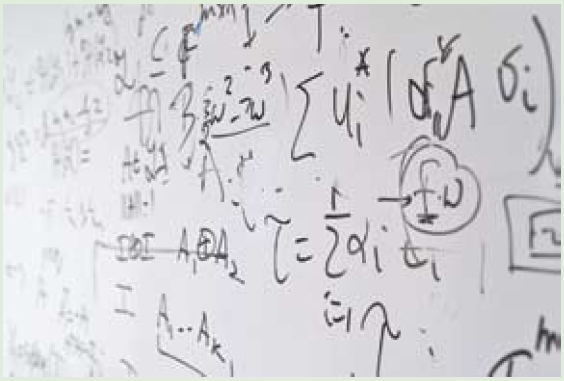
Have you ever been talking in a group, and started speaking at the same moment as someone else? You stop, pause and excuse yourself. After that one of you will talk first, and the other will wait politely. Of course, no one waits for too long, to avoid an awkward silence in the conversation.

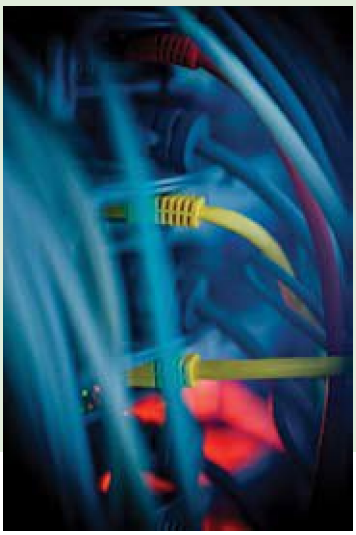


Wireless communications can work in a similar way. When you use WiFi on your laptop, iPhone or other gadget, then transmissions should happen one at a time. The WiFi system uses a similar rule for polite conversation, where people pause for a random amount of time before they transmit, to give other people a chance to talk. Similar to a real conversation, there is a trade off between how long transmitters wait and how efficient the network is: if you pause for too long, the conversation moves slowly; if you don't pause enough, then people keep jumping in at the same time.

WiFi is one of the things that we study at the Hamilton Institute. You could take a guess about how long to pause for in a WiFi network. However, if you can understand what is happening theoretically, then you can say exactly how long to pause for to get the best performance from your network. Our aim is to use mathematical analysis that tells us how to understand, improve and design networks. Using the right theoretical tools lets us say how a system must behave.

The nice thing about mathematical theories is that they are 'reusable'. The algebra that you learned in school works well regardless of whether it is applied to physics, economics, electronics or any subject. At the Hamilton Institute, there are people working on problems in areas such as Communications Networks, Biology, Automotive Design and Robotics. The one thing we have in common is that we use mathematics to understand our problems.

Recently, over a polite conversation at lunch, people from the biology and networks group were chatting about how some anti-HIV drugs worked. We discovered that the mathematical approach that had been used while studying wireless networks was the same approach that was needed to understand the action of the anti-HIV drug! In drug therapy, though, one does want to be as impolite as possible when interfering with the viral infection.



Another problem tackled by the network team at the Hamilton Institute relates to TCP, the protocol that is used to carry most of traffic across the Internet. One of the things that TCP does is control how fast data is sent into the network, so that the network is not overwhelmed. While traditional TCP works quite well on slower networks, people had spotted that it would have problems moving data over long distances and very fast networks. This was an important problem to solve, as many scientists now need to move huge amounts of data between research groups (one example is the data produced at the Large Hadron Collider in CERN).

When the Hamilton team began working on the problem, there were several proposals on the table for how to improve TCP. By building mathematical models of how TCP works, the team was able to understand why particular problems arose with some of the proposals. More importantly, the mathematics also showed how these problems could be fixed. Hamilton's version of TCP is now available as a part of Linux, and the mathematical tools used to design it are still being used to improve the design of TCP. The mathematics used includes linear algebra, probability theory and control theory, which we also use to understand how cars make their way through cities.

At the Hamilton Institute we have a mix of projects covering both the development of advanced mathematical tools and how these tools can be used to solve real-world problems in ICT and biology. Projects at the Hamilton Institute are supported by funding from Science Foundation Ireland, the Higher Education Authority, Enterprise Ireland, the European Union and industrial companies, particularly from the ICT and pharmacy sectors. Making advances in applied research projects is driven by our advances in basic research. This is our recipe for success at the Hamilton Institute, and we believe that a successful research landscape in Ireland equally benefits from the right mix of theoretical and applied research.

For more details:

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