ES4 Final Research Paper
Effect of Microprocessors on Transportation
(Spring 2020)

Qijin Chau

***Abstract* — A microprocessor (Fig. 1) is an integrated circuit that incorporates all the functions of a central processing unit of a computer. This tiny computer has had a huge impact on transportation, a sector in society that has already revolutionized the lifestyle and well-being of humans. The use of microprocessors has become an integral part of land, water, and air transportation. Engineers have been taking important steps in areas of hardware and software to provide upgraded service, functionality, efficiency, and comfort, along with increased safety, conserved energy, and reduced pollution and costs.**

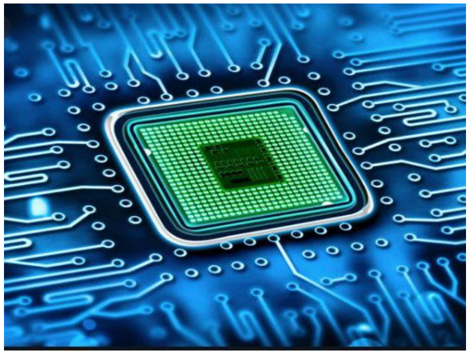

Figure 1 Picture of microprocessor

I. Introduction

Less than 250 years ago, powered transportation including ships, cars, trains, and airplanes were nonexistent. Today, it is hard to imagine life without these modern forms of transportation. The possibly of boarding an airplane in Boston and fourteen hours later be across the world in Beijing, China, is such an incredible feat. Prior to powered transportation, humans had to walk or rely on animals like horses and camels to travel. These types of travelling were slow, unsafe, uncomfortable, and inconvenient.

Finally, in the late 1770s, the start of motorized and powered marked major milestones for transportation beginning with the first steamship and steam-powered train. In the late 1800s, Karl Benz gave birth to the first modern car. Then in the early 1900s, the Wright brothers flew the first air-powered aircraft.

The invention and adoption of these transportation methods radically improved the standards of living of people around the world. Countries economic growth and development profoundly benefitted from both the direct and indirect effects of transportation infrastructure. Apart from accessibility improvements, transportation infrastructure development brought along easier, safer, faster, and more reliable trade and investment opportunities to the previously connected and unconnected regions. Products could be delivered around the world and traded for other products in days by ships and trains rather than months by camel or sail. Through the multiplier effect, access to goods, services, and employment opportunities was provided in these regions with transportation infrastructure. These positive outcomes of effective transportation systems are even more pertinent to developing countries that are more desperate for these economic boosts[5].

By the mid to late 1900s, as airplanes became faster and more prevalent, global travelling only took hours. Reducing flight times, brings the world much closer together and allows people to explore, tour, and invest around the Earth. “Globally transportation and communication are changing every aspect of human life, from trade to manufacturing, education, research, entertainment, culture, and defense” [5]. As time progressed, the production of aircrafts skyrocketed because these benefits.

Modern transportation has drastically changed how people live and operate by making travelling and trading easier, safer, faster, convenient, and more reliable. Who would have guessed that a computer that can fit in the palm of your hands would radically improve the transportation sector once again?

Starting from automobiles to vessels to aircrafts, microprocessors were rapidly introduced to key products, a handful of which dominate the transportation sector like cars, railcars/trains, boats, ships, and airplanes. The purpose for the functionality of microprocessors differed between products however the reasons for the improvements were always similar.

II. Cars

An embedded processor is a type of microprocessor designed into a system to control electrical and mechanical functions. Nowadays, the average middle-class American household includes over 40 embedded processors. Half of them are not even inside the house. About half of the processors are in the garage. Embedded processors provide a ready source of power, ventilation, and mounting space that are easily deployable in cars.

The first car that used a microprocessor was the 1978 Cadillac Seville. Now only four decades later, the same chip that displayed mileage and other trivia on the Cadillac’s dashboard would barely be able to adjust the mirrors on the cars today. Microprocessors are so desirable in cars because they add high-profile features that consumers love, and these processors provide better profit margins than add-ons like leather seats and undercoating[3].

Microprocessors have revolutionized the capabilities of modern cars. Today, car manufacturers manage to squeeze microprocessors almost everywhere including the side and rear-view mirrors, wheel rims, headliner, gas tank, seat cushions, headrests, and bumpers. These processors can control anti-skid braking systems, dashboard gauges, air comfort, entertainment systems, and more[1]. None of these processors are essential however they do improve the comfort, safety, and usability for car owners. Features like seat warmers and automatic trunks that sense your foot are examples of improvements that consumers love.

Only two or three processors are needed for the GPS navigation and the automatic distance control. Imagine having over 100 processors in your vehicle. Imagine the capabilities, performance, and power consumption. Oh wait, these types of cars do exist today. The current 7-Series BMW and S-class

Mercedes contain about 100 processors apiece[3]. On the other hand, these digital microprocessors do not come cheap. If you want to purchase either of these cars, hopefully you have over eighty grand available because that is only the starting price. Even an economic car still has a few dozen different microprocessors within. Most likely one's transportation appliance has more microprocessors than their Internet appliance.

Outside of cars, microprocessors have also upgraded traffic control signals using sophisticated algorithms to reduce congestion, travel time, and fuel consumption. Furthermore, automatic vehicle monitoring is being field tested for improved urban transportation[2]. In modern society, cars are in such high demand because people are lazy and want the easiest and fastest way to get to their destination. Thus, optimizing efficiency and time wasted in day to day driving by improving factors in urban transportation like traffic signals is another key function of microprocessors in the transportation sector to satisfy consumers and boost consumption.

III. Railcar Systems

Virtually all rail operators depend on microprocessors and computers for smoother and more reliable operation at high levels of safety. Microprocessors also provide lower maintenance and operating costs. The lives and safety of commuters in British Columbia are greatly improved by the microprocessors incorporated into the BC Transit system. At the touch of a button, the BC Transit system can modify its dispatching strategies in order to meet changing traffic conditions, like increased passenger demand or a stalled car[1]. Carrying a typical daily load of 150, 000 passengers, at the rate of about 10, 000 passengers per hour, any efficiency improvements for the operators or safety improvements for the passengers are tremendously helpful and crucial. Also, the capacity that railcars have push product development because railcars are so effective in carrying and transporting large quantities of product and passengers.

Another life changing impact that microprocessors provide for rail operators is the simplification of maintenance through automatic diagnosis of failed components and systems on each car. In the Vancouver system, just two microprocessors are used to help detect malfunctions and mistakes by monitoring up to fifty components and systems, including brakes, motors, doors, power supplies, heating, ventilation systems, and even the microprocessors' own operations[1]. If any failures are detected, this information is immediately transmitted and recorded in computer memory at the system's management center for the operators to see.

According to David B. Turner, "... electronics, particularly in the form of microprocessors, is playing an ever-increasing role in helping automotive and rail transport to remain competitive"[1]. As the manufacturers for automobiles continue to rely on microprocessors in their design to control more functions, the rail transport companies must do the same in order to compete. Railroad companies had to persistently test prototype microprocessor-based systems that employ computer networks, digital packet communications, and satellite technologies. Railroads had to fight in order to remain relevant in today's ever-changing society with new technology constantly being developed and old ones improving. A competition that contributes to American capitalism but can also drive companies out of business and leave people jobless. A cascading effect that many people would not associate with microprocessors considering the amount of positive contributions they have for various sectors of society.

IV. Boats & Navigation

The process of navigation consists of collecting data then processing this data through computation to answer questions. In the early days the computational process was relatively simple. First, arithmetic converted the dynamics of the chip log into vessel speed. Second, using this speed, geometric construction, heading from a magnetic compass, a probable position was computed. Computation became more sophisticated as nautical astronomy and celestial measuring instruments were developed. These computations using input from data became significantly easier when equipment designers began to integrate microprocessors into the electronics of boats. The microprocessor can be programmed to perform statistical manipulation on the various incoming data. Now just a hand-held compass used for sighting charted objects along with a microprocessor can be used to compute position. The processor can collect the data, integrate, process, and then turn the isolated facts into a coherent, useful picture[4]. The motion computer on a vessel can now continuously update and display the vessel's position which makes travel by sea safer and more efficient thanks to microprocessors.

Even in the late 1900s, people knew that if these tiny computers were able to be sold at low prices, they would be in huge demand from small commercial and the yachting communities. These tiny computers with large memory and capacity made "automatic computation of all of the processes in celestial navigation, including even nighttime visibility of the horizon" into a reality[4].

Fast forward to today, satellite systems can provide continuous, global positioning through microprocessors. These advances stimulated equipment and software design that rapidly elevated the levels of navigation system price/performance ratios. Many navigators including the marine navigators surely benefitted from these advances.

Aside from ships' microprocessor-based satellite navigation system, microprocessors in vessels also provide reliable monitoring of structural safety and engine performance in order to optimize fuel economy. Constant monitoring help control pollution in the world's major bodies of water by making sure the right amount of fuel is used and no leakages are occurring[2]. On top of fuel monitoring, some ships adapted a system that uses microprocessors to analyze water sample to discover the parts-per-million of oil discharged overboard[2]. Keeping record of these measurements is progress towards the goal of making marine travel as eco-friendly as possible.

V. Air

In 1903, the Wright Brothers flew the first successful powered aircraft. The aircraft was estimated to weigh roughly 625 pounds including the pilot and flew at an approximate 30 miles per hour. Less than a century later, an average commercial airplane weighs well over 100 times more and flies about 20 times faster than the aircraft flown by the Wright Brothers. The increase in aircraft size, speed, and flight duration had to be accompanied with innovations to ensure the safety and comfort of the people on board. Microprocessors had a huge role in the transition from the first powered aircrafts to the aircrafts we see flying around today.

In the late 1900s, the Transportation System Center (TSC) developed, tested, and evaluated a few technologies for airplanes that incorporated microprocessors. First, an airborne radar-beacon collision-avoidance system. At the time, the system provided airplanes with warnings of threats of collisions with any other aircraft within about 37 kilometers. This range has increased greatly in the aircrafts developed today. A crucial addition to aircrafts for the safety of passengers made possible by microprocessors.

Second, a visual light signal at the beginning of the runway to act as a confirmation signal to pilots prior to takeoff. The signal serves as a backup to the voice confirmation from a flight controller. TSC developed this signal in the aftermath of the disastrous accident involving two Boeing 747s at the Tenerife airport in the Canary Islands last year[2]. The signal is another addition that boosts the safety of everyone on board.

Third, a multichannel voice-response system used for weather briefings to pilots. The system provided pilots with direct access to weather information via conventional touch-tone telephone. When a pilot requested specific weather information, the inquiry is then transmitted to a computer for processing. After processing, the requested weather information is retrieved, converted to regular speech, and sent back to the computer onboard for the pilot[2]. Weather briefings to pilots have also significantly improved since this multichannel voice-response system. Having quick and easy access to the weather allows the pilots to focus on piloting the plane and limit distractions.

A main objective for airports is to regain landing capacity and reduce delays, without degrading the current high level of safety of air carriers[2]. Delays have been increasing with the increased use of heavy aircraft. Implementing systems with microprocessors have demonstrated the feasibility of reducing delays an average of roughly fifty to sixty percent of the time.

VI. Conclusions

Experts predicted that in the beginning of the 21st century, the automotive industry will represent one-fifth of the consumers for microprocessors, making this sector the biggest market[6]. The demand to be able to travel safely from one destination to another as soon as possible, has driven constant product development in the transportation sector. In today’s world, time is money therefore modern forms of transportation like cars, trains, ships, and airplanes have played a huge role in improving the economic well-being of society.

Once microprocessor-based management systems revolutionized the transportation sector, every transportation product received a spike in popularity. This is because the addition of microprocessors has been able to propel these forms of transportation a step further by providing additional improvements towards comfort, safety, and fuel economy. As functions like condition monitoring, fuel metering, speed limiting, cruise control, and emissions control became integrated with the microprocessor-based management systems, transportation also became more cost efficient and eco-friendly.

Furthermore, the power of microprocessors and their demonstrable ability to expand and improve vehicle performance provides operators with effortless capabilities at the touch of a button. However, like most things in the world, these performances come at a price. The more microprocessors used and the larger the enhancement, manufacturers need to justify their investments in their product by increasing the cost of sale in order to return positive revenue. The long-term goal is that one day, society can “look beyond the stages of competitive products [and money] and encourage the use of the processing capabilities for solving the social questions of safety and congestion”[6].

References

[1] G. Kaplan, "Transportation: Microprocessors monitor rail car systems software optimizes the headway in Miami's people mover microprocessors replace relays in mechanical switches and signaling AC propulsion systems improve Adhesion, simplify maintenance," in IEEE Spectrum, vol. 24, no. 1, pp. 59–61, Jan. 1987.

[2] G. Kaplan, "Transportation: Electronics galore: Microprocessors broaden impact onland, sea, and air transport," in IEEE Spectrum, vol. 15, no. 1, pp. 59–62, Jan. 1978.

[3] J. Turley, “Motoring with microprocessors,” Embedded.com, Aug. 11, 2003 (Online). Available: https://www.embedded.com/motoring-with-microprocessors/ (accessed Apr. 18, 2020).

[4] M. Rogoff, "Computers and navigation," in Proceedings of the IEEE, vol. 71, no. 10, pp. 1199–1200, Oct. 1983.

[5] Mohmand, Yasir Tariq, Aihu Wang, and Abubakr Saeed, "The Impact of Transportation Infrastructure on Economic Growth: Empirical Evidence from Pakistan," Transportation Letters, vol. 9, no. 2, pp. 63–69, Mar. 2017.

[6] Wright, D.S. Transportation, “Current on-board vehicle systems,” in Springer Transportation, vol. 17, no. 3, pp. 239–250, Sept. 1990.