BATH, DRAINS AND WEB 2.0

Rod Angood
Director of Computer Services
University of Bath
UK

Abstract

This paper describes the challenge of the impact of Web 2.0 demands on data traffic by first-year students at the University of Bath, UK. A sudden increase in data demand from students living in city centre residences threatened to overwhelm the University's network. The solution was to install dark fibre through the City's waste water system which proved fast and cost-effective with very little disruption to road traffic.

The Context: The University of Bath

The University of Bath (bath.ac.uk) is located just 2 km from the World Heritage Site City of Bath (whc.unesco.org/en/list/428) on the downs that overlook the old Roman Spa city; much loved and adopted by the Georgians.

The University's own heritage and history is anchored in the disciplines of Science and Technology. Faculties now include Science, Engineering and Design, Humanities and Social Sciences and Schools of Management and Health.

The University has around 13,000 students. Around one third are studying at post-graduate level and two thirds at an undergraduate level. Around two thirds are UK students and one third come from overseas. It is a world-class research institution, with strong links to industry and enterprise and is one of the UK's top ranking universities. Current research covers a wide range of areas from developing new drugs to tackling cancer and diabetes to the quality of life in developing countries. The University also hosts a large Sports Training Village on site, includes a number of Olympic athletes amongst its students, and it is one of the UK's two top universities for sports science. It takes a particular pride in its approaches to optimising the experience of its students and to reducing its environmental impact.

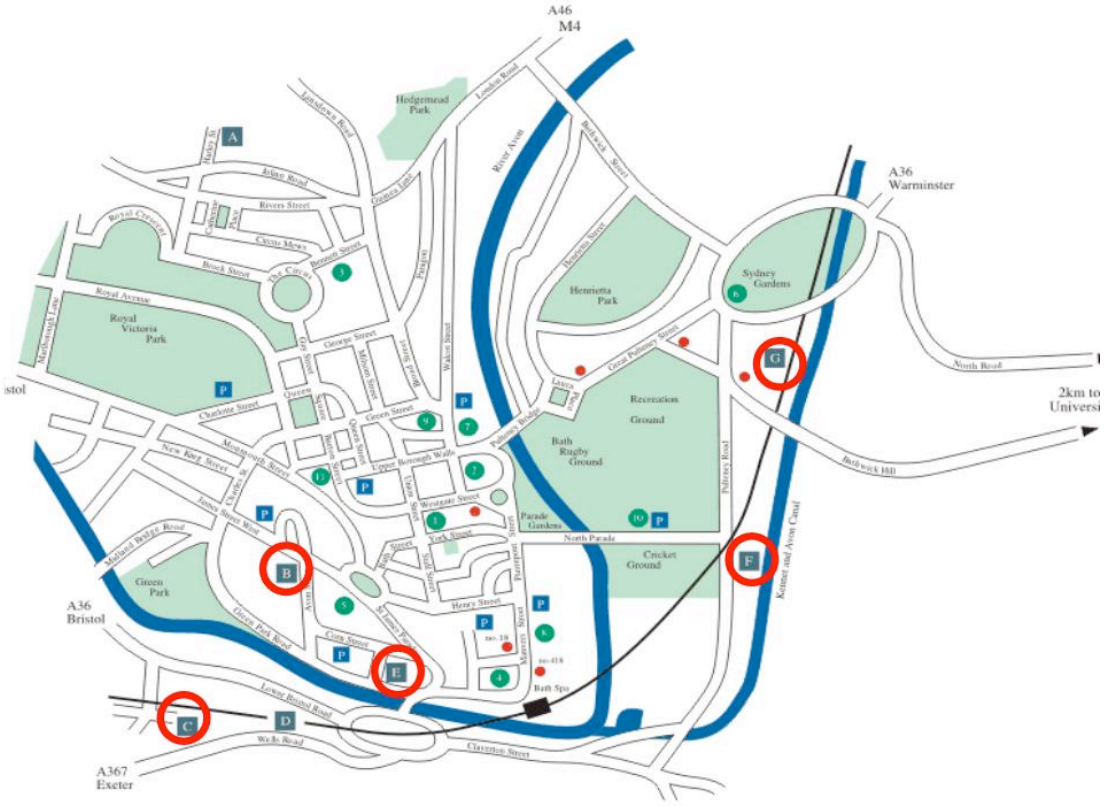
Halls of Residence

The University offers Halls of Residence accommodation to all of its new intake undergraduate students each year and provides around 3,200 rooms for student residence. The students are all of the 'Netgeneration' and most are used to personalised, social and multi-media resources (Doolan, 2007). All of these rooms

are connected to the University's network services and to the Internet and students can use their own IT equipment to connect to, and use, these services.

As well as the student accommodation on campus, the University has five Halls of Residence situated in the city of Bath, up to 4 kms from the University. Many of these accommodation centres offer in excess of 130 rooms per building, providing around one fifth of the first-year residences. Until recently these buildings were each connected back to the University's campus network through 10 M bps circuits, leased from the national telephone company.

Figure 1: Map of Bath showing residences



Linking Technology

The University of Bath is connected through the UK regional network (South West England Regional Network) to the UK national academic network (JANET).

There is significant on-campus network capacity. The campus backbone runs at 10 G bps whilst edge switches servicing buildings operate at 1 G bps/100 M bits per second. Delivery of services to individual PCs is at the minimum rate of 100 M

bits per second. The University has been a forerunner in the development of management information systems, supporting, for example, online student registration and fee payment and staff self-help for the Human Resources (HR) system. A new Finance system built around workflow modelling went live in August 2007.

All social spaces, building foyers and most of the external green areas of the campus are wireless enabled. Students can, for example, sit by the lake and access University administration and learning services. Bath was the first UK University to develop specialised Assistive Technologies for students with learning difficulties and disabilities. More recently, we completed a project providing e-lounges on campus for students and staff. The e-lounges comprise a mixture of wireless connectivity, laptop docking points and thin-client terminals, deployed in a space where visitors can take food and drink.

The Problem

In late 2006, the University's five city-based Halls of Residence became the focus of a data traffic density problem. The 10 M bit leased lines linking the city residences to campus were flooded by a remarkable, unpredicted and rather sudden increase in data traffic rates.

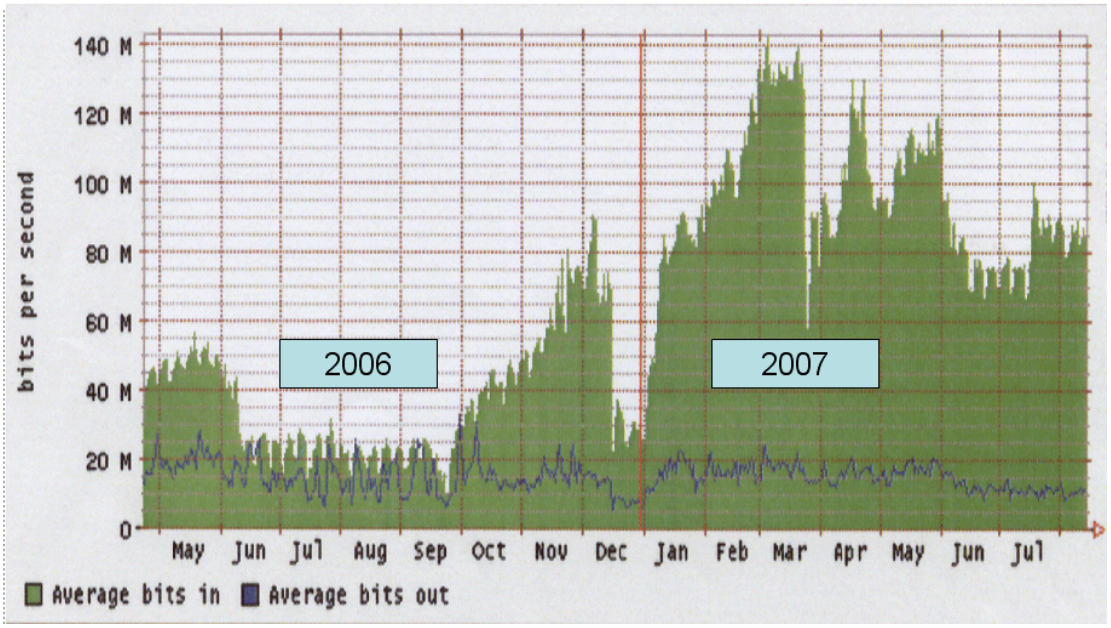
Prior to September 2006, routine incoming data traffic levels to the University varied between 20–50 M bps and the leased line connections to the buildings in the city were coping admirably with the traffic between these buildings and the campus. From the beginning of October 2006 — commensurate with the start of the new Semester — incoming data traffic levels to the University quadrupled in the space of just 5 months and then consistently remained at, or around, these higher levels.

The sudden increase in incoming data traffic was consistent with the students' accessing external (i.e., beyond the university provision) Web sites. Our investigations soon uncovered that our new student intake was exploiting Web 2.0 sites, services and applications. In particular, the students had discovered sites such as YouTube and were pulling video material from these sites back to their own PC in their university residential room for entertainment.

This needs to be put into context. This activity represented a "video-on-demand" link between the site in question and the individual students' PC which requires an uninterrupted stream of that video material to the PC. Typical download data rates for this kind of video service from such Web 2.0 sites is of the order of 200K bps/user, but can be higher, e.g., 900K bps/user for high resolution video. Given the high number of individual student rooms within the city-based Halls of

Residence (many in excess of 130), any 50 of these students in any one of the Halls downloading video on demand simultaneously would completely swamp the bandwidth capacity of the leased links that were in place at this time. We recognised that Web 2.0 applications like YouTube suit single consumerism (Harris, 2008) but take no account of the impact on data lines of multiple residences in one building.

Figure 2: Data traffic



It was evident that the University's 10M bps leased lined connections to the City locations had become swamped, as a relatively small number of students in each hall attempted to bring video on demand to their individual PCs. Other students in the same halls found it impossible to use many of the other network-borne services under this additional traffic onslaught. Combined with the traffic from on-campus locations, the overall effect additionally compromised the data transfer rate of the University's firewall and overloaded the regional network links to the JANET National network point of entry in nearby Bristol.

Complaints from students began to escalate as the various services foundered and my Directorate of Bath Computing Services came under significant pressure to resolve the problem.

Managing this new user-triggered phenomenon would either require the development of restrictive use policies or the provision of an accommodating technical response.

Preservation of our existing data links and infrastructure would have implied a need to restrict or outlaw access to Web 2.0 sites for the City-based residences**.** The University did not feel it was desirable, or even viable, to impose those kinds of restrictions on first-year students, arriving with expectations of access to Web 2.0 for entertainment, social interaction and also perhaps for informal learning. A technical response involved several interlocking elements:

- expanded capacity of the links between the City-located halls and the campus;
- expanded capacity of the links between the University and the regional network point of entry to the JANET National network;
- upgrade of the University's firewall and traffic management system;
- the provision of additional compensating services for the future that could to some extent replace the students' on-demand interests with more manageable 'multi-cast' and IP-based offerings.

The Options

Expanding the capacity of the leased lines to the City from the campus was not attractive — it was expensive and represented significant investment in a solution with no resilience or redundancy capacity without further considerable cost.

Replacing the leased lines with the University's own fibre infrastructure, however, was associated with an enormously problematic digging dimension, disruption to the City of Bath, and significant expenditure. Over recent years, many of the large Georgian properties in the City have been converted into flats and apartments which has generated a significant increase in road traffic density and attendant congestion problems. The prospect, therefore, of laying in a new fibre infrastructure and having to dig up kilometres of heritage city site roads, was unattractive and may not have received support from the City to grant way-leaves (permissions to dig up sections of the road and divert road traffic).

Both of these options were costly and generated a variety of associated problems.

As in many cities, the national telecommunication company had cornered the market in providing a network with sufficient capacity to take all existing and forecast traffic for the entire region served. This was based on the assumption that telecoms traffic, particularly data traffic, would continue to grow exponentially for

the foreseeable future. In practice, as noted above and shown in Figure 2, Web 2.0 and its appeal to younger students changed demands at a keystroke.

What was needed was a solution representing the best attributes of each of the options; the rapid expansion of needed network infrastructure capacity without the challenges and consequences of road disruption, the investment in which could be managed over a long period of time whilst providing the potential for future service and capacity development.

The Solution

The chosen option was the deployment of dark fibre, with unlimited bandwidth, through the city's sewer network. Dark fibre is optical fibre, dedicated to a single customer, and the customer is responsible for attaching the telecommunications equipment and lasers to 'light' the fibre (Shim, Lee, & Yun, 2006). Dark fibre or unlit fibre is the name given to individual fibres that have yet to be used, within ducts and conduits that have been already laid. At Bath, we chose to arrange for the fibre to be laid, 'lit' and deployed immediately.

We choose the supplier H2O© (www.h2onetworksdarkfibre.com) to provide bespoke fibre links, utilising Bath's existing underground waste water pipework system. The use of the existing sewerage network allowed for provision that was faster in terms of installation and data transport rates than either of the two options above that were rejected. It also afforded dramatically lower costs with the added bonus that the rates of leasing are a fixed cost over long periods of time, greatly easing financial planning. Not only that, but by using existing underground systems, the network proved secure and ensures business continuity, with little need to disrupt the road system.

The Outcome

Work commenced in April 2007 and was completed within 5 months. The network was up and running by the start of the academic year in September 2007. The University managed to deploy 14 km of new fibre infrastructure to the student residences and other buildings, providing a resilient dual loop connecting them all back to campus for around just 100 metres of road dig in the traffic-congested heritage site city centre. The whole package was planned, implemented and delivered in a project lasting just 6 months.

The fibre in the network is long-term leased to the University. Its unlimited bandwidth capacity provides the University with future scalability. To scale up,

we simply change the interfaces within the equipment that drives the infrastructure — we can light the fibre to almost any bandwidth rates.

We have installed dual fibre paths to all the five residential buildings in the City in a ring, connecting them, in a double loop with geographic separation. This approach provides total resilience to all buildings through either of the pathways. In this way we feel we have 'future-proofed' our student network provision, which clearly previously became 'out of date' rather suddenly and unexpectedly. On the back of this infrastructure we have deployed free television and radio channels and Voice Over IP services for all student rooms — both on and off campus.

From the start of the 2007 academic year (October), students' network access from the City Centre residences was far less restricted for all users with a fast service for accessing University sites and services as well as Web 2.0, with an overlay of new, additional services.

Adding Value

The expanded capacity of the dark fibre solution provided by H2O allowed the University of Bath to consider the delivery of additional services to the students in all halls. The University opted for Inuk's "Freewire" service that provided TV, Radio and Voice Over IP telephony services to all the rooms in every hall.

Inuk Networks© (www.inuknetworks.com) provided us with a bespoke content solution for the students in Halls, with broadcast content from a range of sources. Their content offering includes:

- Licensed re-broadcasting of UK free-to-air channels.
- Licensed delivery of UK Premium channels and on-demand content.
- Full range of licensed International channels, both free-to-air and Premium.
- Integration of existing University video content into a dedicated University TV channel.
- Digital Asset Management and Channel management for universities that need support to create or repurpose their own multi-media content.

Inuk's IPTV service; hosted from a central location, acquires the feeds, converts them to multicast streams and feeds them onto the JANET backbone. They are then delivered to Regional Networks, onto the recipient university and finally to the students' rooms. The latest advances in video codecs are incorporated into the product to ensure that the offering is of high quality at reasonably low bandwidth.

By April 2008, 66% of all students in University accommodation, including the City Centre residences, were using these services.

The students are now highly satisfied with their service and access conditions. The University no longer needs to try and impose restrictions on off-campus network traffic. All students have VOIP telephony facilities, access to 20 free TV channels and 15 free radio channels, in different languages and can subscribe to further services.

Discussion and Conclusions

For the University of Bath, installing dark fibre and immediately lighting and deploying it in the waste water system, has so far proved an excellent solution to the student demands for Web 2.0 for social, administrative and learning use, for halls of residence located in the city centre. We see it as a positive solution for the City and for the University environments, since it uses existing pipework, and is scalable in the future with no disruption to capital investment, roads and traffic.

The savings in costs are both capital and ongoing compared to the two options we rejected. Previously we found that telecoms providers suddenly increased their prices, which is difficult for universities with their tight financial controls on services to accommodate. Our chosen (Drains and Web 2.0) solution offers the stability of fixed prices, is beneficial to resource planning, and gives us more flexibility than previously.

Dark fibre deployed into existing pipework is a much lower cost option than installing new networks. The cost of installing cables is mainly due to the civil engineering works required in order to get the cables installed. Such works include planning and routing, obtaining permissions, creating ducts and channels for the cables, and finally installation and connection, and are estimated at 60% of the total cost. It therefore makes sense to plan for and install significantly more fibre than is needed for current demand, to provide for future expansion and provide for network redundancy in case any of the cables fail.

Being able to access and network University-owned and -supported buildings within a high-density, traffic-sensitive area is a major problem solved for the University of Bath and contributes to our students' online social and learning access. The dark fibre methodology can be successfully applied in any city or town with ready-made sewer ducts, making it an extremely cost-effective solution, and an environmentally sound one. The successful use of dark fibre through sewers for businesses in central London has commenced the debate of its potential for networks to domestic homes (Hadfield, 2007; Ofcom, 2008).

There remains the issue of the mixed responsibility for the equipment and the fibre itself (Gilmore, 2005). Although this is theoretically a problem, there have been no issues to date at Bath. New and emerging technologies call for new thinking. Research continues into dark fibre's potential for further deployment in Higher Education contexts (JISC, 2008).

References

Doolan, M. A. (2007). Web 2.0: Personalised learning in a dynamic multi-mode learning environment to support group-based assessment. In *Proceedings of Online Educa* (pp. 274–277). Berlin.

Gilmore, M. (2005). *Dark fibres have dark secrets.* Retrieved April 20, 2008, from http://www.fia-online.co.uk/pdf/Articles/art1005.pdf

Hadfield, W. (2007). *Newham Council targets a starring role at the Olympics with dark fibre.* Retrieved April 20, 2008, from http://www.computerweekly.com/Articles/2007/01/17/221233/newhamcouncil-targets-a-starring-role-at-the-olympics-with-dark.htm

Harris, C. (2008, February 21). *All hail dark fibre — The bandwidth saviour?* Retrieved April 20, 2008, from http://community.zdnet.co.uk/blog/0,1000000567,10007358o-2000537720b,00.htm

JISC. (2008). *Aurora Project.* Retrieved April 20, 2008, from http://www.essex.ac.uk/dces/department/news/newsletter/31_03_08.aspx

Ofcom. (2008). Retrieved April 20, 2008, from http://www.geo-uk.net/ news.html?newsid=200

Shim, Y., Lee, H., & Yun, K. (2006). The growth of Internet broadband in Sweden: Contributing factors. *Journal of Advanced Media and Communication, 1*(2), 122–138.