DIGITAL EUROPE: DIGITISING INDUSTRY, EMPOWERING PEOPLE
ANDRUS ANSIP, EUROPEAN COMMISSION VP FOR THE DIGITAL SINGLE MARKET OUTLINES WHY SCIENCE AND RESEARCH PLAY AN INTEGRAL ROLE IN CREATING A DIGITAL EUROPE

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Queueing theory: the solution to unsustainable wait list practices

David Stanford, Richard Boucherie, and Peter Taylor outline how queueing theory could help tackle some of the challenges in the healthcare sector.

Most readers can appreciate that governments are continually challenged by demand for new services and medications while striving to limit health care from consuming an ever-increasing proportion of public revenues. Increasing demand is, in part, due to an ageing population, but it is also due to the cost of new drugs and high-tech treatments. Arguing whether or not these increasing costs should be avoided is an important debate in many countries, including the Netherlands, where it has resulted in a reduction of the number of treatments being reimbursed by healthcare insurers.

As shown in Global Health Observatory (GHO) data, delayed access to care is known to reduce the quality of that care. While the Netherlands’ healthcare quality is at the top of many worldwide rankings, the Dutch Healthcare Authority (NZa) recently sounded the alarm about increasing access times. Various reasons, including the insufficient numbers of medical specialists, were listed as common causes.

Increasing the numbers of medical specialists or diagnostic facilities has often been employed to reduce access times in healthcare. However, the cost increases of such solutions are unsustainable. Widely in the Western world, healthcare costs already represent about 10-15% of the GDP, making healthcare the largest industry in these countries. In contrast, a proper implementation of queueing principles in the healthcare system often yields better performance for less cost than additional resources do. Consider the following example: In 2006, the Academic Medical Centre Amsterdam (AMCA) scanning facility approached the Center for Healthcare Operations Improvement & Research (CHOIR) at University of Twente for help with scheduling. Patients for the two non-emergency CT scanners were waiting up to four weeks for treatment. The AMCA intended to add a third CT scanner to reduce waiting times.

**CHOIR**

When CHOIR researchers looked at the logistics of the patient flow, they observed large variability in both the arrival times of patients from other facilities in the hospital and in CT scanner occupation times, since a small proportion of patients required the administration of contrast fluids. In queueing theory, variability is known to be one cause of access delay. The CHOIR team advised that patients should arrive ten minutes earlier than scheduled and that the contrast fluid should be administered in an adjacent room when necessary. These two measures reduced both the mean time the CT scanners were occupied and its variability, thereby reducing the average CT access time to two days with the two existing scanners. Ongoing collaboration with CHOIR currently enables AMCA to run the CT facility as a walk-in facility, with negligible access time.

The above story is a good example of what can be achieved when queueing theory is brought to bear on problems of congestion in healthcare facilities. Queueing theory is the branch of mathematics which models congested systems in which randomness features prominently. The first such models, from the early 1900s, responded to needs in the rapidly-expanding telephone network. Since then queueing theory has been used for applications as diverse as design of production lines, theme park operations, and Internet data traffic.

Randomness is a key factor confounding a health facility’s ability to provide timely access to care. The times when people need health services are not predictable, and there is considerable variability in both the service duration and the resources required to provide appropriate treatment. The relative acuities of the patients present and how they evolve over time, the interactions between distinct health services, and the number of nurses, doctors, beds, and ancillary facilities available are all aspects that can vary widely.

The fact that variability is among the main factors influencing access is well-known to queueing theorists; in fact, it is a key aspect considered in queueing practice. In healthcare, however, variability is too often ignored.
Averages are treated as if they occur with certainty, leading to degradation of medical care, as illustrated in the CT example above.

In recent decades, queueing theorists have had success in improving health system delivery. Along with academics interested in scheduling, they have impacted areas as diverse as emergency room waiting times, operating room schedules, medical short-stay units, and the connectedness of the emergency/acute care/subacute care pathway.

Organ transplantation
One frequent challenge is the fact that waiting times for organ recipients of the ‘universal donor’ blood type O used to be notably longer than those of other blood groups, because too many O organs are cross-transplanted into recipients of other blood types. In November 2010, this led to the Eurotransplant zone insisting upon ABO-identical transplantation of kidneys. This strategy penalises recipients with rarer blood types (in Europe, B and AB) due to their much smaller number of donor organs. A queueing solution that balances the needs of both large and small-populated blood-type pools was presented in a ScienceDirect article.

Clearly, continual increases in the fraction of government revenues devoted to healthcare are unsustainable. A proven alternative which can no longer be ignored is to improve the logistics processes, invoking operations research techniques such as queueing theory and simulation. These models give solid evidence to wary practitioners of the effectiveness of new working methods in a safe setting.

We close with one further call. It is still widely true that doctors and nurses receive no training in health system congestion and its impacts upon timely delivery of healthcare. This lack of any training in queueing principles tends to lead to repeated re-inventing of the wheel, often based upon faulty intuition. For meaningful improve-