smart classroom will evolve towards smart interaction and real-experience perception teaching and training based on VR/AR/holographic technology.
- The smart classroom has strict requirements on network transport and requires that the network provide transport assurance.



03 Smart Campus

As the basis of smart education, smart campus builds a full-coverage broadband campus network and provides high-speed pipes for various teaching applications. It also provides full security surveillance to ensure campus safety. Using IoT, big data, and AI technologies, smart campus builds a fully-connected green smart campus to intelligently manage people and things.

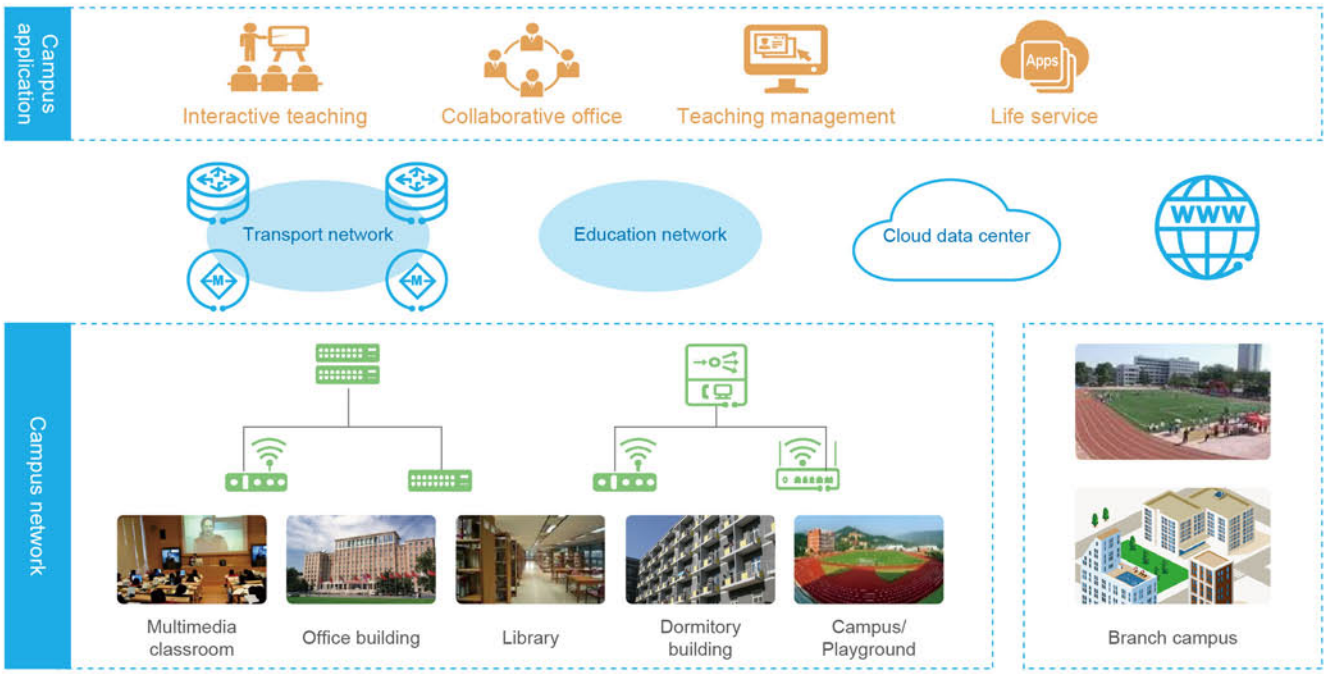
3.1 Broadband Campus

3.1.1 Scenarios and Current Situation

Broadband campus construction refers to the construction and reconstruction of campus network infrastructure. Its ultimate goal is to realize full access and full coverage of the campus broadband network.

- Campus with wireless coverage in all scenarios: Supports mobile learning, mobile teaching, and mobile office applications.
- Fully-connected ultra-broadband campus: Meets teaching and office requirements and supports peak hour concurrent access.
- Office collaboration and convergence campus: Supports daily collaborative office, administrative conferences, mobile office, and desktop office applications.
- Campus with network behavior management: Supports audit of users' Internet usage, implementing GreenNet and avoiding unhealthy overuse.
- Simplified O&M campus: Supports intelligent campus network planning and automatic deployment, wired and wireless network convergence, and service and policy automation.

Figure 3-1 Overall architecture of the broadband campus



Campus with wireless coverage in all scenarios

With the diversification of campus mobile terminals, teachers and students demand access to the campus network anytime, anywhere. As more mobile applications are deployed on campus networks, Wi-Fi coverage in all scenarios has become a prerequisite for construction of the campus broadband network. The gigabit IEEE 802.11ac standard is the mainstream, and the wireless gigabit era is coming.

However, traditional campus Wi-Fi networks face the following challenges: Wi-Fi coverage is poor. In some areas, there is no signal or users fail to connect to the network even though there is a signal. For example, many obstacles in dormitories cause serious signal attenuation, and some places do not have Wi-Fi coverage at all. In high-density scenarios such as lecture halls and gymnasiums, device access capabilities are often exceeded. Adding Wi-Fi nodes complicates planning, deployment, and maintenance, and deployment of both wired and wireless networks makes O&M complex.

To achieve optimal coverage, campus Wi-Fi network construction oriented for smart education needs a solution adapting to various application scenarios.

1. Multimedia classroom

A multimedia classroom is an ICT-based teaching environment formed by adding computers, electronic whiteboards, projectors, digital video display platforms, physical projection display platforms, and sound pickup and amplification devices to traditional classrooms.

A multimedia classroom has diverse mobile terminals, and the number of concurrent access users is excessive. In this case, the integrated smart classroom gateway device with the built-in access point (AP) function can be selected. The smart classroom gateway integrates functions such as routing, switching, security, Wi-Fi, central control, audio and video output, and server. It is easy to deploy and provides unified access for electronic whiteboards, projectors, cameras, and intelligent teaching terminals. This meets diverse teaching service requirements and supports interaction between teachers and students in electronic classrooms.

2. Teaching buildings (with common classrooms), libraries, and administrative office buildings

In open or semi-open indoor scenarios, there are many concurrent users, requiring neat deployment and convenient construction. In this scenario, you can select three radio frequency (RF) APs that support dual 5 GHz access, can work at 2.4 GHz and dual 5 GHz frequency bands simultaneously, and can be equipped with intelligent high-density omnidirectional antennas with automatic switching based on user locations. In addition, the APs support smart roaming, enabling terminals to roam between neighboring APs with better signal quality, ensuring enterprise mobile office service experience.

3. High-density scenarios such as lecture halls, auditoriums, dining halls, and stadiums

Academic lecture halls and gymnasiums may hold hundreds or thousands of people. Wireless users are densely distributed and require concurrent access and seamless roaming in the area. Due to the limited access capability of a single AP, many APs must be deployed. As a result, co-channel interference between APs is severe and performance deteriorates. To solve this, deploy three-RF devices that support intelligent high-density small-angle directional antennas and dual 5 GHz access, and can work at 2.4 GHz and dual 5 GHz frequency bands simultaneously. These implement high-density access in high-interference environments.

4. Apartments and dormitories

The walls of apartments and dormitories are densely distributed, and wireless signal attenuation is severe. The number of concurrent users in peak hours is large. Online videos and games have high requirements on bandwidth. The central AP + room distributed remote unit (RU) solution or the room converged gateway solution implements full coverage. The converged gateway solution is more suitable for converged access of voice, TV, and Wi-Fi services in a single room. If only Wi-Fi coverage is required, the central AP + room distributed RU solution suffices.

5. Outdoor campus and playgrounds

Outdoor scenarios high requirements on dust protection, waterproof, and have surge protection. Wireless coverage is wide. Trees and buildings interfere with signals. Industrial-grade outdoor APs with high protection and easy installation can be mounted on poles or walls to provide directional or omnidirectional wireless coverage. In this case, the dustproof and waterproof ratings of APs must be at least IP67, and the APs must have fully embedded lightning protection components and be resistant to both low and high temperature.

Fully-connected ultra-broadband campus

The 10GE/40GE aggregation switch electronic networking and 10GE full-fiber passive optical LAN (POL) networking solution can be used to construct an ultra-broadband campus network, meeting the video service-centered bandwidth requirements of future campus networks.

Switch electronic networking is flexible and features efficient local forwarding. It applies to scenarios with a large amount of local horizontal traffic interaction, such as teaching, office, and intelligent IoT. POL networking has advantages such as high bandwidth, long transmission distance, and simple maintenance of passive optical networks. It applies to scenarios such as vertical traffic forwarding and multi-service convergence. Examples scenarios include converged access of voice, TV, and Wi-Fi services in apartments and dormitories, and sporadic access of outdoor video surveillance cameras on campus. The optical and electrical converged mode flexibly meets various campus application scenario requirements.

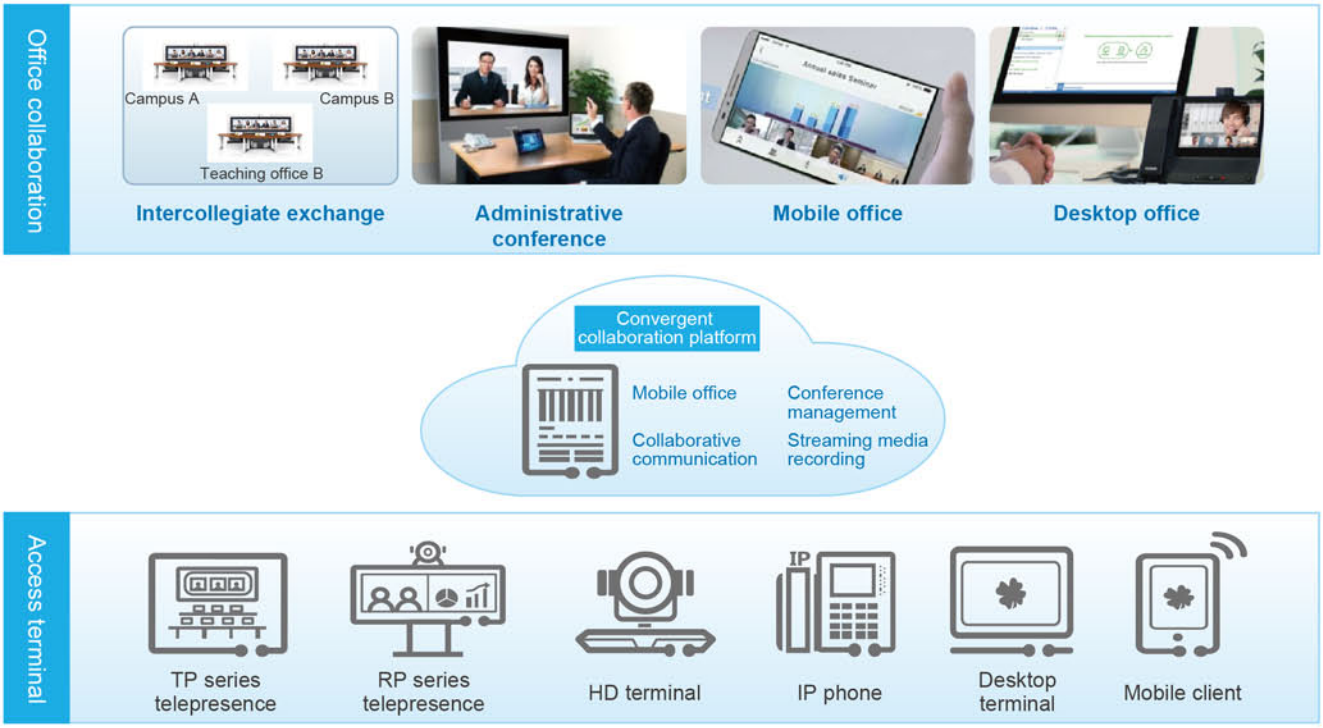
Office collaboration and convergence campus

Campus office collaboration includes office collaborations between school administrators and teachers, between teachers, and between parents and teachers, meetings between education departments and schools they manage, and between the main campus and branch schools or subsidiary institutions. It also allows for teacher qualification assessment, teacher training, and teaching quality assessment. These collaborations require unified communication, video conference, mobile office, and desktop office.

In these scenarios, access terminals must be deployed in office areas and conference rooms, and a converged collaboration platform must be deployed in the cloud to support mobile office and provide unified communication and video conferencing.

- The unified communication function provides multiple communication channels, such as instant messaging, voice, and multimedia conferencing, to support concurrent access by terminals anytime, anywhere.
- The video conference function provides HD telepresence through desktop terminals and mobile terminals, enabling seamless integration of conference rooms, office desktops, and mobile devises, providing consistent service experience for multiple terminals.

Figure 3-2 Office collaboration and convergence campus



Campus with manageable network behaviors

Construction of all campus networks must comply with Order No. 82 of China's Ministry of Public Security and Wireless Internet Access Security Management Regulations for Non-Business Public Areas. This requires that security audit be conducted on Internet usage of all campus network users, ensuring that Internet access can be traced. The GreenNet function can be provided, which uses a unified network management system to filter inappropriate content and monitor networks, controlling and managing students' online time and Internet surfing content.

Simplified O&M campus

Campus network deployment, service provisioning, maintenance, and management can be simplified using intelligent planning and deployment, service and policy automation, and wired and wireless network convergence.

1. Intelligent planning and deployment, improving efficiency

Tools such as the Wi-Fi intelligent network planning tool implement automatic and precise Wi-Fi network planning, ensuring the optimal wireless signal coverage.

An intelligent management and control platform is introduced to support offline network topology planning and device pre-configuration, automatically obtain pre-configurations for device deployment, implementing quick plug-and-play service rollout, and supporting deployment by scanning a QR code. In addition, the platform can reduce configuration errors in the deployment phase.

2. Free mobility and policy automation

When users roam about a campus, their IP addresses change frequently. Traditional IP address–based user rights control and experience assurance methods cannot adapt to this change. Therefore, the unified planning of security groups and service policies based on user identities gradually is becoming mainstream.

In this planning mode, the access location and IP address of users can be ignored. Service policies and IP addresses are decoupled to ensure consistent policies and experience as users roam, greatly simplifying planning and configuration. In addition, policies can be defined using natural language. During policy deployment, automatic translation is converted into automatic delivery of network configuration, improving efficiency.

3. Wired and wireless network convergence management

Construction and O&M of traditional wired and wireless campus networks are separate. Construction costs are high and O&M is complex. Smart campus network construction can be implemented by integrating devices, such as switches and access controllers (ACs), to implement integrated transport and convergence of wired and wireless networks. This includes unified configuration and management of wired and wireless networks, and unified authentication and management of their users.

3.1.2 Scenario Value

Build a premium broadband campus network to provide basic transport assurance for smart education.

- The all-scenario wireless campus with full Wi-Fi coverage provides teachers and students with high-quality experience anytime, anywhere.
- The fully-connected ultra-broadband campus meets the requirements for video-oriented high-bandwidth service transmission on campus networks.
- Convergent campus communication ensures smoothness and improves office collaboration efficiency.
- Campus Internet access management achieves GreenNet and avoids unhealthy overuse.
- Convergence management of wired and wireless campus networks enables service and policy mobility and simplifies O&M.

Value-added operation of campus big data

- Commercial value-added campus Wi-Fi operation: Open APIs allow access to information such as Wi-Fi terminal location data, user authentication information, and Internet access logs. In this way, operators can implement value-added operations with partners to improve business value.
- Campus users' Internet access data can be collected to meet compliance requirements and provide data sources for subsequent big data analytics and operations.

3.2 Safe Campus

3.2.1 Scenarios and Current Situation

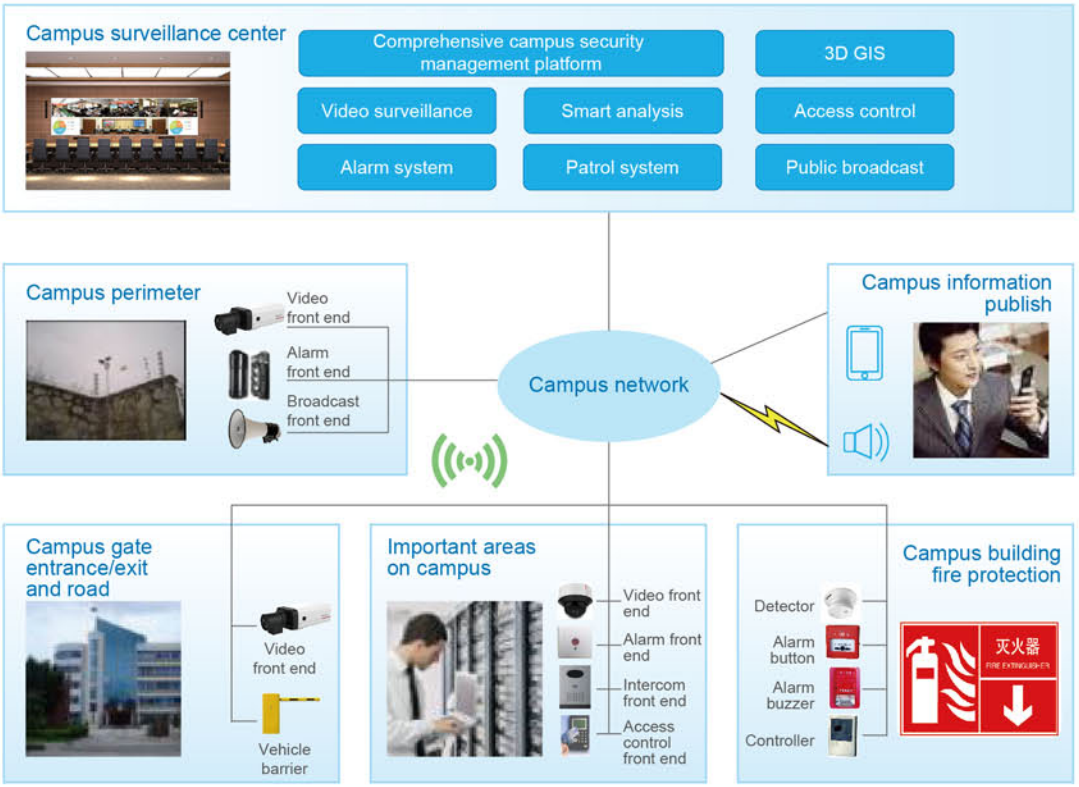
Safe campus is a comprehensive security system that integrates HD video surveillance, intelligent analysis, personnel and vehicle checkpoint, patrol, access control, alarm, and 3D geographic information system (GIS). It achieves personnel protection, physical protection, and technical protection to implement all-scenario, all-weather monitoring and management to ensure campus security.

Campus security construction must be improved because it faces the following main problems:

- Video surveillance coverage is incomplete, and analog video quality is poor.
- After an incident occurs, it is difficult to collect evidence.
- Identifying and preventing intrusion into the campus is difficult.
- Security systems are independent and not converged, which may lead to delayed processing and cause more losses.

Safe campus construction for smart education can be improved from the aspects of HD video surveillance, intelligent video analysis, perimeter security and intrusion alarm, access control management, electronic patrol, and public broadcast, providing a safe teaching environment.

Figure 3-3 Overall architecture of safe campus



HD video surveillance in all scenarios

HD cameras are deployed at campus entrances and exits, roads, campus perimeter walls, teaching buildings, office buildings, libraries, dormitories, outdoor areas, and playgrounds, providing full coverage. Based on the surveillance scenario, select dome cameras, box cameras, or checkpoint cameras, comprehensively managing and controlling personnel and vehicles. In addition, infrared cameras can be used to improve nighttime monitoring.

Video surveillance storage uses a fully-networked digital HD system. Video storage gradually evolves from traditional network video recorders (NVRs) or storage servers to cloud storage, facilitating expansion and future application.

Intelligent video analysis

Intelligent video analysis reduces human interference and improves human defense efficiency through intelligent front-end analysis and platforms. Pre-event and post-event intelligent analysis provides preemptive warning and quick response after events, respectively.

- **Intelligent front-end analysis**: Includes intrusion detection, tripwire detection, abandoned object detection, and loitering detection.
- **Intelligent platform analysis**: Includes linkage between box cameras and dome cameras, panoramic stitching, and crowd counting. Panoramic stitching supports real-time display of three-shot panoramic stitching, controls the display of videos on the wall, and provides more information in a single picture, facilitating macro control.

Perimeter security and intrusion alarm

An intrusion detection system is deployed at a campus' perimeter and important areas. It supports multiple technical protection measures and integrates with physical protection measures such as alarm loudspeakers to protect restricted areas.

- **Perimeter security**: Detection systems, such as infrared radiation, electronic fence, and vibration optical fibers, are deployed at the campus perimeter.
- **Indoor intrusion**: Infrared microwave intrusion detection systems and glass detection systems are deployed in important areas (such as campus administrative regions and laboratories).

The alarm system can be associated with cameras of various types to monitor the campus perimeter. The 3D GIS and intelligent video analysis measures identify intrusion and out-of-bounds personnel, automatically generate alarms, and notify security personnel.

Access control management

Through access control management, users and vehicles on campus can be controlled and managed. The access control system can be connected to the alarm and video surveillance systems to coordinate response.

- The access control system is deployed at the campus entrances and exits to check the access rights of personnel and vehicles.
- The access control system can also be deployed in important areas, such as administrative areas and labs, to manage personnel access.

Electronic patrol

Electronic patrol devices can be deployed in important areas such as teaching buildings, labs, and administrative buildings in a centralized manner to implement offline patrol and record patrols by campus security personnel, managing and supervising security guards and personnel on campus and regulating patrol. 3D patrol works by simulating personnel patrol lines based on the 3D GIS and automatically reviewing patrol line videos, saving time and effort.

Public broadcast

A public broadcast system can be deployed indoors or outdoors to allow background music playback, service broadcast, and emergency broadcast. The public broadcast system can be associated with the alarm system and video surveillance system. In case of emergency, the public broadcast system can be used as the emergency broadcast media. Through the control switching device of the broadcast center, the public broadcast system can make emergency calls to the broadcast areas to guide evacuation.

3.2.2 Scenario Value

Create a safe campus environment to ensure normal daily teaching work.

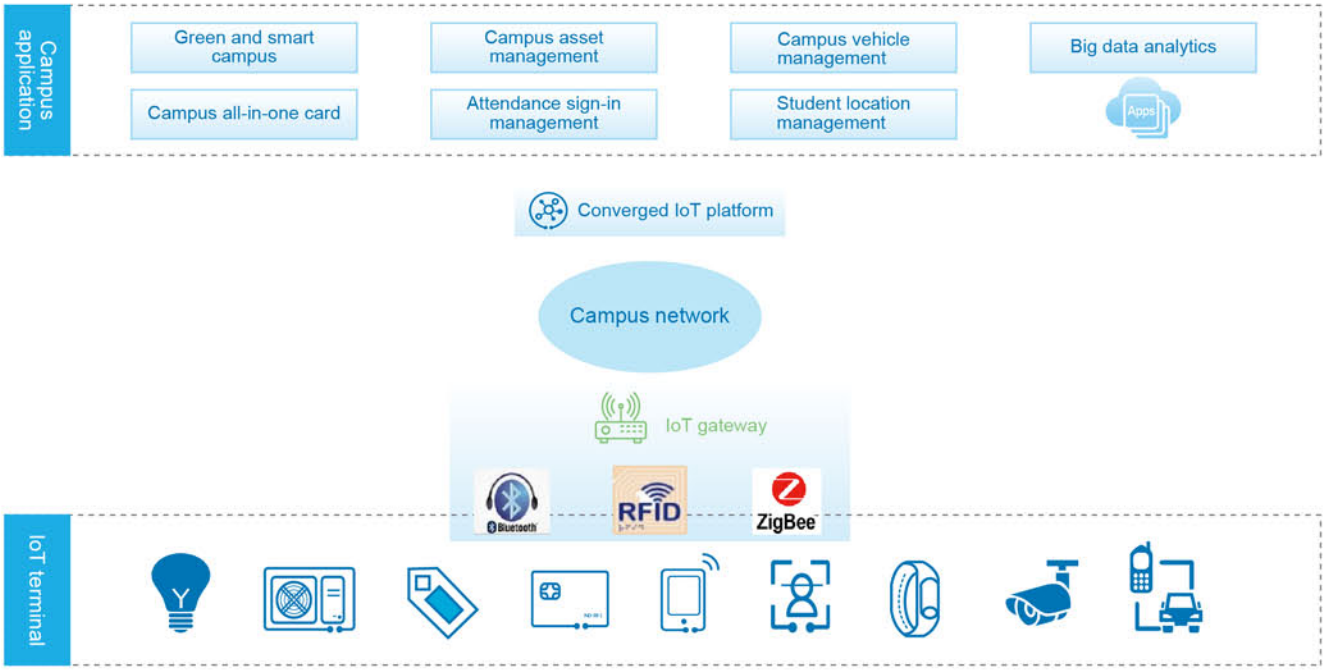
Security protection is implemented before, during, and after events to ensure campus security. For example, pre-event no-dead-corner coverage or all-weather surveillance in all scenarios and intelligent prevention and control by area minimize security incidents. If an incident occurs, visualized command and dispatch, multi-personnel collaboration, real-time control of onsite information, and quick response minimize the impact of accidents. After the incident, intelligent image search, quick panoramic investigation and evidence collection, and accurate locating help to quickly solve the case.

3.3 Intelligently Connected Campus

3.3.1 Scenarios and Current Situation

Using IoT, AI, and big data technologies, campus smart devices are fully connected to build a green and smart campus with people and object management.

Figure 3-4 Overall architecture of the intelligently connected campus



Green smart campus

Build a green smart campus based on IoT to create a comfortable teaching and office environment and reduce energy consumption and maintenance costs.

- **Automatic control of campus lighting**: Brightness and movement combo sensors, object detectors, and an intelligent lighting control system are deployed to implement automatic switch and light adjustment. Lights can be automatically switched on or off based on the time segment scheduling policy. For example, lights are automatically turned on at work time and automatically turned off during lunch break in office areas, and lights are automatically turned off at night in student dormitories.
- **Automatic control of the heating, ventilation and air conditioning (HVAC) system on campus**: Temperature and humidity sensors and automatic control systems are deployed to automatically adjust the cold and hot water valves of air conditioners based on the temperature and humidity. Air quality monitors are used to automatically adjust the air conditioning and fresh air systems based on parameters such as the detected indoor air carbon dioxide, PM2.5 particulates, and formaldehyde. Motion sensors and object detectors are used to adjust the air conditioning and fresh air systems to energy-saving mode when no one is present. The air conditioning and fresh air systems can be automatically turned on or off based on time scheduling.
- **Centralized monitoring of large-scale campus facilities**: The status of the water supply and drainage system, power distribution system, and elevator system are monitored centrally, reducing maintenance costs.

In addition, real-time data collection helps collect fine-grained statistics on energy consumption of campus water, electricity, and heating, and power consumption of campus air conditioners, lighting, and power systems. It also analyzes consumption data of water, electricity, and gas on campus, enabling users to monitor consumption in real time, improving efficiency and reducing consumption.

Campus asset management

Traditional campus assets are manually recorded and managed, which is inefficient and causes high and inaccurate labor costs. In addition, asset locations are difficult to obtain and assets are easy to lose.

Intelligently connected campus achieves smart management of campus assets based on Wi-Fi and IoT. It provides functions such as automatic asset go-live, location tracking and stocktaking, and visualized asset usage management, improving asset management efficiency and preventing asset loss.

- **Automatic asset go-live, location tracking, and stocktaking**: A location label is attached to an asset. Radio frequency identification (RFID) or Bluetooth is used to implement automatic asset go-live, real-time location tracking, and stocktaking. The asset management system integrates the electronic fence and map functions. When core assets are outside a specified boundary, alarms are automatically generated to prevent asset loss.
- **Visualized asset usage management**: A current label is attached to an asset to determine the asset usage status based on collected current of the asset, and improve analysis of asset usage frequency and duration to provide quantitative data for procurement evaluation.

Campus all-in-one card

A campus all-in-one card allows one card, mobile phone, QR code, or even face recognition system to replace all cards in school management and life, including student cards, work permits, entry cards, library cards, computer usage cards, medical certificates, and consumption cards. In addition, the school can dynamically manage the situation of each cardholder, improving school management.

- **Identity identification**: Provides functions such as channel authentication, electronic access control, and attendance sign-in.
- **Learning and medical service**: Provides functions such as book borrowing, score query, and in-school medical treatment.
- **Financial services**: Includes online payment, recharge, and consumption record query.

Attendance sign-in management

Teachers sometimes perform roll-call, which is inefficient and occupies class time. Moreover, some students may sign-in for others, resulting in inaccurate attendance records.

Based on Wi-Fi, IoT, and AI technologies, intelligently connected campus supports multiple electronic sign-in modes such as campus all-in-one cards, smart bracelets, mobile apps, and face recognition to automatically collect attendance statistics and improve attendance management efficiency.

- **Sign-in using campus all-in-one cards**: Campus cards can be used for automatic sign-in through RFID-based identify identification.
- **Sign-in using smart bracelets**: Smart bracelets have the positioning function and can be connected to the attendance system on campus to automatically sign in.
- **Sign-in using mobile apps**: When a student's mobile phone accesses the AP covered by a classroom, the app can automatically sign-in the student. (If the student's mobile phone accesses the AP in another area, the app does not implement sign-in.)
- **Sign-in through face recognition:** Cameras can be installed in classrooms to implement automatic sign-in based on face recognition. In addition, individuals can be accurately identified, preventing students from signing in for others and implementing refined management of education.

Student location management

Using IoT, positioning, and video surveillance technologies, students can be located in real time and their movements can be recorded using their positioning terminals (such as smart bracelets and campus cards). One-click emergency help and electronic fence security protection functions are provided to prevent students from leaving school or accidents during class.

- **Student incoming and outgoing sign-in**: The system implements automatic sign-in for students using their positioning terminals when they enter or exit campus. The system sends sign-in information to parents in real time.
- **Real-time location monitoring**: The location and distribution of students on campus can be displayed in real time, and the total number of people in each teaching building and dormitory can be collected to ensure student security.
- **Movement track query**: Users can view student movements over a specified period of time to learn about frequent activities and provide better learning guidance and life care. If an incident occurs in the school, the historical track playback function can be used to trace it.
- **One-click emergency help**: If a student encounters a sudden or critical situation, they can use the intelligent terminal for one-click alarm help and related personnel can be notified of the emergency.
- **Electronic fence security protection**: An electronic fence can be constructed in a specific area of the campus to implement functions such as out-of-bounds warning and long-time retention warning. If a student leaves or enters an area without authorization, the system immediately warns them to prevent the student from leaving school or accidentally getting lost.

3.3.2 Scenario Value

Build a smart IoT campus to create a comfortable teaching and office environment.

- Energy conservation reduces energy and O&M costs. Automatic sensing and intelligent control create a comfortable campus teaching and office environment.
- Automatic campus asset stocktaking and location visualization improve campus asset management efficiency and prevent asset loss.
- Campus all-in-one cards facilitate learning and life of teachers and students.
- Electronic attendance sign-in enables automatic student attendance taking, improving attendance management efficiency.
- Student location management prevents students from leaving school or accidents during class.

Value-added campus operation through big data

The converged IoT platform and campus all-in-one case system are used to collect students' learning and life data, providing data sources for subsequent big data analytics and operation.

3.4 Transport Requirement

Campus Wi-Fi access

Build an HD Wi-Fi access campus network. The bandwidth starts from 16 Mbit/s, supporting 1080P HD transport. The target bandwidth is 100 Mbit/s, which supports 4K ultra-HD experience, and will even support VR/AR in the future.

Campus broadband network

Build a fully-connected ultra-broadband campus transport network to achieve gigabit access to desktops, beyond-10GE upstream aggregation, and beyond-gigabit campus network egress.

Campus service transport

Campus services include teaching and office work, campus security protection, and campus IoT, involving voice, Internet access, video, and IoT services. Especially as video services develop from SD and HD to 4K/8K, 1080P HD has become the lowest standard for new video conferences and video surveillance. Campus service transport has strict requirements on networks.

- Teaching and office work includes multimedia classroom, video live broadcast/VOD, desktop office, convergent communication, and video conference.
- Campus security protection mainly refers to HD video surveillance.
- Campus IoT includes low-rate data collection (for example, the bandwidth of sensor information collection is less than 100 Kbit/s), interactive collaboration (the bandwidth is less than 1 Mbit/s), and HD video surveillance control.

Table 3-1 Network transport requirements of campus services

Service Type	Access Bandwidth per Terminal	Latency	Packet Loss Rate
Desktop office	Basic office: ≥ 10 Mbit/s Image browsing/Video playback: ≥ 25 Mbit/s	≤30ms	≤0.01%
1080P HD video conference	≥ 4 Mbit/s	≤100ms	≤0.1%
1080P HD video surveillance	≥ 8 Mbit/s	≤150ms	≤5%
1080P video playback	≥ 16 Mbit/s	≤100ms	≤1%
4K video playback	≥ 50 Mbit/s	≤40ms	≤0.1%

3.5 Summary

- The functions of wireless coverage in all scenarios, fully-connected ultra-broadband campus networking, and campus convergent communication enable a premium broadband campus and provide teachers and students with a high-experience learning and office environment anytime, anywhere.
- A comprehensive campus security protection system ensures a safe campus and implements all-scenario, all-weather monitoring and management to ensure campus security.
- IoT, AI, and big data are used to build a smart IoT campus and create a comfortable teaching and office environment.
- Smart campus services have strict requirements on network transport and require that the network provide transport assurance.

04 Smart Analysis

With the advance of education informatization, a new generation of AI technologies is maturing. AI in education (AIED) implements smart analysis of students' classroom, learning, and exercise behaviors, as well as teachers' behaviors. Targeted learning and teaching guidance are becoming smart education standards.

DATA
SEARCHING
VERIFICATION
CODING
SENDING

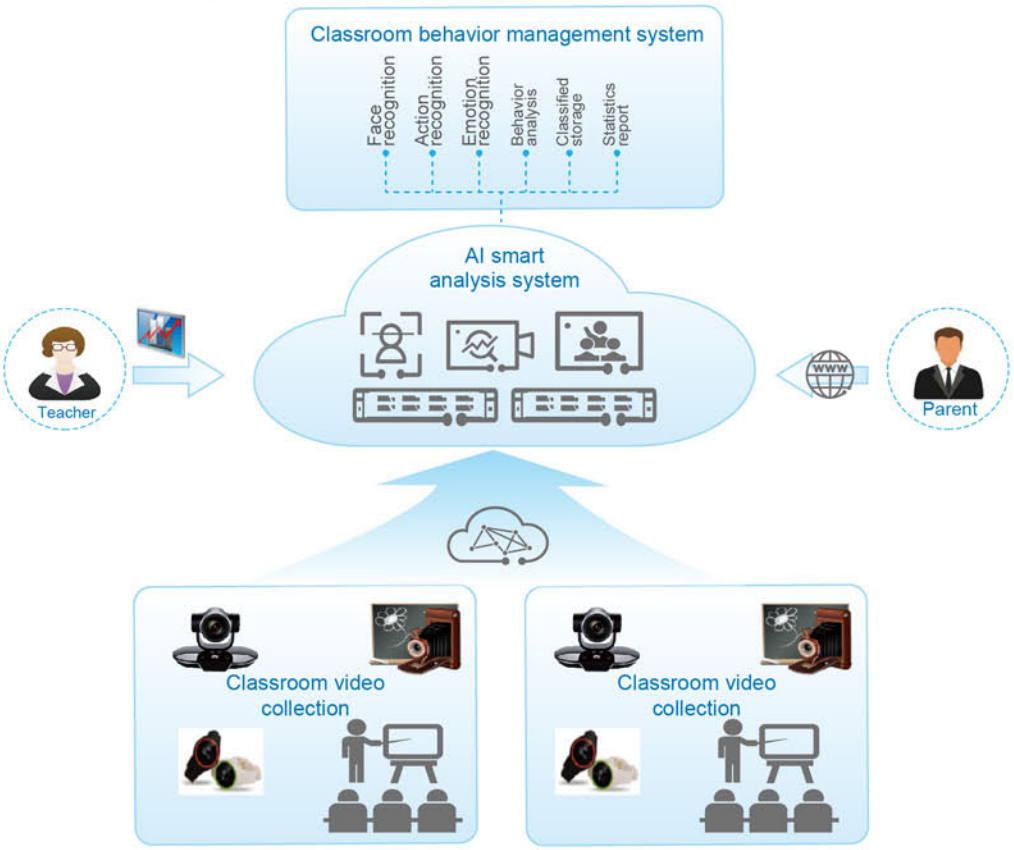
4.1 Classroom Behavior Analysis

4.1.1 Application Scenario

Students' classroom behavior analysis uses AI in teaching. Specifically, it uses video AI technology to intelligently identify and analyze student behaviors and emotions based on the behavior model, such as inattention, irrelevant activities, and cheating on exams. When the definition of cameras is sufficient, faces and facial expressions can be identified, helping collect statistics on students' attendance rate and identifying abnormal behaviors. This helps students cultivate good learning habits and improve learning efficiency, and enables immediate diagnosis and treatment of mental or physical issues.

Composition of the classroom behavior analysis system

Figure 4-1 Classroom behavior analysis system



The student classroom behavior analysis system consists of the AI-based analysis system, information collection terminals, and client application. The terminals and platform are connected over the network.

- The video information collection terminals require that full-coverage HD cameras be deployed in the classroom. Depending on classroom size, one or more video information collection terminals can be deployed. The cameras send the collected classroom information to the AI-based analysis system in real time.
- Smart bracelets are used to collect student information, assist in precise video surveillance, monitor heart rate, and detect abnormal behaviors.

- The AI-based analysis system analyzes learning behaviors and facial expressions, and displays analysis statistics by time, category, and person.
- Client applications running on mobile phones, tablets, and computers are used by principals, teachers, and parents to quickly view students' classroom behavior data.

Application scenarios of classroom behavior analysis

The major application scenarios of students' classroom behavior analysis are as follows:

- Face recognition helps check students' attendance and record students' locations.
- Students' good and bad behaviors in the classroom are identified in real time and presented to teachers and parents, enabling them to provide targeted guidance.
- Alarms are reported when students behave abnormally, such as mental abnormalities and physical abnormalities. This helps teachers respond quickly, report serious cases, and contact parents to avoid accidents.
- Teachers use the behavior management AI system to guide classroom behavior.

4.1.2 Industry Landscape

Currently, video-based classroom behavior analysis can implement face recognition and collect statistics on attendance rate, raised-head rate, and cheating in exams. However, the application of refined face recognition is not mature, and the facial expression identification accuracy must be improved. For example, determining whether students are inattentive or in pain must be improved.

With the application and development of learning analysis, the important component of classroom behavior analysis is becoming increasingly important, and corresponding classroom behavior analysis technology is maturing.

4.1.3 Scenario Value

Help teachers and parents provide targeted education and improve teaching quality.

Classroom behavior analysis helps schools improve teaching efficiency and quality. Parents can better understand their children's performance and provide daily guidance, promoting children's healthy growth.

Identify students' abnormal behaviors in a timely manner to avoid accidents.

Classroom behavior analysis can quickly detect students' abnormal classroom behaviors, such as mental abnormalities and physical abnormalities, and handle them quickly to avoid accidents.

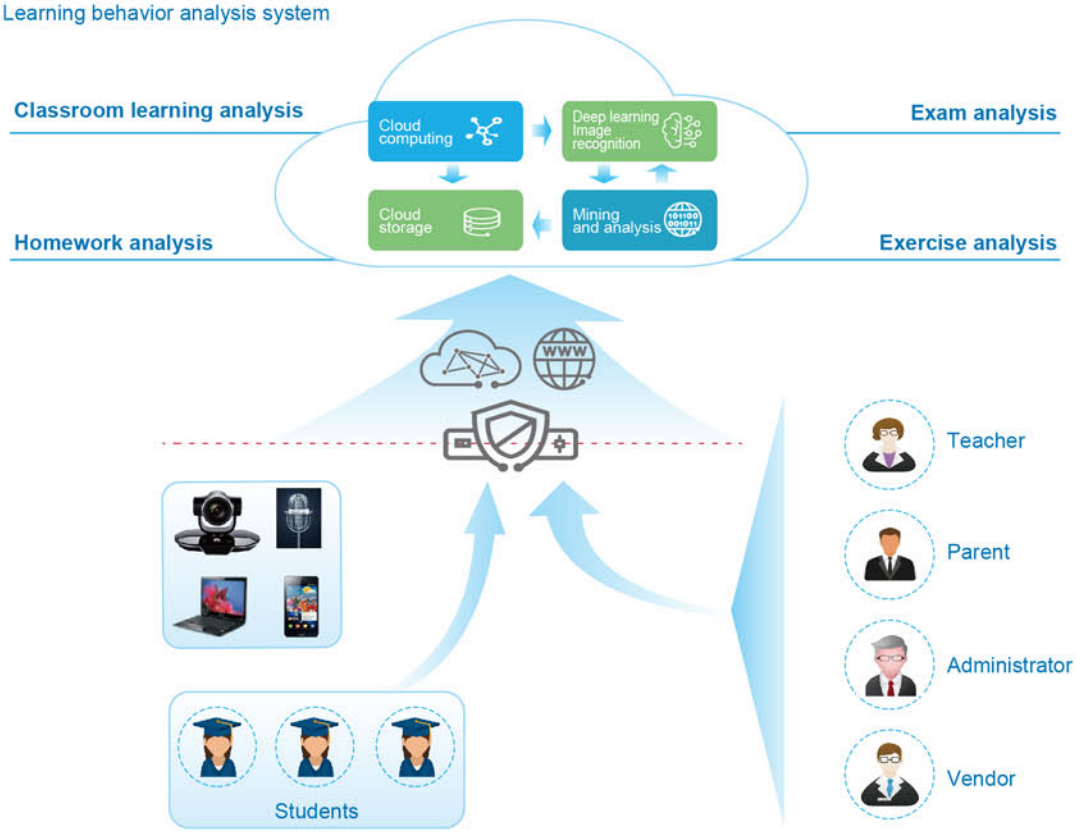
4.2 Learning Behavior Analysis

4.2.1 Application Scenario

Student learning behavior analysis is another important application of AI in smart education. It uses big data and AI to intelligently identify and analyze students' learning, homework, exercises, and exams; fully detect student's learning status; and constantly give feedback. For example, based on each student's learning model, the system provides personalized coaching and learning paths to improve performance. Simultaneously, it guides teachers to better-design teaching.

Composition of the learning behavior analysis system

Figure 4-2 Learning behavior analysis system



The learning behavior analysis system consists of the learning behavior AI-based analysis system; video, image, text information collection terminals; and client application. The terminals and platform are connected over the network.

- The video information collection terminals require full-coverage HD cameras deployed in the classroom. Depending on the classroom size, one or more video information collection terminals can be deployed in the classroom. The cameras send the collected classroom information to the AI-based analysis system in real time over the network.
- Video and text information is collected using tablets. A single classroom supports the access of 30 to 50 terminals.
- The AI-based analysis system implements classroom learning, homework, and exams, and displays statistics by time, category, and person.
- Client applications running on mobile phones, tablets, and computers are used by principals, teachers, and parents to quickly view students' classroom behavior data.

Application scenarios of learning behavior analysis

The major application scenarios of students' learning behavior analysis are as follows:

- Analysis of students' classroom behavior. The analysis results are presented to teachers and parents, enabling them to provide targeted guidance.
- The system analyzes students' homework, exercises, and exams, dynamically evaluates their mastery of materials, and automatically or intelligently plans learning paths and content. This avoids rote learning, enables targeted learning and practice, improves learning efficiency, and stimulates student interest.
- Learning behavior analysis of all students guides teachers to continuously optimize the teaching design, improving teaching quality.
- The analysis of students' overall learning behaviors promotes development of mixed education in both offline and online modes. Based on learning behavior analysis and intelligent planning, the system provides students with predictive analysis of learning content and personalized teaching and coaching, improving offline teaching efficiency and optimizing online teaching.

4.2.2 Industry Landscape

Learning behavior analysis is a hot topic in smart education. Various extracurricular education institutions have launched services based on students' homework and exercises. However, it is merely applied in school teaching. Currently, teachers use third-party apps to arrange homework and target their education.

With Chinese government promotion of AI in education, learning behavior analysis based on big data and AI technologies will inevitably become applied in school teaching. With technological advancement, data accumulation, and improvement of the knowledge map and algorithms, educational data will become the lifeblood of the education system and bring to life traditional and formulaic teaching research.

4.2.3 Scenario Value

Help students develop personalized learning behaviors and improve their achievements.

Learning behavior analysis accurately analyzes students' classroom learning, homework, exercises, and exams to form individual learning archives and develop a personalized learning and improvement recommendations. These quickly improve students' achievements and stimulate their interest in learning. Parents can fully understand their children's learning situation and cooperate with schools to improve their children's learning habits.

Help teachers optimize teaching design and improve teaching quality.

Schools and teachers can accurately master the learning and teaching data, continuously optimizing teaching design, quality, and education management.

4.3 Sports Behavior Analysis

4.3.1 Application Scenario

Survey data on Chinese students' physique shows declining physical health. The obesity rate continues to rise at a rate of 2% to 3% every 5 years. The proportion of students with poor eyesight is increasing. The detected poor eyesight rate of primary school students reached 45.71%, that of junior high school students reached 74.36%, and that of high school students reached 83.28% in 2017.

To improve students' physique, improving physical exercise has become a goal of all parties. To scientifically manage students' sports status, sports behavior analysis using big data and AI technologies has become a hot topic in smart education. By dynamically monitoring and intelligently analyzing students' physical exercise, the system can identify sports types and the amount of exercise and detect laziness. This helps avoid excessive exercise and physical injuries and realizes the automatic measurement of some appraisal items.

Sports behavior analysis method

Today's effective sports behavior analysis methods include intelligent sensing analysis and intelligent video analysis.

1. Smart sensing analysis

An infrared probe is used to detect the body parts that a person is exercising. Alternatively, a smart device, such as a card or a bracelet, identifies the person's location changes, analyzing exercise items. The appropriate smart sensing analysis method differs by situation. For example, during long jump, the distance is calculated by an infrared sensor; during sit-ups, the number of sit-ups is calculated based on the back-to-ground times and elbow extensions. However, this method cannot be used to automatically identify exercise items, and one system cannot measure multiple exercise items.

2. Smart video analysis

Using AI analysis on bracelet data and collected videos to complete sports identification and measurement, the smart video analysis method collects and analyzes student physique data. Smart video analysis can also identify human faces and associate human faces with personal data to implement data storage and big data analytics.

Compared with smart sensing analysis, smart video analysis can be applied to a wider range of activities. It can concurrently identify and analyze multiple sports types, and automatically count the sports activities, such as jumping rope, running, and sit-ups. It can also identify whether students are being lazy, for example, taking shortcuts while running or resting during an activity. Moreover, it can identify whether some sports behaviors are harmful, and even identify some violations. In addition, the face recognition technology implements better binding with collection objects.

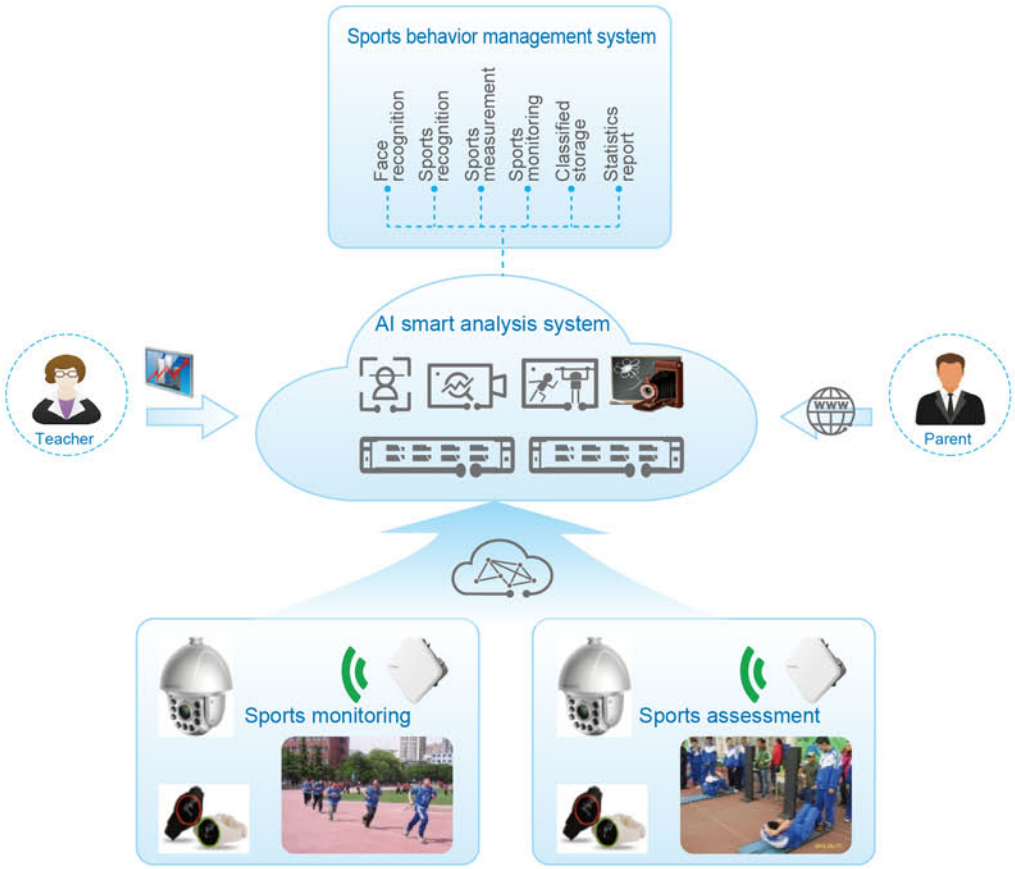
However, smart video analysis has high requirements on video and model technologies and is difficult to implement. For example, it requires a variety of precise video identification models, especially when there are many students, posing great challenges to technologies. Currently, smart bracelets are used to analyze data such as student locations, movement paths, and heart rate. The identified sport types and basic personal information (age, physique, weight, and physical abnormalities), along with heart rate data, can help perform precise sports management and identify risks preemptively.

The two analysis methods can be used independently or together. Regardless of the method, all video, sensing, and bracelet data are sent to the cloud and intelligently analyzed and monitored using AI. For example, if the AI model identifies a running activity, it automatically combines data such as the heart rate from the smart bracelet and basic personal information (such as physique data and historical sports information) to determine whether the exercise is excessive. If a personal risk threshold is reached, it is reported immediately, and an alarm is simultaneously generated on the smart bracelet.

Application scenario of sports behavior analysis

Sports behavior analysis is not only used to monitor students' exercise status and detect laziness, but is also used for exercise measurement and appraisal.

Figure 4-3 Sports behavior analysis system



1. Exercise monitoring

The sports monitoring scenario requires cameras or sensor probes/terminals, smart bracelets, and a cloud AI system. Multiple cameras or sensor probes/terminals are deployed in the playground or stadium to implement identification and monitoring. The system can automatically identify sports types. The sensor probes/terminals can sense changes in activity positions, and identify sport types with the cooperation of other means. Video and sensing information are uploaded to the cloud system for analysis, and intelligent monitoring is performed on students' sport behaviors.

- **Anti-laziness exercise monitoring**

  A physical education (PE) teacher can log in to the AI system through their mobile phone or tablet to identify students who are not participating in sports activities. When a student stays on the runway or on the playground, the sports behavior management system can intelligently detect that the student leaves the specific area based on the video data or the location track identified by the sensor probe, and push the related information to the teachers' device. This makes it convenient for teachers to supervise and manage students.

- **Anti-excessive exercise monitoring**

  Teachers log in to the sports behavior management AI system through their mobile phone or tablet to record the physical data of each student. In the sports behavior management system, the excessive exercise and alarm threshold of different students can be automatically calculated or manually set based on students' physical and historical data.

  During exercise, students can wear smart bracelets to allow precise measurement and monitoring. For example, the path and running distance of students can be identified through videos. The tracks on smart bracelets can help calculate students' speed and monitor the heart rate to calculate exercise intensity. If the sports behavior management system detects that exercise intensity of a student reaches the critical alarm threshold, it pushes information to the teacher's device so they can avoid danger caused by excessive exercise.

2. Exercise measurement and appraisal

Students' exercise items can be automatically measured by video analysis or intelligent induction information calculation, reducing the statistics manpower and achieving objective and fair appraisal.

During a sports test, the identity of a student can be confirmed through face recognition or smart card swiping. The camera or sensor probe deployed in the appraisal or test area is used to collect various types of exercise information, such as running, sit-ups, and pull-ups. If the camera is used, a specific sport type can be identified using video AI. The sensor probe is only used for specific exercise items, but it is easier to use and provides more accurate measurements. The cloud system automatically tracks the appraisal process, performs measurement analysis, and saves the video or sensing data to facilitate appraisal process verification.

4.3.2 Industry Landscape

Sports behavior analysis is in the initial stage. It is mainly used for the appraisal of specified actions, such as pull-ups, sit-ups, and long jump, which can be identified and calculated using cameras or measured using sensor probes. In addition, sports behavior analysis can monitor running indicators, such as the running distance, and identify and calculate the number of circles run using a sensor probe and smart bracelet. However, sports behavior analysis is not currently applied in anti-laziness monitoring or anti-excessive exercise monitoring, which will be a direction for future development.

Calculation using sensor probes is mature. If used, a sensor probe must be bound to a specific exercise item and its deployment must meet requirements. The sensor probe can only be used for counting of the bound item.

AI is developing in video recognition and analysis. It supports personnel tracking, positioning, and movement tracking, and can identify some basic sports activities. However, the action analysis of crowds in more refined and open scenarios still requires improvement.

4.3.3 Scenario Value

Sports behavior analysis helps supervise students' sports activities and urge students to exercise and enhance their physique. In addition, personalized monitoring helps identify excessive exercise risks preemptively, achieving healthy exercise and avoiding injury.

4.4 Teaching Behavior Analysis

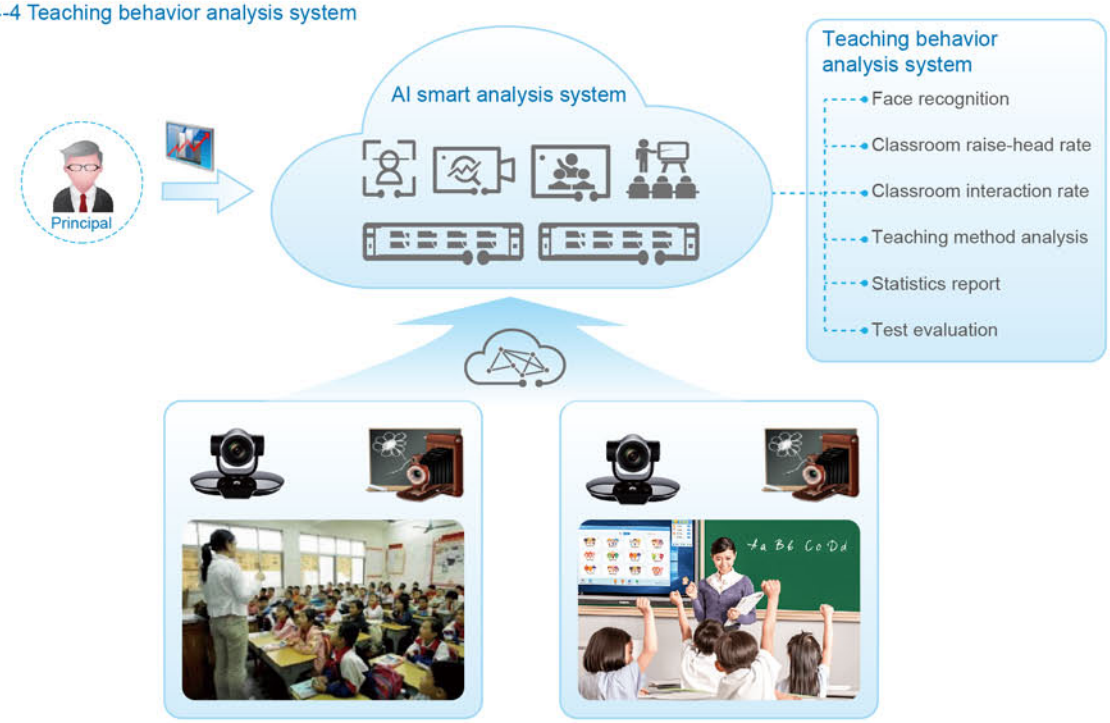
4.4.1 Application Scenario

Teaching evaluation is a process of studying the value of teaching and learning, including the evaluation of teachers, students, teaching content, teaching methods, teaching environment, and teaching management. It applies especially to the evaluation of students' learning and teachers' teaching process. As a component of teacher evaluation, teaching behavior analysis analyzes teachers' methods and interactions with their class to evaluate quality.

The theoretical basis of teaching behavior analysis is teaching method and effect analysis. Good teaching methods include not only lecture, practice, demonstration, and blackboard-writing, but also an appropriate time allocation between these activities. For example, the ability to teach only the essential and ensure plenty of practice. The teaching effect is also reflected in students' interactive response, for example, whether students think and speak actively. Undoubtedly, good teaching requires concentration in the classroom and an active atmosphere. Based on these characteristics, teaching analysis uses the video AI analysis to identify and analyze the interaction between teachers and students, and students' classroom attention (such as the raised-head rate and positive response rate).

Composition of the teaching behavior analysis system

Figure 4-4 Teaching behavior analysis system



The teaching behavior analysis system consists of classroom video collection terminals, smart teaching terminals, AI smart analysis systems, and client applications. The terminals and platform are connected over the network.

- The video terminals and smart teaching terminals deployed in the classroom collect videos and teaching information from the classroom in real time and upload it to the cloud AI smart analysis system.
- The AI smart analysis system performs teaching analysis, identifies teachers' teaching behaviors and interactive behaviors of teachers and students, and collects and stores behavior information by time and category to generate behavior analysis statistics.
- Client applications running on mobile phones, tablets, and computers are used by the principal or other administrator to view teaching behavior analysis data.

Application scenarios of teaching behavior analysis

The key application scenarios of teaching behavior analysis are evaluation of:

- **Teaching methods**
  The smart analysis system identifies and collects statistics on lectures, exercises, presentations, blackboard-writing, and other behaviors, calculates their time allocation ratios, and evaluates teaching methods. Generally, teaching methods vary by course and stage of the course, and must be carried out based on the specific course design.

- **Teaching effects**
  The smart analysis system evaluates the teaching effect by analyzing the head-raised rate and hand-up rate of students. The head-raised rate reflects whether students are interested in and focused on the course, and the hand-up rate reflects students' interaction in the classroom.

4.4.2 Industry Landscape

As a direction of teacher evaluation, teaching behavior analysis emphasizes process evaluation rather than teaching result evaluation. Teaching behavior analysis is now becoming the focus of schools. Some colleges and vocational schools have begun using facial recognition to collect statistics on the attendance rate and head-raised rate.

Teaching behaviors are the sum of a series of behaviors. They require smart judgment after comprehensive behavior analysis. In addition to an independent behavior model, a behavior association model is also required to implement complete identification and analysis of teaching behaviors, and related technologies must be improved.

4.4.3 Scenario Value

Through the evaluation of teaching behaviors, schools can master teachers' teaching process in real time and positively direct teaching methods when necessary. For parents, evaluating teaching behavior lets them directly feel the teaching process and have more faith in teaching, facilitating interactions between home and school.

4.5 Transport Requirement

The classroom, learning, sports, and teaching behavior management AI systems must accurately identify personnel actions, faces, and facial expressions, requiring high video quality. In addition, they must collect the images and text information of teaching terminals, and sensor terminal information. They have the following requirements for teaching network transport:

- Classroom information collection: HD camera video information collection requires access of three to four cameras in a single classroom and requires a single-channel bandwidth of at least 8 Mbit/s. Collection of images and text information of teaching terminals requires access of 30 to 50 tablets in a single classroom.
- Playground information collection: HD camera video information collection requires access of four to six cameras. Sensor terminal information collection requires access of more than six sensor probes.
- Information collection of students' smart bracelets: Each classroom has access of 30 to 50 smart bracelets.
- The upload of information collected by various terminals to the intelligent behavior analysis system requires a low-latency and high-bandwidth private line network.
- The access of a large number of terminals and users to the cloud server requires a high-performance and high-bandwidth network.

The following table lists the network transport indicators required for smart behavior analysis.

Table 4-1 Network transport requirements for smart analysis

Service Type	Number of Terminals	Access Bandwidth	Latency	Packet Loss Rate
Video terminal access	3–4 per classroom 4–6 per playground	≥ 8 Mbit/s per terminal	≤150ms	≤5%
Teaching terminal access	30–50 per classroom	≥ 2 Mbit/s per terminal	≤200ms	≤5%
Classroom gateway access	1 per classroom	≥ 50 Mbit/s		
Sensor terminal access	6 per playground			
Smart bracelet access	30–50 per class			
Cloud private line access for class learning information collection		≥ 50 Mbit/s, depending on the actual situation of a school	≤100ms	≤0.5%
Cloud service access		Concurrent access of 1000 cameras		

4.6 Summary

- Smart analysis is the "brain" of smart education. Using big data and AI, smart analysis enables analysis of classroom behavior, learning behavior, sports behavior, and teaching behavior, providing direction for teaching improvement.
- Behavior analysis in smart management is an emerging feature and is increasingly recognized by the education industry. Future development will focus on more technical applications, which play an important role in improving teaching quality and student physique.
- Various behavior analysis imposes strict requirements on network transport and requires that the network provide a transport guarantee.

05 Smart Management

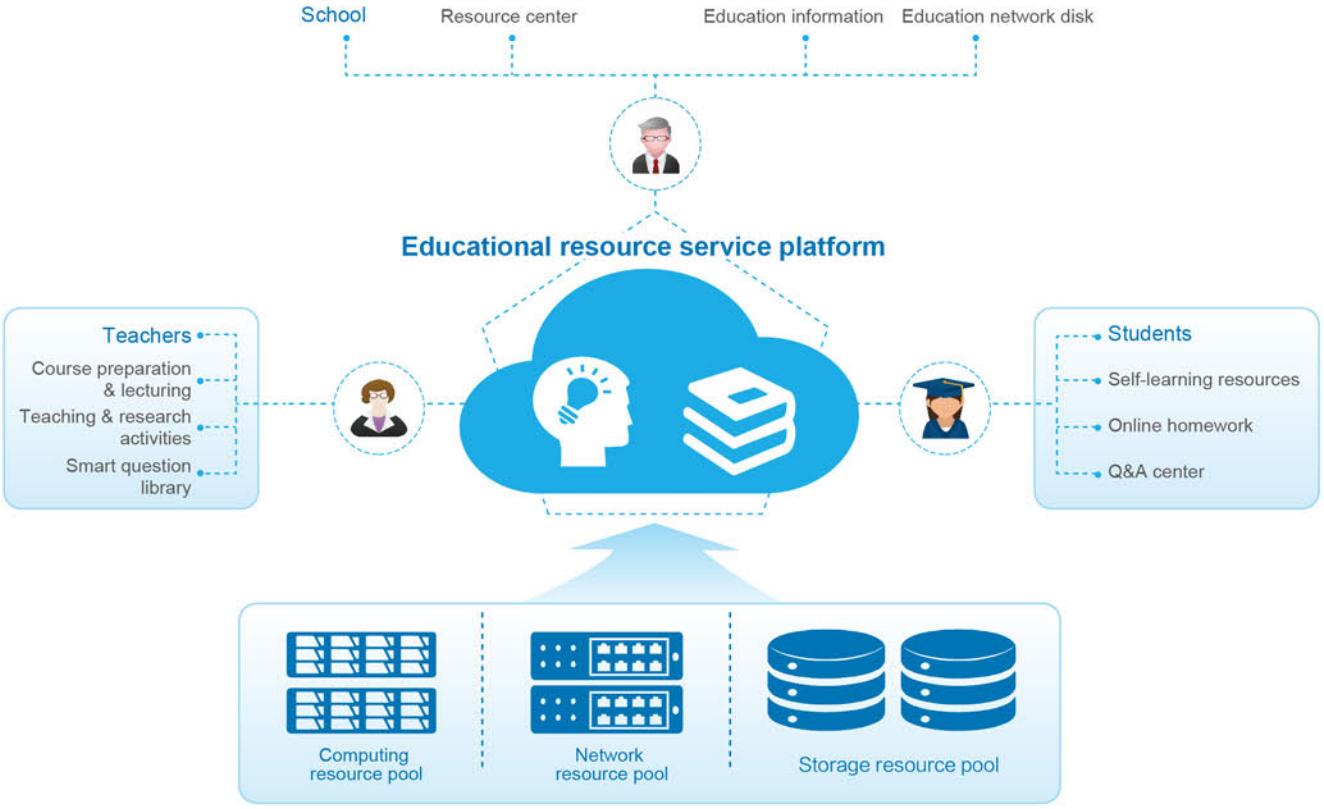
In observance of the Chinese government's "Internet + education" strategy, smart management platforms are being built based on various information technologies such as cloud computing, big data, and AI. These platforms automatically collect, aggregate, and associate different information. By integrating information about people and services, the platforms provide smart management services, including for educational resources, education management, educational spaces, and student development archives.

5.1 Educational Resource Service

Smart education is all about openness, sharing, interaction, and collaboration. The educational resource service enables more open educational resources to be shared, interacted with, and coordinated. This promotes the balanced development of high-quality education and improves teaching quality.

5.1.1 Application Scenario

Figure 5-1 Educational resource service platform



The educational resource service platform provides a number of services such as resource centers, educational consultation, and education network disks, assisting teachers with course preparation and lectures, teaching and research management, and smart question libraries. It also provides students with self-learning resources, online homework, and Q&A centers.

- **Resource center**
  The resource center integrates various high-quality teaching resources of a typical school, including teaching cases, learning cases, courseware, test papers, and homework, serving each teaching phase.

- **Course preparation and lectures**
  The teacher-oriented course preparation and lecturing module can generate courseware in just one click using resources in the resource center. Teaching courseware can be imported to electronic whiteboards and shared in educational spaces, or it can be provided for online teaching purposes.

- **Smart question library**
  The educational resource service platform can intelligently generate test papers by chapter, knowledge point, question, and difficulty, and can generate a large number of questions. This facilitates teachers and provides targeted trainings for students at any time.

5.1.2 Industry Landscape

With the promotion of China's educational strategies, the educational resource service platform has been deployed in all regions. However, most of the platforms are deployed in private clouds or internal networks, with few deployed on public clouds. The "Internet + education" strategy is part of the government's Education Informatization 2.0 drive, and cloudification and intelligence, trends that achieve better resource sharing and a more balanced development of education, are growing in importance.

5.1.3 Scenario Value

Educational resource services create more openness and sharing, guarantee the selection of the best educational resources, promote fairness in education, and improve the quality and efficiency of educational services.

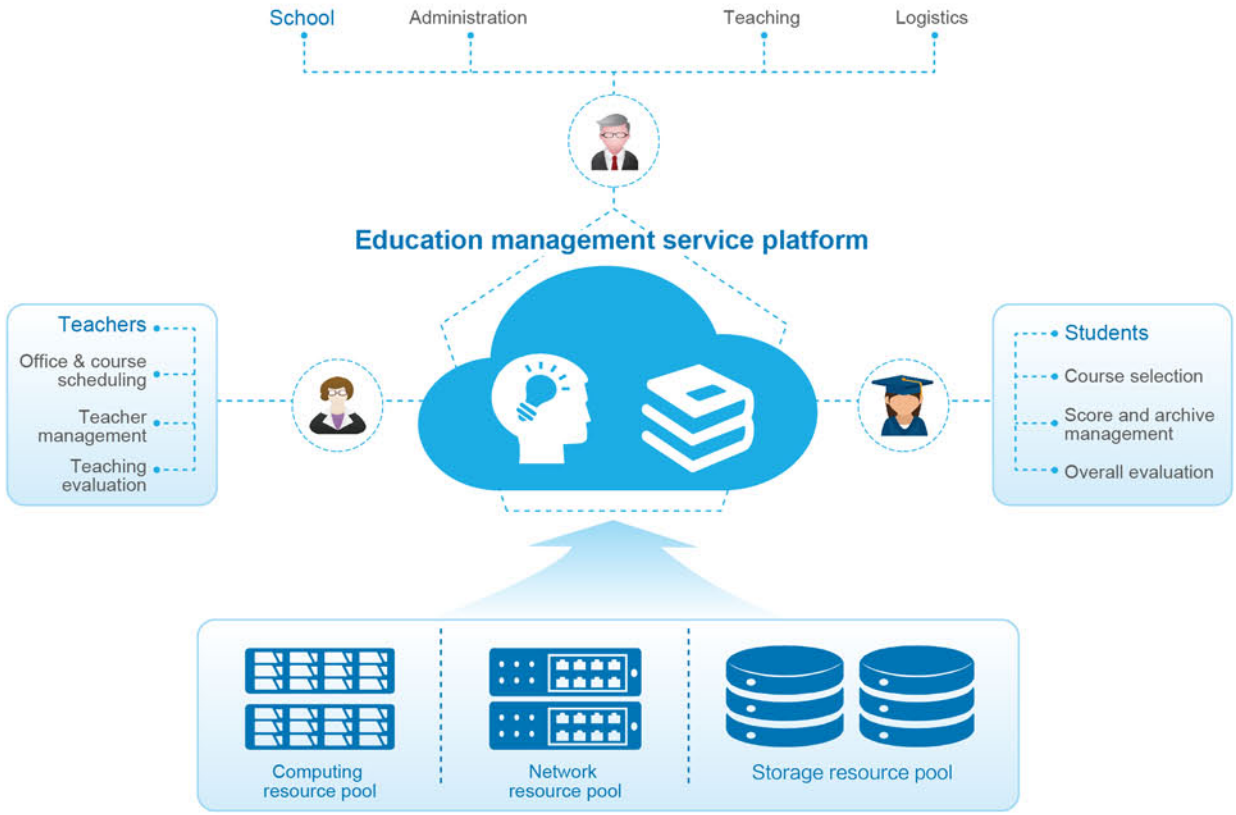
5.2 Teaching Management Service

The teaching management service provides comprehensive services for teaching staff, students, and parents alike. It makes it easier for teachers to perform their duties, students to select their classes, and parents to access teaching information and information on their children's performance.

5.2.1 Application Scenario

The education management service platform provides administrative, management, and logistical services with regard to teaching. The platform provides teachers with office scheduling, archive management, and teaching quality evaluations, and provides students with course selection, archive/score management, and comprehensive evaluations.

Figure 5-2 Teaching management service platform



- **Administration**
  Administration refers to documents, OA, and other office functions, such as emails, bulletins, processes, and weekly and daily schedules.

- **Teaching management**
  Teaching management includes course management, and teaching and research management. Course management refers to course choices, course scheduling, class selection, and class adjustment.

- **Logistics**
  Logistics refers to the management of the teaching staff's attendance, salary, and so on.

- **Comprehensive evaluation of students**
  Students are evaluated from all aspects, including their academic level, attitude, physical and mental health, personality development, and quality report.

5.2.2 Industry Landscape

With the promotion of China's educational strategies, the education management service platform has been deployed in all regions. However, most of the platforms are deployed in private clouds or internal networks, with few deployed on public clouds. The "Internet + education" strategy is part of the government's Education Informatization 2.0 drive, and cloudification and intelligence, trends that achieve better resource sharing and a more balanced development of education, are growing in importance.

5.2.3 Scenario Value

The teaching management service facilitates the work of teaching staff as well as parents' queries. It provides smart course scheduling and selection for more stratified teaching in the future, which significantly improves teaching efficiency and the overall running of a school.

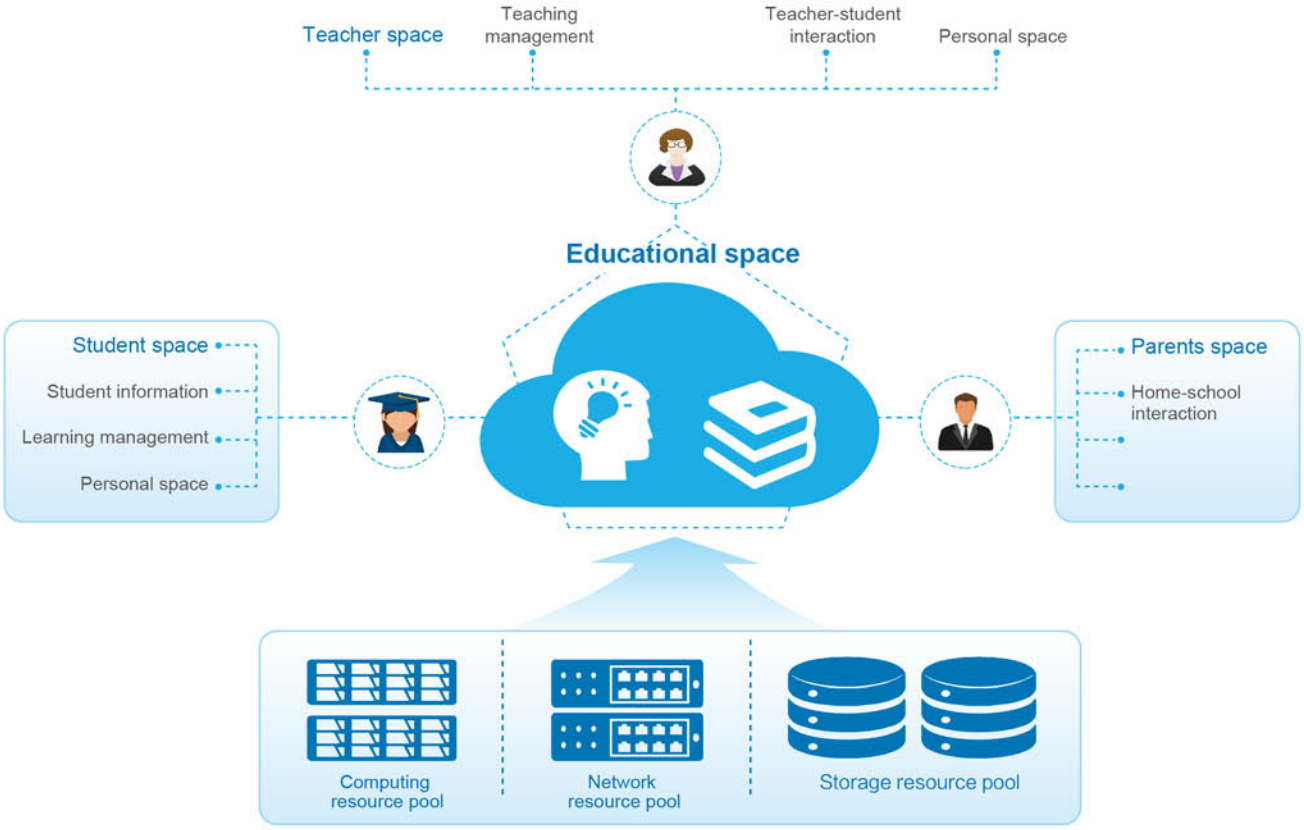
5.3 Educational Space

Educational space provides interactive and personal space for teachers, students, and parents, implementing teaching and student management and facilitating teacher-student interaction and home-school interaction.

5.3.1 Application Scenario

The educational space service platform provides both interactive and personal space, offering teachers teaching management, teacher-student interaction, and personal space services, and providing students with personal information, learning management, and personal space services. Parents are also provided with home-school interaction services.

Figure 5-3 Educational space service platform



- **Teacher space**

  Teacher space refers to teaching management, teacher-student interaction, personal space, and so on. Teaching management covers the management of teaching courses, course resources, work exhibition areas, and transcripts. Teacher-student interaction provides interactive discussions for teachers and students. Personal space refers to teacher information, personal logs, blogs, and photo albums.

- **Student space**

  Student space includes students' personal information, learning management, personal space, and so on. Learning management covers homework, progress records, course and practice information, and growth records. Personal space refers to logs that detail their personal experiences, as well as blogs, and photo albums.

- **Parent space**

  Parent space builds a platform for interactive communication between parents and schools. Through this platform, parents can see details about their children's attendance, curriculum, school life, and sports, including their examinations and assessments, their physical health, and different information with regard to teaching.

5.3.2 Industry Landscape

With the promotion of China's educational strategies, the educational space platform has been deployed in all regions. However, most of the platforms are deployed in private clouds or internal networks, with few deployed on public clouds. The "Internet + education" strategy is part of the government's Education Informatization 2.0 drive, and cloudification and intelligence, trends that achieve better resource sharing and a more balanced development of education, are growing in importance.

5.3.3 Scenario Value

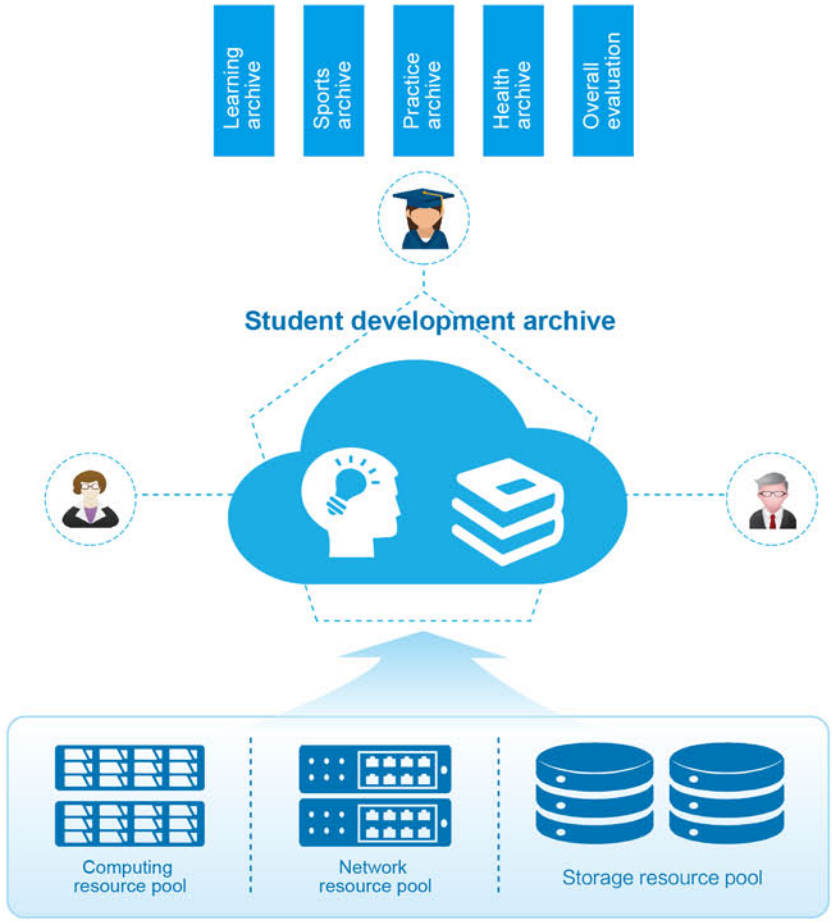
Educational space facilitates both teacher-student and home-school interaction, and enables teachers, parents, and students to participate in the students' learning process. This paves the way for more accurate planning and guidance and improves the educational quality.

5.4 Student Development Archive

An important part of smart education, development archives are a collection of information on a student's learning, hobbies, sports, and physical information, all of which can be used to analyze their learning behavior. In turn, this information can assist teachers in their duties and foster student development.

5.4.1 Application Scenario

Figure 5-4 Development archive platform



The development archive service platform uses big data and AI technologies to collect information on students' learning, practice courses, sports, and physical information in real time. It then performs smart analysis to generate dynamic development archives. Development archives include learning archives that record students' learning performance and progress, sport archives that record the results of physical examinations and extracurricular activities, practice archives that record practice courses, and health archives that record information on students' health. The system can then provide a comprehensive evaluation of each individual student's development.

5.4.2 Industry Landscape

Development archives focus on the management of learning. In the future, with the reform of high school entrance examinations, the management of students' sports, practice courses, and health will be strengthened. In addition, most development archive platforms are deployed in private clouds or internal networks, with few deployed on public clouds. The "Internet + education" strategy is part of the government's Education Informatization 2.0 drive, and cloudification and intelligence, trends that achieve better resource sharing and a more balanced development of education, are growing in importance.

5.4.3 Scenario Value

Development archives are helpful for teachers, parents, and students alike to get a better understanding and appreciation of students' development, and they provide targeted guidance on teaching and student cultivation.

5.5 Transport Requirement

- **Platform access capability**: The smart management platform supports simultaneous access by a large number of users.
- **Network capability**: The network must support remote broadband access for teachers, students, and parents, with smart management platforms at different levels interconnected through private lines.

5.6 Summary

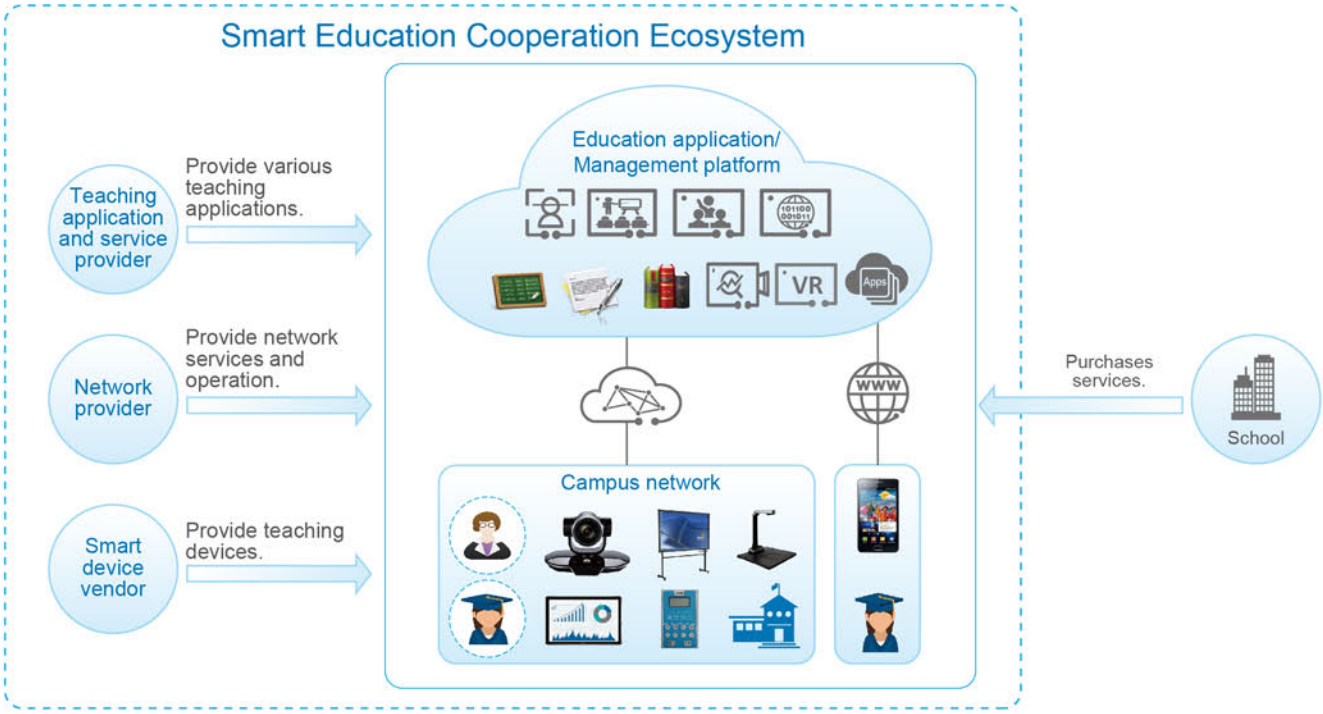
- In observance of the Chinese government's "Internet + education" strategy, smart management platforms have been built based on various information technologies such as cloud computing, big data, and AI. The platform provides smart management services, the very basis of smart education.
- The educational resource, education management, educational space, and development archive services provided by smart management help improve teaching quality and promote fair development in education.

06
Business Models of Smart Education

6.1 Business Integration

The provisioning of smart education services involves various smart devices, campus networks, transport networks, cloud data centers, education applications, and management platforms. Naturally, this involves multiple parties. To provide better services for schools, a representative, which can be a school, integrator, or operator, is needed to guide E2E solution integration.

Figure 6-1 Smart education cooperation ecosystem



6.2 Business Model

Depending on the business model and the school's service experience, integration is led by different parties.

6.2.1 School-led Business Model

The school takes the lead in purchasing smart devices, entrusting the integrator to build and maintain a campus network, and leasing private lines and Internet access services from operators. The school can purchase smart education applications and management services from third parties, or build private cloud data centers and entrust the integrator to complete the ecosystem integration and build applications and management services.

Table 6-1 School-led business model

Service	Description	Provider	Business Model
Smart device	Cameras, tablets, sensor terminals, and IoT terminals	Device vendor	Purchase devices and make a one-off investment.
Campus network	Campus network construction and maintenance	Integrator	Campus network construction is a one-off charge, and campus network O&M is charged monthly or annually.
		Operator	
Transport network	Cloud private line and Internet connection	Operator	Purchase services. The services are charged monthly or annually.
Data center	Cloud platform	School	Build private clouds by themselves, and make a one-off investment.
		Operator	Purchase services. The services are charged monthly or annually.
		Third-party CSP	Purchase services. The services are charged monthly or annually.
Education application/ Management platform	Various smart education applications and management services	School/Integrator	Complete the ecosystem integration (or get the integrator entrusted by the school to do so), and make a one-off investment.
		Application and management service vendor	Purchase services. The services are charged monthly or annually.

Integration led by a school places high requirements on the school, as the school needs to deal with multiple providers. Only universities and high schools with strong informatization capabilities should select this model. In addition, in this model, each provider independently offers services, resulting in issues such as poor cooperation, difficulties in providing E2E experience assurance, and high usage costs.

6.2.2 Integrator-led Business Model

Unlike the school-led business model, the integrator-led business model only requires the school to raise requirements, with E2E solution integration being completed by the integrator. For example, the integrator needs to purchase devices, construct the campus network, purchase private lines from operators, and build cloud platforms or purchase cloud platform services from third-parties to integrate or purchase applications and management services.

Table 6-2 Integrator-led business model

Service	Description	Provider	Business Model
Smart device	Cameras, tablets, sensor terminals, and IoT terminals	Terminal vendor	Purchase devices and make a one-off investment.
Campus network	Campus network construction and maintenance	Integrator	Campus network construction is charged one-off, and campus network O&M is charged monthly or annually.
Transport network	Cloud private line and Internet connection	Operator	Purchase services. The services are charged monthly or annually.
Data center	Cloud platform	School	Build private clouds by themselves, and make a one-off investment.
		Operator	Purchase services. The services are charged monthly or annually.
		Third-party CSP	Purchase services. The services are charged monthly or annually.
Education application/ Management platform	Various smart education applications and management services	Integrator	Complete ecosystem integration and make a one-off investment.
		Application and management service vendor	Purchase services. The services are charged monthly or annually.

The integrator-led business model releases the school's investment in solution construction, but the school still needs to deal with multiple service providers. This model still has issues with poor cooperation efficiency between providers, difficulties in providing E2E experience assurance, and high usage costs.

6.2.3 Operator-led Business Model

The operator needs to complete E2E solution integration and provide services for the school. In addition to providing traditional cloud private lines and Internet connection services, the operator can extend its services to the campus network, providing, for example, services for broadband campuses, safe campuses, and intelligently-connected campuses. It can also cooperate with excellent education service providers to implement ecosystem integration and provide cloud platforms, education application services, and CDN content delivery services, thereby further improving the school's service experience through device-pipe-cloud packaging.

Table 6-3 Operator-led business models

Service	Description	Provider	Business Model
Smart device	Cameras, tablets, sensor terminals, and IoT terminals	Terminal vendor	Purchase devices and put one-off investment.
Campus network	Campus network construction and maintenance	Operator	Campus network construction is charged one-off, and campus network O&M is charged by month or year.
Transport network	Cloud private line and Internet connection	Operator	Purchase services. The services are charged by month or year.
Data center	Cloud platform	Operator	Purchase services. The services are charged by month or year.
Education application/ Management platform	Various smart education applications and management services	Operator	Purchase services. The services are charged by month or year. (The operator completes ecosystem integration and shares operation revenues with service providers.)

Operator-led business models not only improve service experience by means of device-pipe-cloud collaboration and service packaging, but also better promote ecosystem improvement and application enrichment. In addition, content can be reused on clouds, which reduces a school's usage costs and promotes the use of smart classrooms. It is an ideal model for the integrations of smart education.

6.3 Summary

- The integration of smart education can be led by a school, an integrator, or an operator.
- Depending on the business model and the school's service experience, integration is led by different parties. Operator-led business models offer the best service experience and are the ideal model for promoting the integration of smart education.

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