Where code acts: passionate imitation, infrastructures and making programming work

Abstract

Some of the recent changes in the writing and circulation of code can be seen in the 'largest code repository on the planet,' GitHub.com. What can we learn from the 13.2 million code repositories on Github.com about where code is acting in the world? This paper suggests that this almost incomprehensible and methodologically daunting number of coding projects should not be understood so much as 'software takes command' of culture, business or power, but more in terms of a crowd sociology. A crowd sociology of coding would look at the ways in which imitation, repetition, and style of expression and abstraction animate code. In other words, how do the 13.2 million repositories attest not so much to the crowd-sourcing of code but to the crowd dynamics of coding today?

Introduction: centres, rules and indeterminacies

SLIDE Introduction -- centres, rules and indeterminacies

What has happened since I wrote *Cutting Code* ten years ago: a disconnected and somewhat decentred world of code production has turned into a highly networked and quite centralised set of practices at one level. The lone figure of the programmer or the highly organised software development team still exist, but the milieu in which they operate has changed greatly. At the same time, the networking of coding, or the transformation of coding into a social media practice, and the growth of social media platforms based on code means that in making sense of code, we face many of the problems that people who analyse network cultures more generally encounter.

Many accounts of code still assume that code is a relatively homogeneous cultural or social space, somehow clean, orderly and predictable like a high-tech factory. Much of the recent work on code focuses on algorithms, and it turns to accord algorithms an almost transcendental power to act in the world, to shape conduct or to order what people do. Much of the current interest in code, and getting people to code flows from this view or relation to code. The French sociologist

Pierre Bourdieu describes how this affect of dazzlement or awe in front of ostensibly powerful or even transcendent scientific objects occurs:

SLIDE experience of code objects

> The experience of the transcendence of scientific objects, especially mathematical ones, that essentialist theories invoke is the particular form of *illusio* which arises in the relationship between agents possessing the habitus socially required by the field and symbolic systems capable of imposing their demands on those who perceive them and operate them, and endowed with an autonomy closely linked to that of the field (which explains why the sense of transcendent necessity rises with the capital of accumulated resources and the qualifications demanded for entry) (Bourdieu 2000, 113–114).

There is much to unpack here and I won't spend too much time doing that. But I like the talk of habitus here, as well as the demands imposed by a symbolic system endowed with a certain autonomy. It seems that those demands are voiced in the efforts to get people to code and to present coding as the solution to various economical and cultural problems (to do with economic development,etc). In the humanities and social sciences, there is also an awful lot of talk about code as abstract machine, and in terms of abstraction. I'm not against that, as certain processes of abstraction are definitely operationally important to code, but I'm not sure that abstraction can help us understand what changes in code. If we respond only to the experience of transcendence or power, then we might miss the dynamics that constitute that power-transcendent effect

TBA: sketch the project that this comes from -- attempt to embrace the 13.2 million repos on Github without picking and choosing, or showcasing examples since that is likely to miss the key points. Many methodological and substantive issues here, but a key one is how we experience code. This paper is part of ongoing attempts to grasp things at the platform level, and to think what that might mean for social theory.

> The initial step can be made through the venerable geographical act of mapping the expanding realm of machinekind, clearly part of the remaining terra incognita. (Horvath 1974, 188)

SLIDE Thrift on software:from 3 geographies -- cities, conduct of conduct, new kinds of order

SLIDE Thrift on contemporary cities and the sixfold characterisation

Writing in 2002, Nigel Thrift and Shaun French asked: 'is there any way of making a more general assessment of software in the city?' (Thrift and French 2002, 314). They sketch some possibilities, ranging from hegemony to haunting:

> It would be easy at this point to fall back on some familiar notions to describe software's grip on spaces like cities. One would be hegemony. But that notion suggests a purposeful project, whilst software consists of numerous projects cycling through and continually being rewritten in code. Another notion would be haunting. But again the notion is not quite the right one. Ghosts are ethereal presences, phantoms that are only half- there, which usually obtain their effects by stirring up emotions – of fear, angst, regret, and the like (Thrift and French 2002, 311–312).

Their own empirical response to the question begins with the Y2K bug, and the long lists of software potentially affected by it: keypad locks, pagers, solar panels, smoke detectors, camcorders, VCRs, elevators. Although these lists now look dated, when a similar listing would include so many things that didn't exist in 2002, Thrift and French's description of the effect of software development on urban space remains recognisable: 'we will exist in a broadband world in which the internet will be a permanently available ‘cloud’ of information able to be called up through a number of appliances scattered through the environment. These appliances will be something more than portals for information. Rather, like many other devices which will not have internet connections, they will be "practice-aware"' (315) and 'will, through a process of cultural absorption into practices, sink down from the representational into the non-representational world, so becoming a part of a taken-for-granted set of passions and skills' (318). The fact that these developments more than a decade later are still very much in train suggests that there is something quite predictable about the development of software and coding in organising urban life and spaces.

What of the more general analysis of software in the city that Thrift and French propose on the basis of the continually cycling and rewriting of code? In 2002 they listed three geographies that were driving code into cities: a geography of *writing code*, a geography of *power and control*, and a geography of *indeterminancy.*

> The first of these geographies is the most obvious, the large and complex geography of the writing of software – of the production of lines of code – a geography that takes in many different locations and many different languages and which has been built up progressively since the invention of programming in the 1940s (Thrift and French 2002, 323).

According to Thrift and French, the geography of software writing clusters around key places and regions: Silicon Valley, New York, London, and a number of auxiliary software mass production zones (often concentrating on tasks like consulting, testing and support) in countries like Ireland and India. China, Russia and Brazil are not mentioned. Second, a geography of power, which they conceived in Foucaultean terms as the conduct of conduct, or massive proliferation of corporeally practiced rules, was unfurling through software: 'in essence, we can say that it [software] consists of rules of conduct able to be applied to determinate situations' (Thrift and French 2002, 325). Through power-geography, software increasingly interlinks rather than compartmentalises urban processes. (Again, the ongoing growth of data analytics, virtualizing computing infrastructures, social media, mobile apps and sensors is largely consistent with this analysis of power.) The final geography is the most open and the least geographically localised:

> the general profusion of software, its increasing complexity and consequent emergent properties, all count as means of producing playful idioms that have not been captured by dominant orders. Software's very indeterminacy and lack of closure provide a means of creating new kinds of order (328).

These playful idioms are largely irreducible to the centres of coding or power-laden control situations, and therefore will take on singular forms, unexpected locations and non-representational aspects. Where does the geography of indeterminacy take shape? Against various attempts to see software and code as either hegemonic, as law, as an epochal shift, as what has always haunted writing, or as the epitome of the post-human technics, Thrift and French sketched the phenomenality of code as a form of traffic:

> Software is more like a kind of traffic between beings, wherein one sees, so to speak, the effects of the relationship. What transpires becomes reified in actions, body stances, general anticipations. We would argue, then, that software is best thought of as a kind of absorption, an expectation of what will turn up in the everyday world.(Thrift and French 2002, 312)

These formulations are the most elliptical in the paper. But the 'traffic between beings' they refer

to here, the reification of 'general anticipations,' the curiously contrasting descriptions of software as absorption *and* expectation could be seen as implicitly urban. They concern 'traffic' and 'the everyday world.'

More than a decade later, when we think about software in ways that apprehends both its power-laden capacity to format lives, experience, space and time, and at the same time, sees software as itself a multiplicity, with its own becomings, differences, and changes, do these geographies help us understand coded cities? Writing in 2014, Thrift again asks about code in the city:

> Take just the case of coded cities understood as a whole. Should we think of them simply as projections of an autistic capitalist power in which all consequences are externalized? Should we think of them as entities gathered around matters of prescribed concern and uninterested in much that lies outside them? Should we see them as tied into a kind of ethic of care by the need to roll over systems which demand resilience? Should we see them as having an increasingly involved dream life, based on projection and retrojection of all the searches, blogs and tweets that are continually being generated? Should we see them as geometric beings, born out of constant requests for navigation? Should we see them as the result of newly found abilities to represent arising out of advances in visualization? There is no set format or single cause but what is clear is that it is increasingly possible for these entities to learn – in however a limited way – to transform themselves, to author themselves either through emergent tendencies arising out of complexity or through simple happenstance which places them in unexpected situations which require adaptation. (Thrift 2014, 13)

Thrift maps out an almost psychedelic sixfold topography of the 'coded city' -- as externalization of capitalist power, as prescribed matter of concern, as care-laden responses to the demand for resilience, a projected-retrojected dream life, as navigational geometry, and as materialized visualisation. And then suggests that something links this diversity: the possibility for 'these entities to learn ... to transform themselves.' Echoing the 2001 discussion of indeterminacy, he attributes this possibility to 'emergent tendencies arising out of complexity' or 'unexpected situations which require adaptation.'

Although I like the sixfold evocation of the coded-city, I don't find emergence or adaptation in general satisfying explanations of transformation. The 2001 formulations on indeterminacy and 'traffic in beings' occasioned by cycling and rewriting codes appear more promising to me because they suggest both the growth in code and the possibility of empirically tracing some forms of movement. I therefore propose that we understand coded cities' 'capacity to learn' most

immediately in terms of *traffic in code.* The 'authoring,' the 'learning', and the transformations should not only be traceable in code, but coding itself is one place where externalizations, matters of concern, geometries, projections, visualizations, resilience-care, etc. come together and affect each other.

SLIDE Thrift on traffic in beings; Knorr-Cetina and Tarde

- Tarde on crowd theory - co-adaptation of imitative fluxes; more like the way that crowds build. In a way, this is what is happening in the injunction to code -- following the crowd is the norm around code -[TBA]
- add text on K-C to this slide: the object of absorption -- not just crowd understood as social-psychological phenomena, but as deriving from a certain identification with and absorption in objects, in things, in infrastructural worlds. The geekiness of code, it's fascination with seemingly trivial or intricate differences and minute details is the symptom of this absorption in the world. But rather than being seen as a reduction of the world to something inanimate, or fetishised or inhuman, I think we can see in contemporary coding the signs of a little recognised but important form of sociality. [TBA]

Exploring the code traffic entails a theoretical move and a theory of movement. The theoretical move is understand the 'traffic between beings' as moving and mixing along various paths (such as those described by Thrift in 2014: projection, geometry, matters of concern, care-resilience, externalization, visualization, etc.) through processes of *imitation*. I'm drawing on crowd sociology, including the work of Gabriele Tarde and Robert E. Park, as a theory of imitative movement. For both Tarde the microsociologist of crowds and Park the urban sociologist, imitation is a tremendously powerful shaping force that semi-consciously effects repetition and invention, and generates new social forms of various kinds (Borch 2012, 58, 144). In particular, Tarde speaks of 'coadaptation of imitative fluxes, a cooperation, even in an individual brain, but always a multitude of agents social and infinitesimal, and their ordinary ideas' (Tarde 1902, 270). While there is much to discuss here (for instance, Tarde's political conservatism and anachronism poses analytical problems), the 'coadaptation' of imitations in combination with a multitude of infinitesimal agents, beneath and around individuals, suggests some ways of tracking tendencies

in code. Examining patterns of imitation in code moves the emphasis away from code-shaping-cities to code-as-crowd. In the code-crowd, imitation is not just follow-the-leader, although this is quite prevalent, but also mutual shaping of imitative fluxes running between people and machines in places.[1]

To treat *code-as-crowd* is not to deny the production and power geographies of code. It is not to say that code does not still act on cities, on space, on public and private practices. High profile and much discussed changes taking place in computational platforms (mobile devices, cloud, etc) and in algorithmic processes (machine learning) intricately reorganise urban life. What transpires there is rapidly reified in actions, body stances, etc. But it might also be worth seeing how cities, with their massive centralising tendencies, with their sometime globe-spanning relationalities, with their density of infrastructures, with their high rates of reconstruction and repair, and above all with their affective-practical-epidemiological contagions *crowd* into contemporary software. We would, from this standpoint, no longer concentrate on following how software, code and algorithms emanate from global centres as hypervisory control structures reorganizing cities. Furthermore, we would no longer focus on isolated pieces of code, systems or applications but on the transverse flows that change how code itself moves and takes shape. We would apprehend coding itself as something closer to pedestrian and vehicle movements in a busy street. That is to say, we might attempt to see software and code as noisy, crowded, propagating aggregates in which juxtapositions, proximities and patterns of imitation multiply through each other, or *convolve*. To see code-as-crowd might bring us a few steps closer to the traffic in beings that transforms itself. The practical paths that opens out from seeing code-as-crowd concerns what we should look in studying software and code. If code is a kind of traffic between beings, if is not only a community but a *metacommunity,* not only an ecology but a crowd, then we need to find places where shape-shifting crowds assemble in code.[2]

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1 This, I should note, is a departure from most crowd theory, crowd psychology and crowd sociology. In most cases, objects hardly figure at all. As I will sketch below, points of identification occurs between systems, platforms, protocols and patterns just as much as between individuals.

2 I'm not going to discuss this in any great detail here as this would require a lengthy methodological digression. In what follows, however, various elements of a different kind of research practice in software-code as relational traffic, or code-as-crowd, are in play, and they draw on various code and data infrastructures ranging from the APIs, cloud analytics platforms such as Google BigQuery, newer forms of database and interactive data analysis environments such as `ipython` and `R`.

From crowd-sourcing to source-code crowding: `git` as code traffic

We can glimpse some of the traffic in code via source code repositories. A huge number of code repositories (possibly around 50 million) are now hosted publicly online at code repository sites such as GitHub.com, Bitbucket.com, code.google.com and SourceForge.com. Focusing on one of these repository hosting platforms -- GitHub.com, allegedly the 'largest code repository on planet' -- might be a way to begin to find a way of beginning to see traffic in code, and to track how co-adaptive, infinitesimal fluxes flow.[3] The name 'GitHub' embodies a tension. `git`, an English word for a male person who acts foolishly or annoyingly, was chosen by Linus Torvalds in 2005 as the name for a new concurrent versioning system for source code, the written texts on which nearly all software development pivots. In 2002, Torvald's work on GNU/Linux epitomised for many people the emergent power of open source collaboration -- 'crowd-sourcing' -- on the internet to build things outside the geographies of the software industry. (But even then, as Thrift and French observed, Linux was a quite centralised hierarchically and industry-supported software project). In turn, `git` is a piece of software, a revision control system for code that allows incremental changes made by many people working a common software project to either coexist or flow together. `git` is today probably the most widely used revision control system for code, followed by the interestingly named `subversion`. `git` was meant to be radically de-centralised in the sense that no particular instance of a git repository would be the 'master.' 'Local' and 'remote' repositories matter to `git` but their differences are only relative. Your local git repository is my remote. And my local git repository is your remote. In principle, a decentralized network of repositories 'push' and 'pull' code to each other. Different repositories would clone and branch off from each other, and occasionally would merge again, but not necessarily. The geography of coding becomes less aligned to individual developers in specific times places and times, and more open to a range of different styles of code movement, ranging from a miasma of micro-projects through to vast hierarchical code contortions. In practice, a whole series of converging and diverging movements of cloning, forking, pulling, pushing, requesting, branching and merging comes out of `git`. These movements, while certainly not unique or unprecedented in the history of inscriptive techniques, occur on a variety of scales. For

3 It might also be a way of undermining the over emphasis on algorithms that blocks light, I would suggest, on the richer cultural and social traffic in code forms.

instance, some `git` commands replicate whole bodies of code, while others simply add, remove or alter small bits of code. These scale-variations, I would suggest, matter to the flows of imitation that occur. Movements of code can take place very incrementally, as small bits of code move around and they can take place on a large-scale as whole bodies of code travel between different bits of software. `git` as a contemporary site of coding merits much more empirical description than this, but for the present purposes `git` represents the distributed cycling and re-writing traffic in code.

SLIDE Git as code traffic

Since late 2007, GitHub has provided a hosting platform for many git repositories. Obviously the name 'GitHub' adds a 'hub' to the de-centred flows of `git`. Given the multiplying scales of code traffic, what do the large code repository platforms like GitHub add? From the perspective of the `git` software, GitHub is just another remote code repository. But given that many, in fact around 13 million, local `git` repositories have GitHub.com as their remote repository, then GitHub becomes a hub for `git`. The network and code traffic that now runs through GitHub is on the scale of a mid-size social media platform. That is, with 13 million repositories, 6 million developers, and around 250 million events in the public event stream, GitHub itself is a kind of code city. It expresses something of the coded city, and the six-fold tendencies we discussed above should be legible there in various combinations.

In a way, this hubness of Github exemplifies the transformations of coding that I'm describing over the last decade or so. When coding itself, which was always a social practice is reorganised as a platform-based activity, then event attempts to de-center or to radically democraticise it can end up generating new forms of centralisation and control.

`git` in code-cities

In the spirit of `git`, GitHub.com as a platform, and indeed as a *social media* platform for coding, promises a radically de-centered patterning of movement. Several hundred GitHub staff are scattered across a dozen or so countries, a somewhat dispersed geography for a relatively specialised software company started in 2007 in San Francisco. GitHub work life is also

putatively non-hierarchical, with no management hierarchy, only a `git`-like structure of fluid teams working on projects. In principal, GitHub itself therefore makes itself into something like a crowd or a swarm.[4] GitHub as a social media platform adds many layers of social media-style interface to code repositories, which by tradition have been rather austere almost Reformation-style architectures. That is, they adorn code repositories with all the social media-style apparatus of following, watching, liking, and tagging. So the social life of code repositories is formatted much more in terms of watchers and followers in the same way that messages on Twitter or pages on Facebook are watched and followed. Imitation and suggestion are very much the modus-operandi of coding on GitHub.

SLIDE Github as growing code traffic

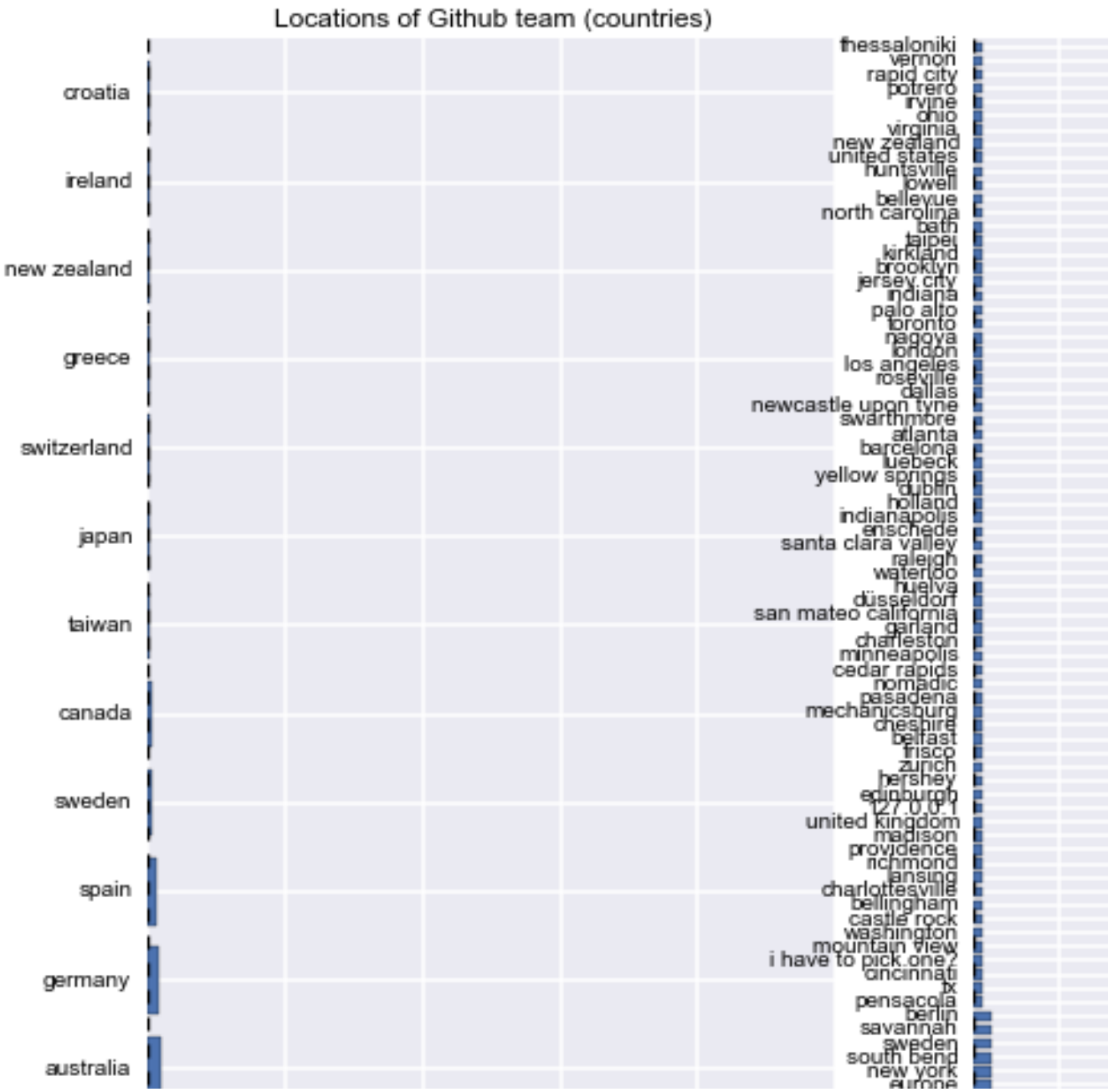
How would a social media platform affect the traffic in beings or the cycling-rewriting practices of coding? If we look at the 233 staff listed as the GitHub team, there is some evidence of their crowd-networked existence as they write code to socially network coding. Hubbernauts such as `defunkt`, `mojombo` or `technoweenie` have thousands of followers and hundreds of repos (i.e. repositories) to their names. Some of their repositories are heavily *forked* (copied), suggesting that 'passionate imitation' occurs around their code. Precisely what is being followed here requires more detailed investigation, but these several hundred team members all use GitHub itself to do their work on building GitHub. So the hub-ness or centrality of GitHub is something to be produced or made via a combination of geography, rules of conduct and new forms of order. As a repository of repositories, GitHub's mode of existence as code is a recursively generated movement propelled in part by the Hubbernauts' network of repositories and their interconnections with other repositories.

4 The only problem with this is that the CEO and GitHub co-founder, Tom Preston-Werner (a.k.a `mojombo`, id = '1' in the GitHub user list -- in other words, the first Hubbernaut ever) has recently had to step down after much publicised allegations of sexist and discriminatory language and behaviour in the workplace [TBA]. I largely leave the workplace dynamics of GitHub aside here, but they are symptomatic.

SLIDE Githubbing as social media

SLIDE Github events -- sociality of coding outweighs coding itself -- why?

SLIDE Geographically centring effects in code -- SF dominates

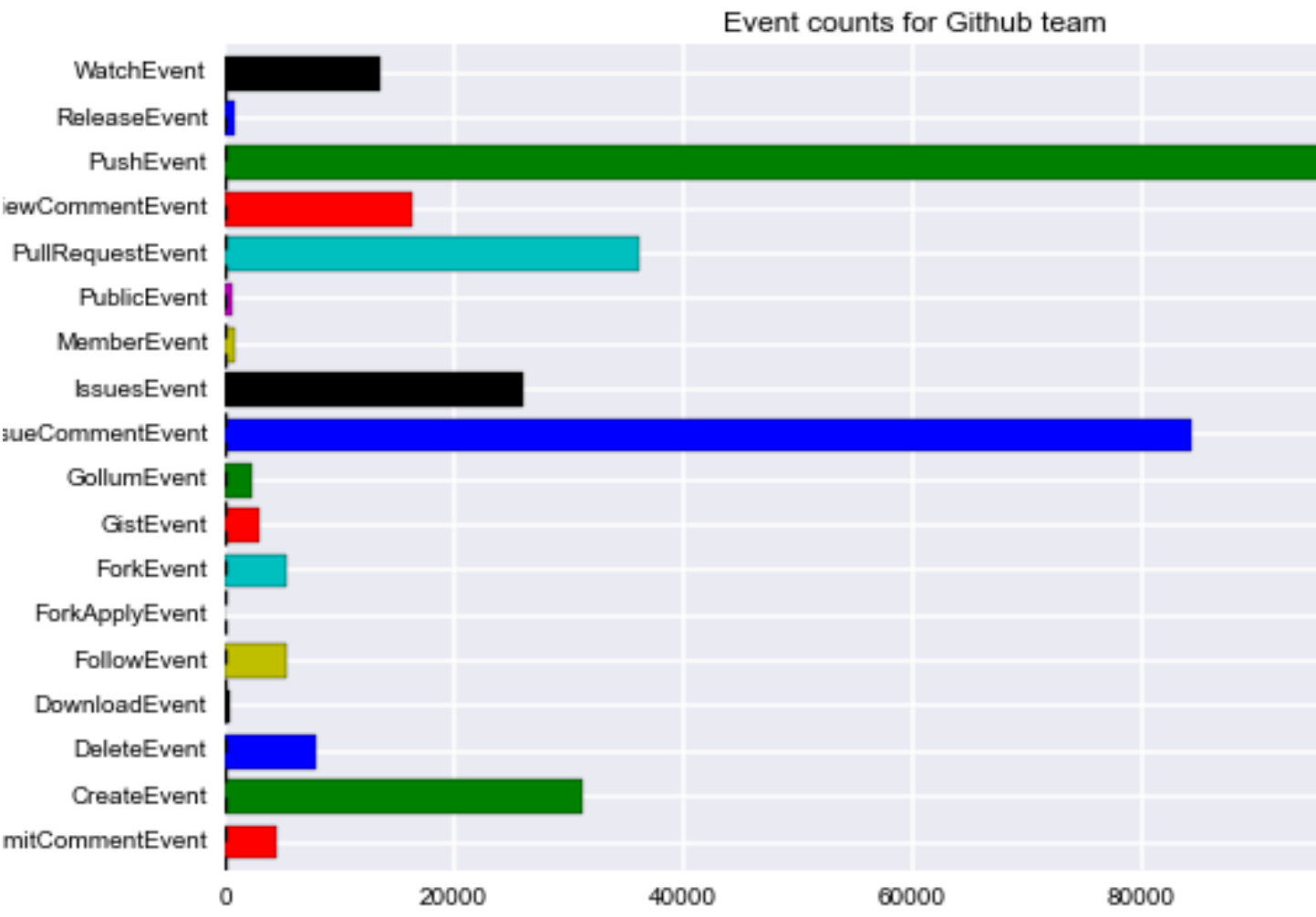

Locations of Github team (countries)
croatia
ireland
new zealand
greece
switzerland
japan
taiwan
canada
sweden
spain
germany
australia
thessaloniki
vernon
rapid city
potrero
irvine
ohio
virginia
new zealand
united states
huntsville
lowell
bellevue
north carolina
bath
taipei
kirkland
brooklyn
jersey city
indiana
palo alto
toronto
nagoya
london
los angeles
roseville
dallas
newcastle upon tyne
swarthmore
atlanta
barcelona
luebeck
yellow springs
dublin
holland
indianapolis
enschede
santa clara valley
raleigh
waterloo
huelva
düsseldorf
san mateo california
garland
charleston
minneapolis
cedar rapids
nomadic
pasadena
mechanicsburg
cheshire
belfast
frisco
zurich
hershey
edinburgh
127.0.0.1
united kingdom
madison
providence
richmond
lansing
charlottesville
bellingham
castle rock
washington
mountain view
i have to pick one?
cincinnati
tx
pensacola
berlin
savannah
sweden
south bend
new york
europe

The geography of their work on GitHub is still very much centred on San Francisco, despite claims of de-centralization. Geographic proximity still matters in code in many settings. But this centring is perhaps less important than the kind of movements that occur in and around it. The table below offers a view on what happens as the several hundred Hubbernauts work on GitHub as a platform.[5] It is important to note that only some of the GitHub code appears here. The GitHub team has private repositories. The most recursive repository of all, `github/github`, the repository that contains the code for whatever GitHub itself is, remains private.

type	**count**
PushEvent	112028
IssueCommentEvent	84098
PullRequestEvent	35990
CreateEvent	31080
IssuesEvent	25953
PullRequestReviewCommentEvent	16390
WatchEvent	13627
DeleteEvent	8033
FollowEvent	5400
ForkEvent	5283
CommitCommentEvent	4542
GistEvent	3063
GollumEvent	2260
ReleaseEvent	910
MemberEvent	897
PublicEvent	569
DownloadEvent	350
ForkApplyEvent	6

Table 1: Repository events generated by GitHub Team since early 2012

5 We can see some of what the GitHub team has been doing in GitHub repositories by running queries against the GitHub API (Application Programmer Interface) or using the GithubArchive.org archived datastream of GitHub activity. All of the numerical data in this paper results from such queries. In the case of Table 1, the query process went: find all the public repositories on which the named 'actor' works, and count the different actions they perform on those repositories. If we run this query for all 233 Hubbernauts as well as `mojombo`, then something of the network of work done on GitHub itself begins to appear.



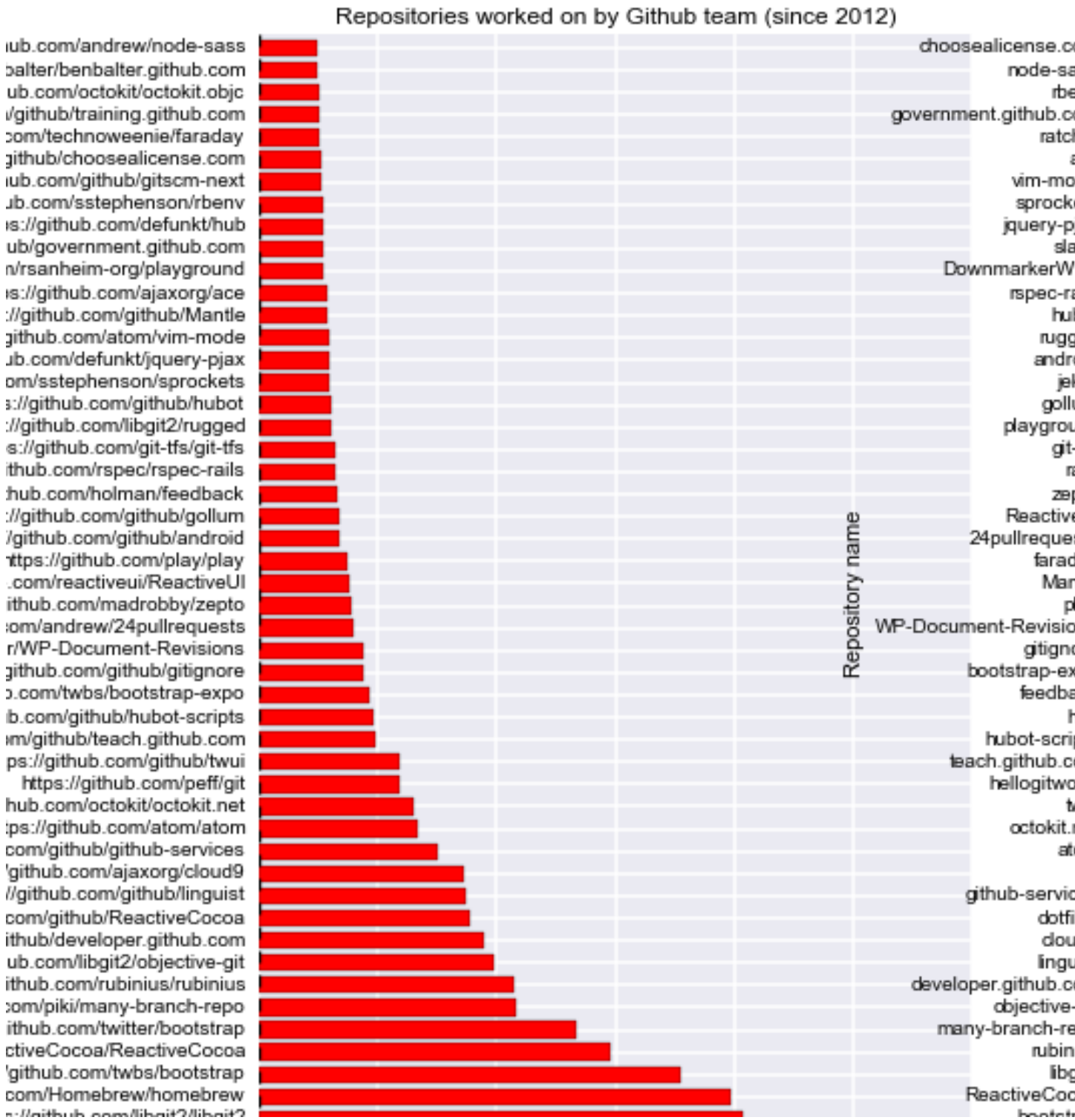
We can see the events shown in Table 1 (and Figure 2) as rough indications of movements in code. In some ways, the formatting of the events in the categories shown in Table 1 is problematic for our purposes because these formats already occlude differences in practice. They mix `git`-related practices such as forking or committing with GitHub-related practices such as pull-request or following. Disentangling what belongs to `git` from what GitHub has added would be difficult, but then this is precisely the kind of thing that would happen in the code-crowd. Putting this difficulty aside, the ratio of different event types suggests something of the flow of code. While PushEvents embody code writing, many other events, including

IssueCommentEvents, PullRequestEvents, IssueEvents and WatchEvents, point to different kinds of traffic in code. 'Social' events outweigh the technical events.

GitHub as collective imitation machine

The GitHub team has participated in some way or rather (including just watching) in a total of 17000 public repositories, but they work much more heavily on several hundred of these (see Figure 3).

SLIDE Github as a collective imitation machine that works through convolution


Repositories worked on by Github team (since 2012)
Repository name

The top repositories present a fragmented view of GitHub as an imitative process. There are quite a few that clearly relate to GitHub or `git` itself. It is hardly surprising that Hubbernauts contribute to the `git` repository or re-implementations of `git` such as `libgit2`, `objective-git`, `rugged`, `hub` (a 'wrapper' for `git`) or `many-branch-repo`. All of these projects are imitations, re-implementations or variations on `git`. They also make contributions to repositories that relate to GitHub, ranging from document websites such as https://developer.github.com or http://teach.github.com, websites that promote or showcase GitHub (https://government.github.com/) or its features (`24pullrequests`), repositories for testing GitHub (`hellogitworld`), repositories that actsas Q&A sites about GitHub(feedback), repositories that contain code for accessing the GitHub APIs (http://octokit.net) or link GitHub with other webservices (github-services) or other code development platforms (`git-tfs`).

As well, GitHub team works heavily on configuring the work of editing code itself. Repositories such as `cloud9`, `dotfiles`, `gitignore`, `vimmode`, `rbenv`, `ace`, and `atom` figure prominently in the contriubtions of GitHubbers, and this is also not surprising as the work of coding involves a lot of editing and drawing on existing code. Configuring editing tools and software development environments is a major preoccupation with software developers. The most worked on repository, homebrew, is just such a configuration repository -- it implements a software package management systems for MacOS computers. In terms of the theory of code-crowd, this configuration work render semi-conscious the practice of moving through, reading and writing code. Configuration work on writing code attracts much attention generally on GitHub. There are also quite a few repositories that concern how people sit down and keep coding. `Play` is a music server: 'We have employees all over the world, but `Play` lets us all listen to the same music as if we were all in the office together. This has actually made a big mpact on our culture' (https://github.com/github/play). Similarly, `Hubot` and `Hubot-scripts` are part of a software robot system that the GitHub team extensively use to maintain the GitHub platform, run the many online chatrooms they use as they work with each other, to continuously deploy the changes they make on the master branch of `github\github` into production and to send updates to various social media platforms. One Hubot runs the whole of GitHub. Finally, many repositories listed here concern the infrastructure of GitHub.com as a software platform.

Some are language-specific environments heavily used at GitHub such as `rubinius`, an implementation of the Ruby programming language. Some such as `rails` are web-framework libraries and they provide much of the dynamic infrastructure that holds GitHub as a collection of servers and databases. Other repositories such as `choose-a-licence` or `linguist` implement GitHub features to do with licensing or tagging repositories by programming language. Since GitHub repositories can also function as webpages, blogs, or wikis, other repositories such as `jekyll` and `gollum` provide code for that. Other heavily used repositories such as `bootstrap`, `zepto` and `twui` provide elements of the graphic layout, colours, styles, fonts and icons that comprise the visual appearance and interactive features of GitHub pages (and I return to this kind of software below).

This brief circumnavigation of repositories that GitHub staff themselves work on or watch begins to flesh out how traffic might move in the code-crowd. The fabric of GitHub as a platform is somewhat recursively constructed and connected by many edges. It folds in many different elements on various scales, ranging from almost micro-perceptual configurations such as editor settings through to large infrastructural developments such as `elasticsearch`. GitHub comprises programming language implementations, server infrastructures, deployment mechanisms, web-frontend frameworks, various social media formats (wiki, blog), Javascript page and graphic elements, as well as the code versioning system of `git`, robots that automate chatrooms and software they plays the same music to developers in different places and time. All of these together recursively construct the platform, with varying degrees of coherence and visibility, ranging from the vital `github/github` repository through to the many public facing repositories that Hubbernauts either release to the world or participate in publically. The loose concatenation of code elements comprising GitHub is, I suggest, typical of the ways in which software hangs together today. Certain elements of the platform hold together more strongly together than others and this registers in the event counts. For instance, the `libgit2` generates a large number of imitative events because the `git` functionality of committing, branching, merging, forking, cloning, etc underpins nearly all of the other flows of imitation associated with the growth of 13.2 million repositories and several hundred million events. Typically, for such entities, it migrates throughout the software development ecosystem so that 'bindings' to

`libgit2` have been made in almost any programming language imaginable, from Delphi to Lua, as well as to database backends such as `MySQL`, `redis`, `memcache` or the ubiquitous `sqlite`. The broader point here is that code traffic in and around GitHub is itself constantly transformed, modified and intensified by the flows of imitation that Hubbernauts themselves semi-consciously generate as they assemble the platform. Music, robots, editors, libraries, databases and webpages intersect with each other in the small-crowd teams of GitHub work and in the object of their mimetic immersion, GitHub itself.

To return to Thrift and French's three geographies in the light of this recursive work of Hubbernauts on GitHub, we can now see that the geographical centring of software writing still largely applies, but subject to some significant transformations in how it relates to urban settings. The `git` version control processes open centres to a more distributed and mutable bodies. It affords heavily borrowing from outside the platform, and makes code visible and at times even public for many others. While the geography of power/control (conduct of conduct) no doubt runs through much of what Hubbernaut's make (and here we could think of the many DCMA takedown notices posted at https://github.com/github/dmca) that seek to limit code traffic in various ways or the repo `choosealicence` that seeks to regulate flows of code according to legal licence), this power geography seems secondary to the geography of indeterminacy that GitHub itself exemplifies and that it seeks to host into being by building out the GitHub platform. Most importantly, we can see GitHub itself as a *convolutional* form, in which different aspects of the coded city -- externalization, projection, visualization, prescribed concern, ethics of care, navigibility -- multiply through each other. This convolutional growth occurs as traffic runs between people and objects of various kinds (logects, codejects, etc). Even one platform, admittedly a key platform for contemporary software development, recursively expresses in compressed form the sixfold flows ranging across navigation, media, externalization of relations of production, etc.

GitHub as convolutional process

The historical growth of code repository traffic since 2008 show something of this human-object multiplication or convolution. The traffic in being can be counted, like all traffic, in terms of

event volumetrics (e.g. 13.2 million repositories). Such numbers, however, give us little sense of the convolutions in that traffic. One important facet of those dynamics relates to what I have just been describing: the composite and concatenated development of GitHub itself as a social media platform that re-codes coding. But the device-specific formatting of code traffic that GitHub builds into events does not by any means account for everything that happens there. That is, all the 'social coding' apparatus they create -- Watchers, Followers, stars, showcases, search facilities, along with their attempts to render crowds more like publics (see the 'showcases' at http://github.com/explore for examples of this public-making) -- does not saturate or exhaust the imitative fluxes on GitHub. Just the opposite, they could be seen as derivative attempts to capture and organize those fluxes. The primary fluxes are more networked than the social media apparatus that GitHub wraps around `git` because they are not reliant on the formats and facades supplied by the GitHub platform. In other words, these convolutional fluxes are the most crowd-like aspects of coding, and they criss-cross geographies, cities, feeding into and overloading the power geography of the code in many ways.

SLIDE Primary fluxes and their capture in categories

- understood in terms of imitations of names and the name structure of repositories -- person + object
- returns us back to the connection between objects and imitative fluxes

SLIDE Contrasting early and contemporary fluxes

How would we sense something of these intense imitative fluxes in the GitHub traffic?[6] Judging by their names, the first 100 or so repositories on GitHub by creation date suggest a rather orderly and sensible traffic in beings. Repository names on GitHub are lightly formatted. Table 2, which shows the first 50 repositories on GitHub, dating from 2007-8, illustrates something of this flux. The first part of a repository name refers to a person or organisation ('mojombo', 'wycats', etc) and the second to the specific code repository. Both parts of the full repository name are interesting. Their relation encapsulates the intersection between people and objects that

6 Here, like Thrift's, my analysis of the coded-city needs to become more psychedelic. Tracking imitative fluxes means engaging with things that inherently lack any full formatting or clear outline. I focus here on the names of repositories and the names of actors. I have argued elsewhere that naming practices and code names spaces offer a rich resource for thinking about recursive and imitative processes in software culture [Mackenzie_2014a]

I think must figure centrally in any analysis of code as traffic, or as imitative flux. For the present purposes, however, the second part of the name is more important since it refers more directly to the code traffcic. In the early days of GitHub, these names are largely comprehensible in terms of the GitHub platform itself. Names like `grit`, a Ruby-language version of `git`, `git-wiki` or `merb-core` (a Ruby web-development framework) nearly all relate to various aspects of GitHub as a platform under development. Other platforms and concerns are already present (`amazon-ec2` or `ebay4r`) but they are somewhat marginal to the work of developing a platform to host `git` repositories.

orde	**r repository name**
1	mojombo/grit
2	wycats/merb-core
3	rubinius/rubinius
4	mojombo/god
5	vanpelt/jsawesome
6	wycats/jspec
7	defunkt/exception_logger
8	defunkt/ambition
9	labria/restful-authentication
10	technoweenie/restful-authentication
11	technoweenie/attachment_fu
12	topfunky/bong
13	anotherjesse/s3
14	anotherjesse/taboo
15	mojombo/glowstick
16	wycats/merb-more
17	macournoyer/thin
18	jamesgolick/resource_controller
19	defunkt/cache_fu
20	bmizerany/sinatra
21	rtomayko/sinatra
22	jnewland/gsa-prototype
23	defunkt/mofo
24	schacon/ruby-git
25	mmower/simply_versioned
26	abhay/calais
27	mojombo/chronic
28	al3x/git-wiki
29	schacon/git-wiki
30	sr/git-wiki
31	queso/signal-wiki

order	repository name
32	drnic/ruby-on-rails-tmbundle
33	danwrong/low-pro-for-jquery
34	mojombo/yaws
35	grempe/amazon-ec2
36	peterc/switchpipe
37	up_the_irons/ebay4r
38	wycats/merb-plugins
39	atmos/fitter_happier
40	brosner/oebfare
41	cristibalan/braid
42	evilchelu/braid
43	jnicklas/uploadcolumn
44	engineyard/eycap
45	chneukirchen/gitsum
46	brosner/django-mptt
47	technomancy/bus-scheme
48	Caged/groomlake
49	sevenwire/forgery
50	lazyatom/soup

Table 2: 50 early repositories on Github.com

A similar list from seven years later in 2014 reveals many complications (see Table 3). The names of people and actors have become increasingly unrecognisable, even allowing for the internationalisation. The people/actor names in GitHub become more and more like random patterns of key presses. (Indeed, thousands of repository and actor names comprise key sequences such as `qwerty` or `asdf` or `poiu` or `lkjh` or `1234`, all of which derive from the keyboard layouts.) And something similar happens to the repository names. Only a few components from the early days are recognisable in type (that is, things like a `blogengine` or `footer-fixed-boostrap`, the `bootstrap` web development framework is almost a fixation for GitHubbers since it provides the look and feel of GitHub itself). Many other elements of this stream are also recognisable and long-standing fluxes on GitHub: `practice`, `Hello-World`, `testing` and `temp` repositories occur in huge numbers on Github (in the order of million or more). These trivial fluxes are like people starting to edge into a crowd, to form part of a mass on the move. Broad swathes of generic imitation surface here too. We can also see here the appearance of quite disparate matters of concern: `game-cho-android` and `AI_Project` may have some similarities, but they at first appearance lie at quite a long

distance away from each other.

orde	r repository name
1 2	m1tsu3/practice
2 t	ylerdmace/ledomme
3 y	ehiaelghaly/xssya
4 i	stvan-antal/commandjs
5 J	ohnKrigbjorn/ObjectOne
6 c	henx/Ci35_1
7 m	ohsenbezanj/AI_Project
8 D	ineshkarthik/blogengine
9 s	apanbhuta/Sapari
10 g	woodroof/chat-gwoodroof
11 t	ryuichi/Hello-World
12 p	rateek0020/NepTravelMate
13 d	iscoverfly/discoverfly.github.io
14 e	van-007/ng-wikiful
15 s	anemat/zipcode-jp
16 d	onreamey/PJKiller
17 d	iscoverfly/discover
18 j	kkorean/MIUI-KK
19 A	rtofacks1/ionic-app
20 j	kkorean/MIUI-JB
21 t	ycho01/rails-i18n
22 O	ksisane/Websockets
23 c	henxiruanhai/XScrollView
24 j	honM17/footer-fixed-boostrap
25 M	cPringle/workshops
26 J	osemyD/testing-laravel
27 w	ngravette/FlogResources
28 E	thico/temp
29 T	ripod2K/cse223p
30 P	arbhat/tango_with_django_1.6
31 M	anuelAlanis/ios
32 k	owito/pnxstudio
33 r	aimana/activiti_merger
34 d	ylanling/connect_four
35 v	ipseo2014/game-cho-android
36 d	ylanling/connect
37 a	naloq/temvoc
38 a	554b554/algorithm-competition
39 a	7657z/12306_2
40 s	cwuhao/jumpybloc
41 j	jfine/post_mail
42 h	4di/PROYEK-TKPPL

orde	r repository name
43 E	XOgreen/TwitchBot
44 e	riccarpenterle/creepcreep
45 p	t1490/ubuntu-example
46 t	strimple/cookie-parser
47 A	ngAven/Pulse
48 l	yc4n/lyc4n.github.io
49 d	rjwhut/elebldc
50 m	ivim/fosiness

Table 3: 50 recent Github repositories

SLIDE Most forked repositories on Github Jan 2013

It is very hard to see any flux of imitation here. Like the many repositories named using convenient patterns of keystrokes, these repositories seem almost like code-noise. If we start counting imitative events, things become a bit clearer. For instance, in January 2013, around 200,000 repositories were forked (or copied). Forking, I'm suggesting, is a basic imitative event in `git`-like practices. The most forked repositories have a now familiar look (see Table 4):

forks rep	ository
1478	bootstrap
1276	Spoon-Knife
763	dotfiles
504	rails
426 ht	ml5-boilerplate
410	jquery
375	homebrew
345	linux
343	android
291 p	honegap-plugins
280	node

Table 4: Most forked repositories on Github in January 2013

SLIDE Bootstrap and its recursiveness

This list is reasonably familiar since it has major platforms like `linux`, `android` and `node` as well as well as the major test repository on Github `Spoon-Knife`. But even if we just take the most forked repository `bootstrap`, this is not a single imitative flux. As we glimpsed already, the GitHub team takes a strong interest in `bootstrap`, a set of components such as buttons, forms, progress bars, tables, typographic elements and colour themes for web front end

development. These visual elements figure heavily in the visual appearance of GitHub as a social media platform, and hence, `bootstrap` already matters to the boostrapping of GitHub itself as a web-based platform. But `bootstrap` itself is not singular entity. Look at what else was forked heavily in January 2013 relating to `bootstrap`(see Table 5):

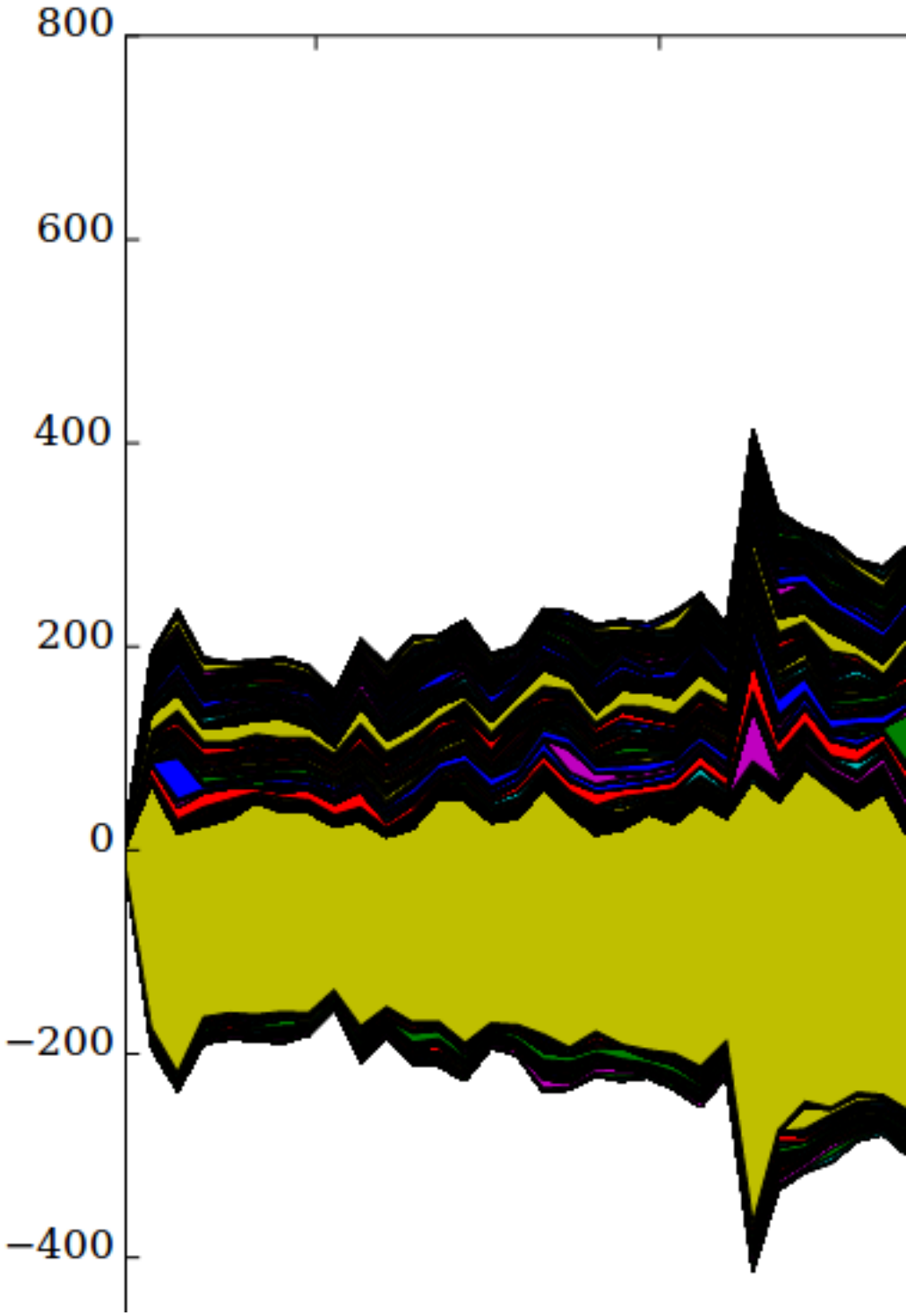
SLIDE Bootstrap and popular forks

SLIDE Bootstrap and its forks

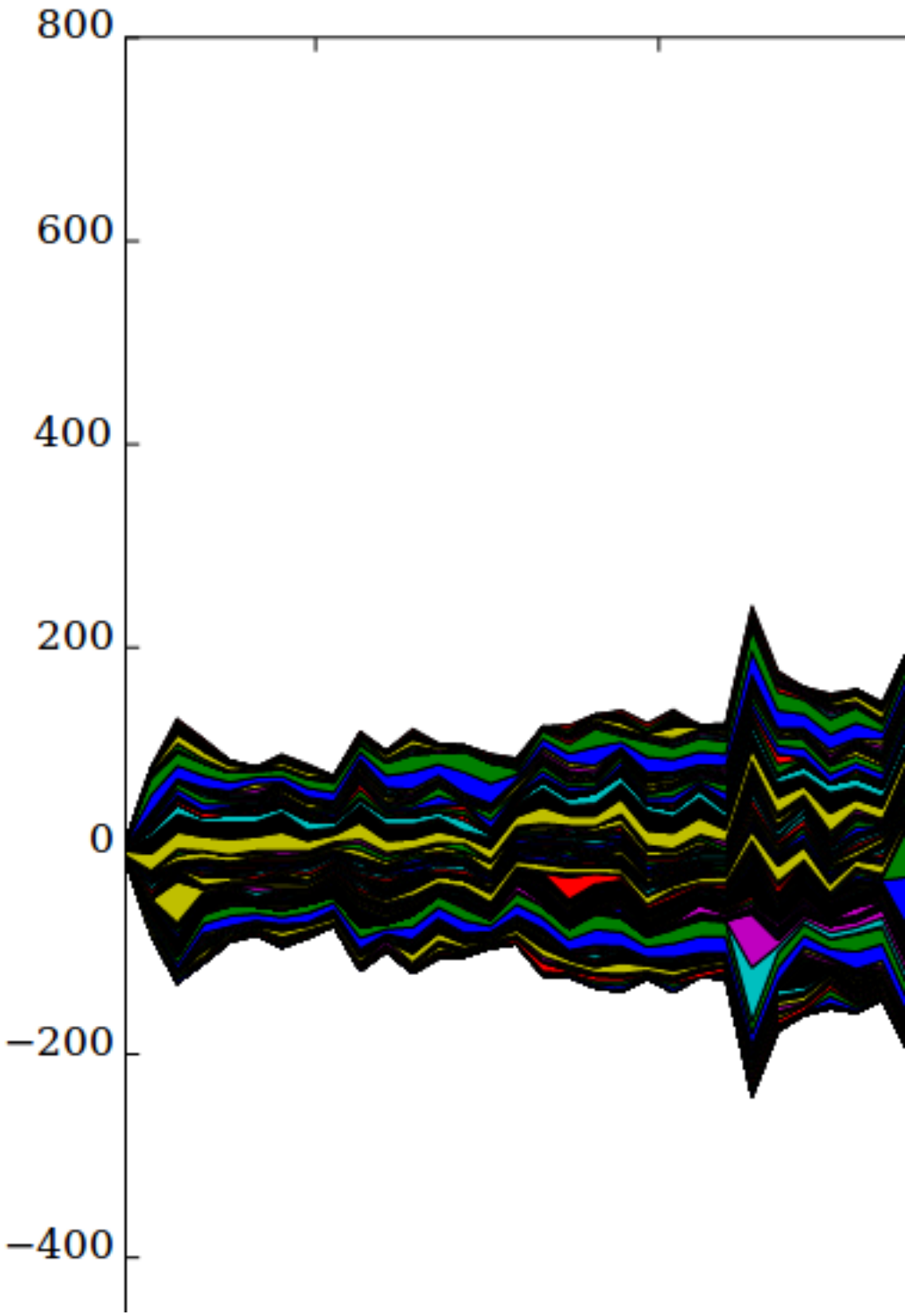
forks	repo
1478	bootstrap
109	bootstrap-datepicker
84	jekyll-bootstrap
60	bootstrap-wysihtml5
54	bootstrap-tour
48	twitter-bootstrap-rails
48	bootstrap-sass
46	bootstrap-datetimepicker
43	jquery-ui-bootstrap
42	bootstrap-modal
40	wordpress-bootstrap
36	bootstrap-daterangepicker
31	sass-twitter-bootstrap
31	Bootstrap-Image-Gallery
26	rails3-bootstrap-devise-cancan
26 bootstra	pwp-Twitter-Bootstrap-for-WordPress
24	metro-bootstrap
24	bootstrap-timepicker
23	bootstrap-toggle-buttons
23	MopaBootstrapBundle
19	twitter.bootstrap.mvc
19	bootstrap-switch
18	google-bootstrap
18	Bootstrap-IE6
17	gwt-bootstrap
17	django-bootstrap-toolkit
17	bootstrap-magic
17	android-bootstrap
16	sinatra-bootstrap
16	CodeIgniter-Bootstrap

Table 5: Forks of `bootstrap` related repositories during January 2013

While it was copied more often than any other repository in that month, the `bootstrap` repository itself is massive overshadowed by all the variational imitations that accompany it. The total count of `bootstrap` related forks during January 2013 is for instance, 3074, almost twice the size of the forks of `bootstrap` itself. Widening the frame a bit, we can see (Figure 4 & 5)that the since 2012, `bootstrap` has been an important imitative flux running through GitHub, and has been the most highly 'starred' code repository on GitHub for several years.


800
600
400
200
0
−200
−400

SLIDE Bootstrap variants without bootstrap


800
600
400
200
0
−200
−400

From these stackplots of ForkEvents associated with the `twitter/bootstrap` repository, we can begin to seem something different about the imitative flux. The imitation varies over time as we would expect, but the patterns of imitation are heavily interconnected with each other through repositories that juxtapose or convolve different repositories with each other. The several thousand bootstrap-related repositories are much more diverse than `bootstrap` itself. They combine variously with mobile devices ('Android', 'iOS'), with web-browser software('IE6'), with various web-development infrastructures (django, rails, ASP, PHP), with media platforms (WordPress, Google, CodeIgniter) and server management systems (sinatra). They respond to events in the main `bootstrap` repository, but also have a life apart from that repository that relates to other platforms and other software projects.

Conclusion

We have little sense of how code flows in cities, or of code-as-crowd. If code itself is flow, with its own recursive and convolutional dynamics working with and against each other, then we might begin to see how see how the centring, conduct and indeterminacies of code arise. I have been suggesting that we can begin to get some measure of it by tracking how code moves through repositories, and through other related settings. The repositories have become something like the public places or squares where crowds assemble in cities. Unlike squares, however, code repositories like GitHub are themselves part of the flow of code. They are part of the co-adaptation of imitative fluxes. The ongoing production of software is very much bound up with the ongoing transformation of urban life through crowd dynamics. As we have seen, GitHub is itself made of and part of the contemporary urban fabric.

The kinds of movements that I have been following on and in GitHub have loosely borrowed from geographies of code cities. They include the centring effects of cities on the geography of software production, the 'conduct of conduct' and the indeterminacies of invention in software. But I have suggested that we can see even in the elementary flow of something like repository names the way in which different geographies come together in the code repositories. This flow of names is a poor substitute for the deeper interactions occurring as bodies of code are cloned, forked, branched and merged.

While I have drawn loosely on the notions of crowd imitation found in Tarde or Park, the more general argument does not depend so much on the precise theory of crowds or urban life in question. For most urban crowd theorists, processes of imitation lie at the heart of crowd formation and development. Imitation, however, is usually either treated as a psychological process of suggestion or, in the more Deleuzean formulations, as something that lies at the very core of flow: as Deleuze and Guattari write, 'assemblages are passional, they are compositions of desire. Desire has nothing to do with a natural or spontaneous determination; there is no desire but assembling, assembled desire. The rationality, the efficiency, of an assemblage does not exist without the passions the assemblages bring into play, without the desires that constitute it as much as it constitutes them' (Guattari and Deleuze 1988, 399). Deleuze and Guattari had already developed a useful theory of crowd assembly, and their notion of assembling as putting together, as composition, seems to me to still offer useful ways of thinking about how source code dynamics or the 'source-crowd.'

There are many other dynamics on GitHub that we might analyse in these terms. The very crude metrics of imitation based on forking could be turned in various directions. I have mentioned the profusion of `dotfile` repositories in the last few years. These repositories can be analysed in terms of micro-gestural and micro-perceptual differentations at work in the writing of code. Choices of colour, font size, line separation, shortcuts for keystroke commands and the multiplicity of configurations for code development could be used to develop a much richer account of how people move through code, almost like a 'gait analysis' for code. Similarly, the metrics of the name space could, at a very different end of infrastructural dimensioning of code help us see how,for instance, the scale of investments in infrastructures ripple across code-as-crowd. Many of the inventive dynamics of GitHub could be identified as externalizations of the investments in the scaling of digital media platforms to match the scales of urban life.

Regardless of these possible directions of analysis, the broader point here is that software today is less like a machine, a system or even an assemblage, and more like a crowd. That is, it has fluxing, flowing and somewhat disordered existence that generates powerful flashes and movements, that creates atmospherics and densely woven patches of order, but remain unstable and dynamic.

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