THIS WEEK

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Guard against a net loss

Moves to create a multi-speed Internet, by abolishing the principle of net neutrality that ensures equal treatment for all data traffic, could push science into the slow lane.

Two decades ago, *Nature* ran a news story warning scientists about what could happen to their computers when the new millennium rolled around (*Nature* **387,** 109–110; 1997). Of course, the doomsayers and their concerns about aircraft dropping from the sky as digital clocks updated to 1 January 2000 were proved wrong, and "remember the millennium bug" became a popular way afterwards to argue for inaction in the face of any growing worry.

The phrase is being used again now — by supporters of a controversial move to alter how the United States governs Internet use. Dark predictions of a two-tier Internet made vulnerable to censorship, these advocates scoff, are massively overblown. Forget the millennium bug. Now, the ending of 'net neutrality' in the United States should trouble researchers: the potential for problems is real.

On 14 December, the US Federal Communications Commission (FCC) is expected to reverse its 2015 move to classify broadband providers as 'common carriers'. For the first time, this would allow Internet service providers (ISPs) to block or slow certain types of content, and to charge users more for fast access to what those companies class as premium content. Supporters argue that this is a more efficient and profitable way to allocate squeezed bandwidth than the current net neutrality. Time-sensitive information, such as instant-video communications, can be put in a fast lane and allowed to overtake less urgent information, such as e-mail traffic.

Academic debate on the topic has been bitter. Some researchers who have studied the likely effects of such a change agree that the FCC and its supporters might have a theoretical case. Strict net neutrality can be shown, in economic models of Internet traffic, to be socially inefficient (M. Peitz and F. Schuett *Int. J. Ind. Organ.* **46,** 16–62; 2016). And offering a fast lane could help some users. FCC chairman Ajit Pai used the example of telemedicine, which he said was being hindered. (Opponents counter that telemedicine could be offered in this way under existing rules; health-care groups including the American Academy of Paediatrics fear that large companies would then dominate.)

This fear of large companies and their pursuit of profit features in many of the predicted weaknesses of a less-neutral network. ISPs, for example, could be paid by tech firms to steer users towards their products.

How this shift might affect science and scientists is not clear — and this is probably one reason why the response to the debate from research organizations has been muted. A notable exception is the Public Library of Science, publisher of the PLOS journals. It has pointed out several times this year that giving ISPs the power to sort traffic on the basis of content, sender and receiver poses a threat to scholarly journals and research.

The changes could affect traffic that routes through the United States, which includes plenty from South America, Central America and the Caribbean. So, in theory, terabytes of data sent from telescope arrays in Chile to physicists in Europe could be stuck in the digital slow lane as ISPs prioritize advertising-heavy social-media messages. Or universities and students, especially those in poorer countries, could face prohibitive access and download fees.

Many critics of the FCC's move argue that it's the principle of equal access to information that really counts — and that will be lost. Certainly, that's one reason why other regions, including Europe and Canada, have fought hard to maintain and safeguard net neutrality. The European Commission, for example, enshrines in law a user's right to be "free to access and distribute information and content, run applications and use services of their choice". (This applies to Portugal — so, despite a widespread claim to the contrary, the nation does observe net neutrality.)

> ***"Universities and students could face prohibitive access and download fees."***

Science has made great strides in recent years to break open the walled gardens of many research fields and spread data and expertise around. The Internet — a scientific tool to begin with — has driven this revolution. As the implications of the US switch unfold, researchers and their representatives must prepare to protect this crucial progress. ■

Safety faster

Bureaucratic drag dents Japan's nuclear science.

When an earthquake struck the JRR-3 nuclear research reactor in Tokai, Japan, in March 2011, the damage was light. Researchers there expected they would be back at work in six months. Now, more than six and a half years later, hundreds of condensed-matter physicists, materials scientists and structural biologists still await the green light from the nuclear regulators. The tsunami triggered by the same earthquake caused meltdowns in three reactors up the coast at the Fukushima Daiichi plant, exposed hundreds of people to high levels of radiation and changed attitudes in Japan towards all nuclear reactors. Eight of the country's eleven research reactors, including JRR-3, have been closed since.

The fear is justified. A government should never place research over the safety of its citizens. At the same time, a key role of all governments is to weigh many risks, including to jobs.

As Japan calculated when it poured millions of dollars into its research reactors, these support some of the nation's most vibrant and internationally prominent research communities, composed of scientists who have produced a steady stream of fundamental breakthroughs and profitable applications. With other countries, notably China and South Korea, now scoring successes in related fields, the delay in restarting the facilities threatens the careers of many scientists, as well as Japan's international competitiveness. It raises the question of how well Japan's regulators are balancing risks from the reactors with the costs of letting fertile research facilities lie fallow.

With its nuclear regulatory agency besieged by criticism for lax oversight of the Fukushima reactors, the government understandably wanted to reassure people that its other nuclear reactors would operate safely. The country's research reactors, like its power-generating reactors, had to shut down until approved under new regulations by a reformed agency. The research reactors ran at a fraction of the power and were less risky than those that fed the grid, and they all had different specifications. So the agency decided to take a "graded approach". That filled researchers with hope of a quick approval when, in September 2014, they applied to restart JRR-3 under the new guidelines.

Regulators reviewing the facility have since held 52 committee meetings and 158 hearings on reactor design, and on earthquake and tsunami threat. Considering each reactor separately turned into a time-consuming process without any clear path to approval. A 2016 road map promised an early-2018 restart. Now, some fear that hope, too, may be dashed.

Meanwhile, scientists and their students have scrambled to find alternatives. Every year, Japan sends about 50 researchers who had planned to use JRR-3 to neutron sources overseas. They carry out a few dozen projects, less than 15% of the number that had been slated at JRR-3. Many researchers have simply switched fields.

JRR-3 was Japan's busiest research reactor. Built in 1962, and upgraded in the 1990s, it had 1,500 users from Japan's Atomic Energy Agency and the country's top universities. In 2010, the year before it shut down, 300 experiments were carried out. Research there led to about 200 papers per year between 2006 and 2010 .

Neutrons emitted by nuclear reactions at JRR-3 were used to study the atomic structures of materials. Neutrons are complementary to X-rays because they can penetrate more deeply and are sensitive to lighter elements. This makes them invaluable in studies of magnetism and high-temperature superconductivity.

"Many researchers have simply switched fields."

These are also fields in which nearby nations excel. Just this week, South Korea restarted its major neutron source, HANARO in Daejeon, after retrofitting post-Fukushima, and China recently unveiled a brand new neutron source, the China Spallation Neutron Source in Dongguan.

Delays in reopening the reactors is costing Japan its edge; and the communities built around the facilities have started to fall apart, according to researchers contacted by *Nature*. The nation needs to find a faster way to command an overhaul of facilities. As some of the testimonies in the hearings point out, it is not clear that the meeting-laden approach is even ensuring safety.

Nuclear safety is paramount. But the careers of hundreds of scientists and Japan's scientific competitiveness are not to be taken lightly. ■

Get past glib

Interdisciplinarity requires us to take time to respect each others' expertise and blind spots.

Consider the following case study — real but purposefully vague to protect authors' confidentiality.

A manuscript is submitted to a Nature journal that combines health and environmental data and modelling to forecast health impacts of anticipated environmental changes. Three editors with different expertise consider the paper; they send it to four referees to cover the specialities involved. All see problems in the paper and it is rejected.

The authors appeal, responding to the critiques. The paper is re-refereed. Two of the referees see improvements; the other two still have concerns, especially in relation to the interpretation of health data. The cycle is repeated several times, with the paper improving at each stage. Eventually all referees are genuinely persuaded — not worn down — that the work can be published. One year after the initial submission, the paper is accepted in principle.

The lead author, an environmental scientist, admitted after publication that running this gruelling gauntlet had led him to realize that he needed to develop a deeper understanding of models used by the health-research community.

There are lessons in this for researchers, editors, funders and institutions about what it takes to avoid what one might provocatively call glib interdisciplinarity. The difficulties in such cases often stem from 'domain inequality': researchers from one discipline have a set of data that speak to impacts that can be understood only by a totally different sort of expertise. If they don't work with the relevant experts, the result is hand-waving.

Related to this is the problem of terminology, when the subtleties of concepts familiar to one field simply haven't been grasped by those from another. Sometimes, referees will call this out in the name of comprehensibility, only to find in a subsequent revision that the authors haven't adequately understood the concept in the first place.

Too often, funders and institutions that trumpet the value of multidisciplinary research fail to support or allow for the risks involved and the time it takes to rise to these challenges — to achieve interdisciplinary domain equality and mutual depth of understanding. Forging new collaborations, and with them, new ways of communicating, can slow a researcher's publication rate. But the efforts are to everyone's advantage.

Note also that cases such as the one above require editors to make a succession of challenging judgement calls. They have to decide that a multidisciplinary paper has the potential to make its case, that the authors have the capacity to rise to the standards of disciplines other than their own and that some trade-off in traditional disciplinary criteria for robustness in interpretation of the evidence might be necessary to capture the broader perspective.

Editors also have to gauge how far to push back while sustaining multiple referees' tolerance and giving authors due opportunity. They sometimes have the daunting responsibility of making the integrative call on a paper's significance (see, for example, http://doi.org/gcmfhn). It may even be the editors' duty, for a technically sound paper with unenthusiastic referees, to overrule all of them and publish it.

After all, interdisciplinary papers are challenging for referees, too. They may fail to recognize the significance of the whole because the component in their own field is not innovative. Valuable indeed is the referee who stands firm by the standards of their discipline yet is able to allow for some latitude when work is addressing a real-world challenge in a way that requires a synergy of knowledge. Such referees must be nurtured.

All that said, even well supported, well conducted, well reviewed and edited work can yield results that cannot be replicated by others, for reasons that are entirely unexpected (see, for example, G. J. Lithgow *et al. Nature* **548,** 387–388; 2017). Without attention to such possibilities by deep-diving into the relevant research, researchers who swallow whole the conclusions from another discipline are asking for trouble.

The gains from interdisciplinary research are essential, especially in addressing grand challenges such as sustainability; together we must take on the tough challenge of not being glib. ■