

<b>Institution: University of Strathclyde</b>
<b>Unit of Assessment: 10</b>
<b>Title of case study: Commercial advantage through computational discovery of dynamic communicators in large digital networks</b>
<p><b>1. Summary of the impact</b> (indicative maximum 100 words)</p> <p>Research by Higham, Estrada and Grindrod into new, computable measures for large, dynamically evolving communication networks has allowed the automatic identification of individuals who act as influencers, or efficient listeners. This research insight has been taken up by Bloom Agency (Leeds), a digital marketing and media agency. Bloom has used these ideas to strengthen their Data Insights Team, leading to investment in new jobs, generation of new business and delivery of better results for their clients. Bloom's commercially available real time social planning software product, Whisper, builds directly on the published research, and is at the heart of the agency's success in doubling staff numbers to 60 in recent months, having grown its annual income by 50% to £2.4Million through the use of these new tools.</p>
<p><b>2. Underpinning research</b> (indicative maximum 500 words)</p> <p><b>Context:</b> In 2009, collaborative research began between Desmond Higham (Strathclyde) and Peter Grindrod (Reading) on mathematical modelling and analysis of evolving networks, leading to [1]. Ernesto Estrada (Strathclyde) also became involved at an early stage [2]. The work studied a common set of players, usually representing people, whose interactions appear and disappear over time. This scenario covers time-stamped peer-to-peer communications (who phoned whom, who tweeted whom, etc.). Prior to this, published work on "evolving networks" focussed on aggregation over time, for example, where links represent friendship, and new links and nodes accumulate. However, online and digital communication is more accurately represented as a network over a fixed population where links appear and disappear over short time scales. Grindrod and Higham [1] began by developing first-principles discrete time dynamical models for these transient digital communications. This research covered stochastic evolving networks, putting forward a new theoretical framework for describing and analysing time-varying connectivity.</p> <p><b>Key Findings:</b> The research in [1] led naturally to algorithmic approaches for identifying those people who act as especially strong influencers, or as efficient listeners, within peer-to-peer networks. This issue is critical for the new media sector, where the rise of advertising spend on buzz marketing requires new ways to categorize individuals' social roles and to target influences. Similar questions also arise in security, where there is interest in agents who "punch above their weight," generating a level of influence that belies their apparent low-key status. The work co-authored by Estrada, Grindrod, Higham and Parsons (a PhD student at Reading) [2] used the ideas in [1] to propose a novel and mathematically consistent generalization of Katz centrality—a standard tool in social network analysis that identifies key players in a complex network. Katz centrality applies only to a static network, the work in [2] deals with the case of evolving networks and opens up the possibility of real-time monitoring and prediction. Time's arrow induces asymmetries for dynamical paths through evolving networks and the paper [2] defined a "communicability matrix" that summarizes the activity in order to support analysis of influence and strategic targeting. The computational building block in [2] is the solution of a sparse linear system, with sparsity determined by the underlying connectivity pattern. The methods, therefore, scale up to the Big Data setting of tens of millions of vertices. Dealing with such large scale networks is a necessary step for convincing commercial exploiters, and allowing them to evaluate the concepts and methods for their own purposes on realistic data sets.</p> <p>This work was further publicized through a two-part expository article in SIAM News [3] and has been extended by Grindrod and Higham in [4] to deal with "topicality" of information. A proof-of-principle case study co-authored with colleagues at Bloom Agency (Leeds) was refereed and accepted as a full paper for the Proceedings of Social Informatics 2012 in Lausanne (acceptance rate 35%). In this work [5] we showed that the computational techniques from [2] and [3] produce influence rankings on very large scale Twitter data that correlate strongly with the</p>

## Impact case study (REF3b)

views of social media experts. We also presented a hands-on demo, [6], where Twitter activity around the conference hashtag was analysed in real time.

### 3. References to the research (indicative maximum of six references)

References 1, 2 and 4 best exemplify the quality of the underpinning research

[1] Evolving graphs: Dynamical models, inverse problems and propagation, P. Grindrod and D. J. Higham, Proceedings of the Royal Society, Series A, 466, 2010, 753-770. **Included in REF2**

[2] Communicability across evolving networks, P. Grindrod, D. J. Higham, M. C. Parsons and E. Estrada, Physical Review E, 83, 2011, 046120.

[3] People who read this article also read.... , P. Grindrod, D. J. Higham and E. Estrada, SIAM News, 2011, Part I: January, Part II: March.

[4] A matrix iteration for summarizing dynamic networks, P. Grindrod and D. J. Higham, SIAM Review, 2013, 55, 118-128.

[5] Dynamic targeting in an online social medium, P. Laflin, A. V. Mantzaris, F. Ainley, A. Otley, P. Grindrod and D. J. Higham, Social Informatics (Proceedings of Socinfo 2012), Lecture Notes in Computer Science Volume 7710, 2012, 82-95.

[6] Demonstration of dynamic targeting in an online social medium, P. Laflin, A. V. Mantzaris, P. Grindrod, F. Ainley, A. Otley and D. J. Higham, real time demonstration at Social Informatics 2012, Lausanne.

### Evidence for quality of research

In this field Professors Estrada and Higham are world leading. Evidence for the quality of the research outputs stemming from these projects is given by the journal publications (Proc. Roy. Soc. A, Physical Review E, SIAM Review, featured article in SIAM News). Further, Higham has given invited, plenary, talks on this work at a diverse range of recent research events, including the SIAM Conference on Applied Linear Algebra (Valencia, 2012), the Heilbronn Institute/Royal Statistical Society meeting on Large Evolving Networks (Bristol 2013), the Big Data and Optimization workshop (Edinburgh, 2013), the NetSci Satellite Meeting on Temporal and Dynamic Networks (Copenhagen, 2013), Bifurcation Theory, Numerical Linear Algebra & Applications (Bath) and the Computational Linear Algebra and Optimization for the Digital Economy workshop (ICMS Edinburgh, 2013).

The work in [2, 3, 4, 5, and 6] arose from a collaborative EPSRC/RCUK Digital Economy funded project "Mathematics of Large Technological Evolving Networks (MOLTEN)", 2011-2013. This involved Higham and Estrada (Strathclyde), Grindrod (Reading) and Mascolo (Cambridge), with Strathclyde receiving £180K.

An EPSRC/Strathclyde Impact Acceleration Account/Bloom Agency funded secondment for the MOLTEN Research Assistant, Dr Alexander Mantzaris, is currently running (2013-2014). This competitively awarded £50K project involves knowledge exchange and follow-on research, based on [1-6].

Higham was awarded a Royal Society Wolfson Research Merit Award (2012-2017) on the basis of the project "Stochastic Modelling and Simulation for Interaction Networks" which builds on the track record in [1-6]. He was also awarded a 12 month Royal Society/Leverhulme Trust Fellowship for 2013-2104 to cover teaching and administration as he extends these ideas into continuous-time models and algorithms for evolving networks.

### 4. Details of the impact (indicative maximum 750 words)

The main academic collaborators, Grindrod (Reading) Estrada and Higham (both Strathclyde) made equal contributions in the co-authored publications that led to this impact.

**Impact case study (REF3b)****Process from research to impact**

Bloom is a Leeds-based digital marketing and advertising company. The Bloom Insight Team, led by Peter Laflin, came across the SIAM News article [3], which cites the Physical Review E paper [2]. After implementing the algorithms in [2] with some success, Bloom contacted Grindrod and Higham and have since engaged in a range of on-going discussions about the best way to apply the algorithms to real social media data and to deal with various practical challenges. In particular, Bloom obtained Technology Strategy Board funding in 2011 to investigate whether the concept of dynamic communicability, which was introduced in [2], can be exploited by their data analytics team. This 12 month project, entitled Digital Business Analytics for Decision Makers, had costs shared between Bloom (£64K) and TSB (£94K). The project led directly to the development of Bloom's planning tool Whisper, which includes a facility to quantify and monitor a client's current visibility and influence in the on-line digital arena.

Collaboration and knowledge exchange with Bloom has also led to a co-authored case study [5] illustrating the success of the approach, and further academic research [4] motivated by issues raised by Bloom. Higham has visited Bloom's offices on three occasions, and members of the Bloom team have visited Strathclyde a further three times. The two groups have co-presented work at two conferences (Digital Economy Annual All Hands Meeting, Aberdeen 2012 and Socinfo 2012, Lausanne). Dr Alex Mantzaris, an EPSRC-funded Research Assistant at Strathclyde from 2011-2013 is now based at Bloom, working on a 12 month joint EPSRC/Bloom funded knowledge exchange project, where further insights from the Mathematics of Large Technological Evolving Networks (MOLTEN) project are being shared. Bloom's policy is to publicize their achievements and position themselves as a leading player in digital media, working alongside cutting edge academic partners. Hence, in addition to running confidential client-driven projects, they have published a number of public domain blogs that showcase this network methodology in analysing, for example, social media activity around television and sports events.

**Types of Impact****Adoption of new data analytics tool:**

The Bloom website for Whisper [Source 1] recognizes the Strathclyde research: "In 2011, we set about building Whisper with the support of a grant from the Technology Strategy Board. Working with the Universities of Reading and Strathclyde, we have been able to implement innovative mathematical algorithms to measure how influence in social networks changes over time." The website also presents a range of topical case studies. Their website states that "Whisper uses social media data to provide a deeper understanding of your customer profile –their brand affinity, their mood, what device they're using and where they are. Whisper can track changes in your customer profile in real-time...(and) pinpoints exactly which social media profiles your brand should be following, monitoring and engaging with during a campaign, helping your brand's message to transfer to new networks as the conversation grows. .. Whisper matches your CRM database with their social media accounts. This means you can use these customers on social media to find new customers and track which accounts went on to purchase. Whisper's ability to show how, when and why a message both starts and stops having impact despite continuing tweets and retweets can help your brand to understand how messages become viral. This information can be used to accurately plan creative campaigns that achieve virality."

In a letter to Higham [Source 2], Peter Laflin, Head of Data Insight at Bloom, makes a range of points that indicate the advances that the company has achieved through the implementation of the research of Higham et al. He confirms that Whisper is the first data analytics tool that can accurately measure impact and Return on Investment from social media. He states "At the heart of Whisper is a specific implementation of your work and the measure of 'influence' is a proxy for your communicability ideas." He estimates "by the end of 2013 Bloom expects to have invested close to £200K in the research and development project around Whisper. "

Laflin explains that "A major use of Whisper is to speed up the market research cycle. By mining social data at scale, and then filtering noise through the use of influence metrics, we are able to quickly and accurately assess the "Mood, Mode and Context" of a conversation, which provides more specific and targeting information than a traditional marketing research would provide. This is

saving our clients' money, cutting the costs of conducting research to assess market conditions and dynamics.”

**Improvement in business plans and performance:** In terms of Bloom and their clients, Laflin states that “Our brand is heavily focused around having unique insight for our clients, and Whisper allows us to deliver this; in fact we changed our brand direction to include “unique insight” as a direct consequence of the success of implementing your ideas. This brand direction has been nominated for a 2013 *Drum Award for the Digital Industries* (DADI). Whisper has opened doors for Bloom; meetings with Adidas, SKY, Nestle, Perform, Peugeot, Emnos, QVC, Centre Parcs, BAT, Virgin Atlantic and ITV have all resulted from Bloom’s ability to use Whisper to uncover unique insight. These brands are becoming clients of Bloom and the reason they are converting is because the technology and insight we can provide cannot be found anywhere else in the market place. Without Whisper, Bloom would not have had the opportunity to excel in these meetings and provide a platform for delivering work on behalf of these clients. Whisper is also providing us with an opportunity to white label analytics to other marketing agencies.” Laflin summarizes the impact by saying “Without your support, or the support of the TSB, this work would never have got off the ground and Bloom would not be speaking to some of the world’s largest brands.”

The Drum, an Advertising/Marketing Trade Magazine, reported on 2 April 2013 that [Source 3] “Leeds-based digital marketing firm Bloom has grown its income to £2.4 million it has revealed, as a result of working alongside brands such as LA Fitness, Anglian Home Improvements and Infosys. The agency, which has doubled its staff numbers to around 60 in recent months, has grown its income by half, it claimed, while also released a real-time social planning tool for brands, Whisper.”

Alex Craven, chief executive of Bloom explained how placing data driven insight at the heart of the agency’s model had impacted, saying: “This change in direction has driven some significant wins for us as we become the agency of record for well-known brands. As real time, content driven campaigns continue to grow in importance for brands, we believe we are well positioned for growth over the next two years.”

**Skilled employment:** Since October 2011, Bloom has hired two mathematics graduates from the University of Leeds, in order to work on embedding the algorithms from the underpinning research [2] into Whisper. Bloom is providing £26K (matching the EPSRC/Strathclyde Impact Acceleration Account funding) to second Dr Alex Mantzaris for 12 months, and has also sponsored a CASE studentship at the University of Leeds that will develop ideas in this area.

#### **Wider recognition for the new technology:**

Bloom’s use of Whisper for Anglian Home Improvements was shortlisted at both the 2012 Some Comms Awards and the 2012 Social Buzz Awards.

Bloom staff Laflin, Ainsley and Otley also co-authored with Grindrod, Higham and Mantzaris an entry in the Royal Society 2013 Picturing Science Competition [Source 4]. Their image, titled ‘*Twitter activity: a snapshot of tweeter-follower interactions as a conversation grows*’, created with the Whisper software, was runner up in the Infographics category, and therefore went on public display at the *Summer Science Exhibition 2013* on 2-7 July in Carlton House garden, attended by Bloom representatives.

#### **5. Sources to corroborate the impact** (indicative maximum of 10 references)

1. <http://www.bloomagency.co.uk/whisper/> supports link to Strathclyde research.
2. Letter from Peter Laflin, Head of Data Insight at Bloom dated August 28, 2013 supports various claims of impact on Bloom
3. <http://www.thedrum.com/news/2013/04/02/digital-agency-bloom-sees-income-grow-24m-it-doubles-staff-numbers> supports claim of economic benefits and growth of Bloom
4. <http://blogs.royalsociety.org/inside-science/2013/07/01/picturing-science-competition-winners/> shows wider recognition for the Whisper software.