Institution: University of Strathclyde		
Unit of Assessment: B10 Mathematical Sciences		
Title of case study: Developments in digital marketing through computational analysis of dynamic social media networks.		
Period when the underpinning research was undertaken: 2009 - 2013		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Desmond Higham	Professor	01/08/1996 – 31/03/2019
Ernesto Estrada	Professor	01/10/2008 – 22/12/2017
Period when the claimed impact occurred: August 2013 – July 2020		
Is this case study continued from a case study submitted in 2014? Yes		

1. Summary of the impact

Research at the University of Strathclyde into the analysis of large, evolving communication networks enabled the automatic identification of strong influencers and listeners within networks. This research led to the launch of Whisper, a commercially available, real time social planning software product, for the digital marketing company Bloom. Since August 2013, Whisper-related sales continued to grow for Bloom through high profile customers including Sky, Virgin Atlantic and ITV. In 2016, Bloom was acquired by Jaywing PLC, a UK-based digital marketing and advertising company, for GBP8,700,000. Whisper is a leading edge technology product for Jaywing and has been used to help major companies revolutionise the way they analyse and connect with target markets through social media platforms.

2. Underpinning research

Context

In 2009, collaborative research began between Desmond Higham (Strathclyde) and Peter Grindrod (Reading) on mathematical modelling and analysis of evolving networks. They were soon joined by Ernesto Estrada (Strathclyde). Together, their work studied a common set of players within a communication network, usually representing people, whose interactions appear and disappear over time from the network. This scenario covers time-stamped peer-to-peer communications, such as who phoned whom, or who tweeted whom. Previously, published work on evolving networks focussed on aggregation over time, such as the study of the accumulation of new links (representing friendships) and nodes. 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.

Key Findings

Grindrod and Higham began by developing first-principles discrete time dynamical models for these transient digital communications [**R1**]. This research covered stochastic evolving networks, putting forward a new theoretical framework for describing and analysing time-varying connectivity.

This research 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 categorise individuals' social roles and to target influencers. Similar situations also arise in security, where there is interest in members of criminal networks 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) [R2] used the ideas in [R1] to propose a novel and mathematically consistent generalisation 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, whereas the work in [R2] 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 [R2] defined a 'communicability matrix' that summarises the activity in order to support analysis of influence and strategic targeting.

The computational building block in [R2] 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. This work was further publicised through a two-part expository article in SIAM News [R3] and then extended by Grindrod and Higham to deal with 'topicality' of information [R4].

A proof-of-principle case study, co-authored with colleagues at Bloom Agency, was refereed and accepted as a full paper for the Proceedings of Social Informatics 2012 in Lausanne (acceptance rate 35%) [R5]. In this work the authors showed that the computational techniques from [R2] and [R3] produce influence rankings on very large scale Twitter data that correlate strongly with the views of social media experts. The authors also presented a hands-on demo where Twitter activity around the conference hashtag was analysed in real time [R5].

3. References to the research (Strathclyde affiliated authors in **bold**)

R1 P. Grindrod and **D. Higham** (2009), Evolving graphs: Dynamical models, inverse problems and propagation, *Proceedings of the Royal Society, Series A* 466: 753-770. https://doi.org/10.1098/rspa.2009.0456

R2 P. Grindrod, **D. Higham**, M. Parsons and **E. Estrada** (2011) Communicability across evolving networks, *Physical Review E,* 83: 046120. https://doi.org/10.1103/PhysRevE.83.046120

R3 **D. Higham**, P. Grindrod and **E. Estrada** (2011) People who read this article also read...: Part 1, *SIAM News,* 44(1) January/February https://archive.siam.org/news/news.php?id=1861 People who read this article also read...: Part 2, *SIAM News,* 44(2) March https://archive.siam.org/news/news.php?id=1869

R4 P. Grindrod and **D. Higham** (2013) A matrix iteration for dynamic network summaries, *SIAM Review,* 55(1): 118-128 https://doi.org/10.1137/110855715 [available from HEI on request]

R5 P. Laflin, **A. Mantzaris**, F. Ainley, A. Otley, P. Grindrod and **D. Higham** (2012) Dynamic targeting in an online social medium, in K. Aberer, A. Flache, W. Jager, L. Liu, J. Tang, C. Guéret (eds) *Social Informatics* (Proceedings of SocInfo 2012), Lecture Notes in Computer Science 7710: 82-95 http://doi.org/10.1007/978-3-642-35386-4_7. Presented and followed by a live demonstration, reported in P. Laflin, F. Ainley, A. Otley, **A. Mantzaris**, **D. Higham** (2012) Demonstration of Dynamic Targeting in an Online Social Medium, Aberer et al., *Social Informatics* (Proceedings of SocInfo 2012), Lecture Notes in Computer Science 7710: 539-542 https://doi.org/10.1007/978-3-642-35386-4_41

Notes on the quality of research: All articles except R3 are published in peer-reviewed journals. The research received funding via competitively-awarded grants worth GBP230,000: Higham (PI), 'Mathematics of Large Technological Evolving Networks (MOLTEN)', EPSRC, 24/01/2011-31/03/2013, GBP180,000; secondment of Research Assistant Dr Alexander Mantzaris, funded from MOLTEN, Strathclyde Impact Acceleration Account and Bloom Agency, 2013-2014, GBP50,000. In addition, 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 R1-R5. This work was also a key element of Higham's successful application to EPSRC/Digital Economy Programme for an Established Career Fellowship in Data Analytics for Future Cities (2015-2019).

4. Details of the impact

The algorithms developed by Higham and Estrada were used by digital marketing company Bloom to develop the product Whisper to analyse large scale social media data for commercial insight. Whisper was used by Bloom to provide insights for a range of clients, including well-known companies Sky and Domino's, and it formed an essential part of Bloom's offering when Bloom was acquired by Jaywing plc for GBP8,700,000. Whisper formed one of Jaywing's three core products at the time and the acquisition enabled Jaywing to bring a suite of AI applications to their offering. Jaywing went on to use Whisper to provide deep market insights for high-profile clients such as Twitter. Whisper has thus helped to transform marketing methods from traditional media to the powerful and increasing use of social media platforms.

From research to impact: development of Whisper by Bloom

Before August 2013, Bloom, a Leeds-based digital marketing and advertising company, contacted Higham and Grindrod on the basis of the above underpinning research. Discussions about the best way to apply the algorithms to real social media data, including a joint demonstration of them at a public conference [**R5**], and how to deal with various practical challenges, led directly to the development and launch of Bloom's planning tool Whisper. According to the Chief Data Scientist at Jaywing (previously employed by Bloom), *'the motivation for our work, and the key to its efficient implementation on large scale data sets, has come directly from the methodology and algebraic framework set out in your papers. I also note that the relevant research groups at Strathclyde and Oxford met with us several times over the years in order to exchange ideas and to makes sure that the novel ideas in the Physical Review E paper* [**R2**] *are fully exploited'*. Outlining the details he explains: *'The algorithms within the Whisper platform apply the "communicability-like ideas" from your Physical Review E paper to the underlying graph structure to identify actors in the social media network that are of interest to advertisers. In short, this gives useful and actionable low-dimensional summaries of vast data sets. Our validations, which we have published with you…show that the automated algorithm gives results that are comparable with those of our in-house social media experts. Of course, the algorithm, which relies on sparse linear algebra computations, scales up to the massive, fast moving data sets of commercial interest that are out of the reach of manual curation'* [**S1**]. Reflecting on the significance of this applicability to large-scale data sets for commercial application, Bloom's Chief Data Scientist concludes that it has been *'revolutionary for Bloom and now for Jaywing'* [**S1**].

Whisper is able to quantify and monitor a client's current visibility and influence in the online digital arena, and is the first data analytics tool that can accurately measure impact and return on investment from social media. These features allow users to mine social data at scale and filter out noise through the use of influence metrics, thereby speeding up the market research cycle. It also provides users with more specific and targeted information than traditional marketing research would provide.

Company performance: use of Whisper by Bloom

Having launched the tool in 2012, between August 2013 and September 2016 Bloom *'used Whisper with many internationally recognized brands, such as Anytime Fitness, Sky, the Premier League, Virgin Atlantic, ITV, the X Factor, Lego, Domino's, Yorkshire Tea and Center Parcs'*, to help them *'understand the audience that interacts with their content and their products and services'* [**S1**]. Specifically, it enabled them to '*identify the influential individuals and the types of content they find most useful'* in order to *'identify opportunities to shape future advertising and marketing campaigns'* for clients [**S1**].

Company performance: Acquisition of Bloom by Jaywing and their use of Whisper

In September 2016, Bloom was acquired by Jaywing plc (a business specialising in data science, marketing and risk consultancy) for GBP8,700,000 [**S1**]. As noted in Jaywing's 2017 Annual Report, Bloom was one of two acquisitions that year which *'provided the business with a dedicated Marketing Technology division and the first step in our international expansion'* [**S2** p.7]. Affirming this, Jaywing's Chief Data Scientist acknowledges that *'a significant factor in the acquisition of*

Bloom by Jaywing was the strength of the technology offered by Bloom, of which Whisper was a fundamental part' which *'demonstrates the significant value developed within the Bloom business through the Whisper technology'* [**S1**]. According to the CEO of Jaywing, the acquisition of Bloom enabled the company to *'bring a set of genuine applications of Artificial Intelligence formally to the market'* and be *'amongst the first to market in our field'* at a time when *'Artificial Intelligence is much vaunted and much discussed…but with precious few delivering on its promise'* [**S3**].

Bringing considerable competitive advantage, the acquisition of Bloom has created economic benefits for both Bloom and Jaywing. Commenting on this in 2017, the Bloom and Jaywing Intelligence Managing Director observed: *'We have seen a flurry of new account wins since our acquisition by Jaywing Plc last year. Our development and adoption of advanced data science into our creative and digital marketing services continues to gain traction with brands in the UK and Australia, including DW Sports and Fitness, Leeds Trinity University and Parklane Group'* [**S4**]. This contributed to Jaywing achieving a top 10 position in Econsultancy's 2019 list of the top 100 digital agencies having generated GBP30,005,619 in UK fee income from digital between 1 September 2017 to 31 August 2018 (building on the success of the previous year which brought in GBP29,521,045) [**S5** pp.32]. Reporting on this, Jaywing highlighted how *'Whisper, our social intelligence tool, has provided ground-breaking research for clients including Twitter'* [**S6**]. This has been achieved by using Whisper alongside the traditional media expertise of Epiphany, a UK PR and communications specialist acquired by Jaywing in 2014, to help clients strengthen their brand presence and digital performance through digital PR.

Users benefits of Whisper via advanced social media marketing methods

In addition to generating business for Bloom and Jaywing, projects utilising Whisper have brought substantial benefits to their clients. Illustrative examples relating to Sky Sports, the Premier League, Twitter, Jewson, Domino's, Anytime Fitness and ADT Fire and Security are detailed below.

Sky Sports and the UK Premier League

Responding to pressure from its competitors, particularly BT Sport who had claimed the rights to air the UK Champions League Football, in 2015 Sky Sports commissioned Bloom to undertake analysis to inform a social media campaign to boost its profile amongst football fans. As outlined in a Jaywing case study, by analysing more than 80 million tweets over a two-month period, Bloom was *'able to visualise how the different football-related communities were connected and who was influential in sharing content and messages between them'* [**S7**]. This insight told them that *'focusing the creative campaign on 'moments' in Premier League history would resonate most with fans'*, enabling them *'to pinpoint the moments most likely to be shared socially'* and provide *'Sky with a list of major influencers and a strategy for how best to engage with them'* [**S7**]. This led to the development of the #PLMoments campaign and creation of an advert which went viral as soon as it was launched on Facebook thanks to the influencers who had been identified through the Whisper analysis. The case study highlights the significance of this for Sky Sports: *'Within the first hour of the video going live it gained over one million views. It also topped the Campaign Viral Chart and has had a total of well over 25 million views. It was the 4th most viewed video of any kind on the internet during its first week and @skysports was the most influential brand on social media during the Premier League weekend'* [**S7**]. Such was the success of this project that it netted Bloom a Social Media Buzz award in 2015 and was highlighted in reports of Jaywing's acquisition of Bloom, with one article explaining that *'Whisper is the intelligence behind Sky Sport's Premier League advert featuring Thierry Henry and iconic moments from Premier League football'* [**S8**].

Twitter UK

In 2019, Jaywing worked with Twitter to help understand Twitter's UK audience in terms of their motivations and how brands can engage with them. This was the first study undertaken by Twitter to understand its audience in the UK. Analysis using Whisper identified 75 sub-communities, with in-depth studies conducted for Music, Health, Football and Gaming and demonstrated the role that Twitter plays within each community and how brands can best get involved with them, such as through providing help and support (such as backing artists). For example, the analysis enabled one particular international brand to target its conversation about gender equality (through use of

the #EqualisingMusic hashtag) to very specific events [S9]. Commenting on this work, the Chief Executive of Jaywing observed, *'this has been a fascinating project to work on, and the perfect brief for Jaywing to answer using our social intelligence tool, Whisper. We've been able to draw on our expertise of analysing conversations on Twitter for over five years to create a brand new methodology to find and categorise communities, and at the same time push the boundaries of data science capabilities'* [S9]. Stressing the importance of this to Twitter, the Managing Director of Twitter UK noted: *'Ten years ago, everything was about followers, virality and engagement. The digital media landscape has radically changed and we needed to rediscover Twitter's unique purpose… We needed to become true experts in our audience and know them better than anyone. This research has allowed us to do that'* [S9].

Jewson, Domino's, Anytime Fitness and ADT Fire and Security

Other projects which demonstrate the range of business benefits achieved through the application of Whisper include an assessment of Jewson's Public Relations position following an accusation of timber laundering by Greenpeace in 2014. Whisper analysis of social media conversations underpinned advice to the Jewson board which informed its response to the issue. As summed up in a Jaywing case study: *'Clear insight informed the right business decisions, which led to protecting the brand reputation and the share price of this FTSE business'* [S10]. In the same year, Whisper guided investment decisions taken by the pizza company Domino's by providing analysis which validated the value of the company's sponsorship of ITV's television show X Factor [S8]. By identifying new business opportunities, Whisper also benefitted Anytime Fitness (an Australian company with clubs worldwide) which, according to a report by Jaywing's Intelligence Managing Director in November 2017, *'saw a 50% uplift in performance, with the system using open data, competitor insight and machine learning techniques to identify potential new locations for its gym franchise'* [S4]. Likewise, ADT Fire and Security *'witnessed a 30% uplift in performance, after it started using AI for pay per click bid management'* [S4].

Market transformation

The above examples demonstrate that, in addition to generating business for Bloom and Jaywing, Whisper has helped to transform marketing methods from traditional media to the powerful use of social media platforms through state-of-the-art data analysis of social media data. The underpinning research addresses phenomena critical for the emerging social media sector, where the rise of advertising spend on buzz marketing requires new ways to categorise individuals' social roles and to target influences.

5. Sources to corroborate the impact

S1 Factual statement from Chief Data Scientist, Jaywing Intelligence, dated 11 January 2019.

S2 Jaywing plc, Annual Report & Accounts for the year ended 31 March 2017, p.7.

S3 Jaywing plc, 'Jaywing plc announces launch of marketing tech powered by AI: Jaywing Intelligence' [online], 16 May 2017.

S4 Stephen Chapman, 'Bloom uses Artificial Intelligence to deliver "record Sales"', *Prolific North* [online], 24 November 2017.

S5 Econsultancy (2019) Top 100 Digital Agencies 2019 Report, pp.32,35,39,48].

S6 Jaywing plc, 'Top 20 position in Econsultancy's Top 100 of 2019' [online], 22 October 2019.

S7 Jaywing plc, 'How listening to and analysing social network data created "the greatest thing in the history of the universe"' [online], no date.

S8 Nick Hill, 'Jaywing acquires Leeds-based digital agency Bloom in £2.41m deal', Bdaily, 1 September 2016.

S9 Gordon Macmillan (Head of Editorial, Twitter), 'Twitter unveils groundbreaking study into its audience', Twitter Blog, 5 September 2019 and Twitter Marketing, 4 October 2019.

S10 Jaywing PLC, 'Case study: Jewson', no date (with Greenpeace article dating it to 2014).