# Big Digital Humanities

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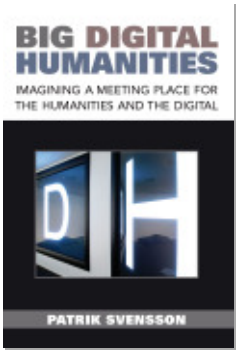


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# Humanities Infrastructure

We are now in a position to consider what types of infrastructure may be useful in facilitating big digital humanities and more broadly in supporting the humanities. Shared, humanistic infrastructure is critical to the big digital humanities as it can support the three premises discussed in chapter 3: the digital humanities as a meeting place, multiple modes of engagement, and the field as a place to engage with the situation and future of the humanities.

It is not possible to imagine digital humanities—or any kind of humanities—without infrastructure. However, most of the humanities may not think of itself in terms of infrastructure, and the digital humanities must engage with infrastructure not just where doing so may come most naturally, such as language technology and archaeology, but wherever there is a need. Engagement is required not just in terms of building and using infrastructure but also in terms of conceptualizing and critiquing infrastructure. Moreover, we need to relate to existing infrastructures such as libraries, digital publishing platforms, and humanities centers and reflect on their conditioning and potential in terms of infrastructural imagination. These humanities infrastructures can provide valuable partners for the digital humanities.

While discussions of infrastructure may not immediately attract considerable scholarly excitement, infrastructure can be seen both as an enabler, facilitating and supporting academic work, and as a relevant object of critical study. Indeed, infrastructure involves using imagination to connect conceptual ideas with material manifestations. In this sense, thinking about an infrastructural agenda for the humanities equates to shaping the future of the humanities and the academy. At the same time, infrastructure is institutionally, culturally, and politically laden, and humanists need to bring their critical awareness to it. Emerging work in infrastructure studies is important here, although such work mostly addresses other domains than the humanities and rarely our own knowledge production. Not all humanities infrastructure can

be subsumed under the digital humanities, but there is potential in seeing the field as an infrastructural platform for the humanities. Big digital humanities, positioned as a meeting place with a broad technological and critical engagement, is a strong platform for articulating the need for humanities infrastructure and perspectives.

This chapter opens with some observations on infrastructure and research infrastructure before describing and critiquing three common models of humanities infrastructure: extending existing infrastructure such as libraries, the notion that the humanities has no infrastructure, and science and technology as a template for how to create humanities infrastructure. The second part of the chapter proposes a framework for research infrastructure—in particular, humanities infrastructure—based on three levels of analysis: conceptual infrastructure, design principles, and actual infrastructure. The level of conceptual infrastructure provides an ideational grounding, and the set of design principles offers a way to connect this conceptual level with the material level. HUMlab at Umeå University offers a detailed case study of how this framework can be used, so digital humanities labs receive particular consideration. The chapter ends with a suggested infrastructural agenda for the humanities.

## Approaching Infrastructure

In some ways, infrastructure is pervasive and transparent.[1] It is a texture that provides electricity, phone services, roads, and many other seemingly basic things, and at least in some parts of the world, we can expect this infrastructure to be there and be reasonably reliable. Infrastructures are interdependent in different ways and often part of very complex systems. For example, in an article critiquing a planned national investment in high-speed trains in Sweden, the authors argue that people travel mostly regionally, that high-speed trains are mostly beneficial for privileged groups of people, that the long-term environmental gain is questionable given the environmental cost of construction, that commercial actors running the trains have other goals than the state, and that any such major investment will decrease infrastructural maneuverability over the next few decades.[2] They also acknowledge that the decision is ultimately a political one. There is certainly complexity here, and increasingly digital technologies play an important role in enabling, expressing and connecting infrastructures. Just think about how cars, road infrastructure, geographical positioning systems, visual map displays, live traffic feeds, automatic reading of traffic signs, parking apps, Über and new driver-less ve-

hicles interact. Infrastructural systems are not and have never been one thing, but are rather situated socially, culturally, economically, environmentally and materially. Infrastructure is also about creating monuments, enacting dreams and packaging things that would not always seem to belong together.

There is a sense of infrastructure that primarily refers to research, cyber, or academic infrastructure,[3] much of which is less pervasive. It is typically costly equipment associated with the sciences, engineering, and medicine—for example, microscopes, biomedical imaging, high-performance computing, and synchrotron radiation facilities. Other kinds of infrastructure, such as libraries, are much less likely to be seen as relevant in relation to recent investments in research infrastructures. According to the Swedish Research Council,

> For an infrastructure to be considered a national infrastructure, it should be freely accessible for researchers within the area and be of national interest, as well as have an independent board with a national perspective and responsibility. There should be a process for prioritising utilisation of the infrastructure, using scientific excellence as the criterion.[4]

Would even a national library qualify as research infrastructure in this sense? Probably not, as libraries are not really part of the framework of research infrastructure and are normally funded in a different way. Most research councils advertising resources for research infrastructure would be perplexed if libraries applied for core funding for themselves. And while prioritizing utilization of resources based on scientific excellence works better for supercomputer centers than for libraries, it would not be impossible to frame libraries in such a way. But is this really what we want to do?

Language plays an important role here, and it is safe to say that there was no real attempt to include the humanities in this text. I am arguing not that the needs of the humanities in this respect are as large as those of science, engineering, and medicine but rather that there is no point in talking about including all areas and fields if that inclusion does not even affect the language and framing of such authoritative descriptions. Furthermore, the text excerpt also makes it clear that we are concerned with facilities or resources that are used primarily for research. The humanities could choose to think differently and more broadly about infrastructure.

Given this discursive framing of research infrastructure, it is not very surprising that the humanities are generally not privileged in the allocation of infrastructural funding. For example, none of the twenty projects that received

grants from the Swedish Research Council in 2014 involved humanities-based infrastructure; the preceding year, only one of the twenty-seven funded projects was humanistic, and somewhat predictably, it was a grant for a language technology work within a European initiative (CLARIN).[5] The situation is similar almost everywhere; moreover, even recent initiatives that sought to articulate a humanities infrastructure have tended to focus on data and access rather than on actual humanistic research questions and the overall mission of the humanities.[6]

Nevertheless, research infrastructure, while traditionally not associated with the humanities, has become a topic of conversation on faculty boards and among humanities researchers. And regardless of the actual allocation of funding, at least nominal humanistic interest comes from funding agencies, councils, and various organizations under rubrics such as cyberinfrastructure, e-science, and knowledge infrastructure. While all of these terms appear in this chapter, I prefer *academic infrastructure* because it does not focus on research only and has fewer connotations than *knowledge infrastructure*. In any case, work is being done to secure funding, define key questions, and align the humanities with an epistemic framework that bears a strong science and engineering legacy. Many opportunities exist, particularly for a field such as the digital humanities, but there are also real risks and important considerations.

Particular attention needs to go to the assumed epistemic and ontological neutrality of the "infrastructure move" and its assumed broad applicability for everything from geology to cultural studies. I therefore consider the risks associated with modeling humanities infrastructure on existing infrastructure, such as libraries, or on a technology- and science-driven paradigm. The humanities should engage profoundly, critically, and unapologetically with their own infrastructural needs. The stakes are high, and the infrastructure movement as a whole can be seen as an epistemic power play, but it has very real implications and possibilities for the humanities and the digital humanities.

## Interlude 6: Framing Infrastructure and a Call for Leadership

As the ex-director of HUMlab and someone involved in building material environments, part of my job is to think about our work in infrastructural terms. This strategy is not just pragmatic but comes from a belief that the material level of infrastructure can articulate deep conceptual foundations and that the interplay between the conceptual and material levels can be very productive.

Infrastructure may seem solid and not particularly subjective, but it is the result of institutional, cultural, political, and conceptual processes. An excellent example of this embeddedness is Nicole Starosielski's work on the infrastructure of undersea cables, which investigates how infrastructure for the "immaterial" Internet is very material, situated, and a result of cultural production.[7] Such knowledge can and should inform our thinking about infrastructure, particularly since funding schemes and ideas of infrastructure are typically not based on humanistic or cultural challenges but rather on those of science, engineering and technology.

When HUMlab applied for infrastructural funding from the Swedish Research Council in the early 2000s, what we imagined clearly did not fit the template offered by the funding agency. In particular, we envisioned a disparate set of technologies in relation to an idea about how that infrastructure could further humanities research. Such funding is often keyed to the idea of expensive scientific apparatuses, and the call explicitly mentioned "functional units." For all kinds of reasons, we did not receive funding, but the process helped us to think about the framing of infrastructure. Such framing must clearly draw on humanities-based notions of infrastructure but also must take cues from areas with a stronger infrastructural engagement to strengthen the argument for humanistic infrastructure.

In the spring of 2012, I had talked with scholars and research leaders from the sciences and medicine at Umeå University. At the same time, various schools at the university, including the arts and humanities, had been asked to identify and articulate their infrastructural needs as a result of a decrease in the national funding for infrastructure and a corresponding increase in the need for universities to fund more of their infrastructure.

My discussions with chemists, biologists, and plant science physicists showed that their operations already had a clear infrastructural framing. Again, this may not be surprising, but I was struck by how this was not just a strategic sentiment: individual scholars saw it as key to their work and a reason for being at Umeå University. They often used the word *platform*, and such a notion can be quite useful (and critiqued, see Interlude 2 in chapter 1). For example, a range of science and medicine disciplines at the university are oriented around a number of key platforms (such as proteomics and metabolomics) that are sets of infrastructures or specific, costly apparatuses and associated methodological competence. These platforms possess a sense of sharing, both in the sense of use and accessibility and in the sense of (external) funding. In practice, however, not all platforms are equally accessible,

and problems may arise when some stakeholders do not know enough to use these devices. However, a story and basic idea matches director-level and researcher-level interest with an infrastructural layer. Furthermore, infrastructure is seen as an instrumental way of connecting different fields and groups. According to the Umeå University Chemical Biological Centre website,

> Although the departments are administratively independent, they have the ambition to share resources (technical platforms) and build up tight networks between the departments to overcome the borders of faculties and universities.[8]

This statement makes assumptions regarding the intersectional capacity of infrastructure. Sharing does not necessarily mean working together closely, but shared infrastructure can undoubtedly help create possibilities. Perhaps just as important as the actual infrastructure is the idea of having common platforms and the idea that individual researchers and groups simply cannot fund or motivate such infrastructure for themselves. Similarly, libraries provide a model for access to materials that is much more cost-effective and structured than large individual or group collections. A parallel argument can be made for resources associated with the digital humanities. This is a matter not just of infrastructure and people but also of ideational and conceptual framing and articulation. This conceptual framing of infrastructure in the humanities should go beyond access to digitized cultural heritage and managing large datasets. At this point, we need to articulate a set of intellectual arguments for humanities infrastructure. Furthermore, we must possess technological vision and an unapologetic attitude toward the humanities' need for infrastructural investments.

In 2006, I took part in a workshop on cyberinfrastructure at the University of California at Irvine along with some key humanities scholars and other interested parties. Dan Atkins, then head of the Office of Cyberinfrastructure at the National Science Foundation (NSF), showed considerable interest in our work, and he asked the humanists present to show leadership in terms of cyberinfrastructure. When I met him again in the spring of 2013 in Ann Arbor, he repeated this sentiment and showed considerable personal engagement in humanities infrastructure at the University of Michigan.

The humanities can and should imagine its own infrastructure, but must also engage in collaborative efforts. I prepared a project proposal about criti-

cal visualization together with a group of scholars in 2014 and one of the key partners was a physicist and visualization expert. The physicist, who runs a large visualization facility, and I had been working together for some time, and we soon realized that our respective visualization infrastructures were very different, but with many links, common challenges, and considerable complementarity. When I sent him a first draft of the project proposal he distinctly critiqued the way I had portrayed science-driven visualization (as largely positivistic). I already knew that science visualization is not necessarily positivistic—in fact humanities visualization often comes across as quite positivistic—but somehow I let a traditional humanities framing of STEM influence my writing. I was wrong and changed the narrative as a consequence.

Our collaboration later led to HUMlab participating in a multiple-site national bid for visualization infrastructure (to the Swedish Research Council). Most of the nodes in this collaboration were science-based and they found our humanities-based infrastructure important since it provided a different, materially manifested model of what visualization and scholarly enactment can be. This type of collaboration can be an important way forward for the humanities, but it requires the humanities to first imagine and build its own infrastructure.

The humanities needs to articulate and argue in favor of humanities infrastructure not to maximize funding but as a way of making strong visions come true. And if the infrastructural engagement results in the humanities declaring that we do not need additional infrastructure, this is obviously also acceptable. The most important factor is intellectual and material engagement.

## Research Infrastructure

According to the *European Roadmap for Research Infrastructures Report* 2010,

> Research Infrastructures are facilities, resources or services of a unique nature that have been identified by European research communities to conduct top-level activities in all fields. This definition of Research Infrastructures, including the associated human resources, covers major equipment or sets of instruments, in addition to knowledge-containing resources such as collections, archives and databanks. Research Infrastructures may be "single-sited," "distributed," or "virtual" (the service being provided electronically). They often require structured information systems related

> to data management, enabling information and communication. These include technology based infrastructures such as Grid, computing, software and middleware.[9]

This definition is fairly typical of the discourse of research infrastructure through its focus on data, instruments, and excellence in research. Another typical feature is the listing of different types of technologies and research infrastructure (which is clearer in the full report). There is no simple way of defining *research infrastructure(s)* or *cyberinfrastructure* since the terms are part of a social, institutional, and political context. Indeed, *infrastructure* broadly refers to "the resources (as personnel, buildings, or equipment) required for an activity" as well as "the underlying foundation or basic framework (of a system or organization)."[10] According to Paul Edwards and his coauthors, the term often "connotes big, durable, well-functioning systems and services, from railroads and highways to telephone, electric power, and the Internet."[11]

In practice, the notion of research infrastructure carries a number of assumptions linked to funding structures and to the idea of a resource of national or international interest. Research infrastructure is typically taken to be advanced and costly, to require national or international funding, to be associated with leading research and researchers, to be part of a system, to extend beyond single research groups or disciplines, to have longevity, and to add significant new research possibilities.

In general, much discussion of academic infrastructure is driven by technology and data and takes place at the structural level. This is partly a result of the selling, reselling, and packaging of new generations of research infrastructure and partly a result of the emphasis on the traditional infrastructural needs of science, engineering, and technology.[12] As with *digital humanities*, the relatively high level of abstraction of a term such as *cyberinfrastructure* allows for descriptions grounded less in specific disciplines and more in a set of high-level epistemic and technological commitments:

> The Advanced Cyberinfrastructure (ACI) Division supports and coordinates the development, acquisition, and provision of state-of-the-art cyberinfrastructure resources, tools and services essential to the advancement and transformation of science and engineering.[13]

As Christine Borgman observes, *cyberinfrastructure* is often defined through example, typically emphasizing the "integrative, collaborative, and distrib-

uted nature of new forms of research."[14] In addition, there is frequently an assumption of very large and complex datasets, currently fueled by interest in big data. While we do not necessarily need to question these assertions, we are concerned with a particular type of discourse and epistemic framework. This implies that a possible humanities alignment with cyberinfrastructure in this sense is, in fact, also an alignment with this discourse and associated assumptions. For example, distributedness in the sense of optiputers or grid computing is far more likely to be seen as research infrastructure than multimodal communication, data exchange, and analysis through small-scale qualitative databases, Twitter, and tools for online ethnography. The emphasis on big data shadows the importance of small data, and a positivistic data and research regime (whether enacted by humanists or others) can lack the critical sentiment central to the humanities.[15]

Another assumption is that research infrastructure is quite costly. Small-scale installations are less likely to receive external funding. The packaging of infrastructure becomes an important issue. Humanities infrastructure is likely to be more multiplex and cheaper than traditional science infrastructure. Here platforms such as labs are useful in the sense that they can frame multiple pieces of technology, a range of expertise and other resources. The humanities needs to both resist and engage with the high-cost assumptions of infrastructure, avoiding expensive solutions for the sake of hitting a high price point and preventing infrastructural and intellectual imagination from being curtailed by a low-cost humanistic sensibility.

It is striking that discourse on academic infrastructure tends to have very little obvious critical inflection. For example, the aforementioned *European Roadmap for Research Infrastructures Report 2010* does not contain a single instance of "gender" or "race." The same is true for many other reports and white papers on research infrastructure. There is also very little political, societal, or environmental concern in such documents. It would clearly be useful to engage more strongly with such perspectives when imagining and articulating academic infrastructure. What critical perspectives could inform the building of new infrastructure? How can our current knowledge infrastructure be critically analyzed? How can such critical inflections be addressed and explored through the infrastructure itself? We need to bring critical sensitivity to academic infrastructure while also engaging with the making of new infrastructure.

In addition, most notions of infrastructure for the academy are very focused on research. If we believe that education and research are intrinsically

connected, we need to think about how infrastructure can serve both needs. This does not apply equally for all infrastructure, but it is an important overall sentiment that the humanities should take care to point out when discussing infrastructure. After all, a key example of humanities infrastructure, the library, serves both education and research. This is one of the reasons why *academic infrastructure* seems like a more useful term than *research infrastructure*.

Academic infrastructure intended for research seems to easily acquire a status and life beyond merely supporting or facilitating research. Research infrastructure is not research or independent of research challenges, and it seems appropriate for research needs and challenges to shape the establishment of new infrastructure.[16] The humanities is thus primarily concerned with research challenges and infrastructural needs identified by the humanities, particularly humanities researchers. A few examples of these needs and challenges include looking at older materials and aesthetics through a digital lens, understanding the dynamics of "Twitter activism" through network analysis, studying the transformation of urban spaces through media technology, tracing narrative structures in computer games, studying the notion of "frames" through working with multiple screen sites, using map-based visualization to find patterns in large sets of archival information, applying text-mining technologies for literary and linguistic analysis, and investigating reading comprehension with the help of eye-tracking equipment.

However, the nature of infrastructure and funding mechanisms normally makes the process more complicated than matching a single research challenge with an appropriate piece of infrastructure. In practice, infrastructure often must be abstractly framed and typically must serve more than one specific research need to qualify as infrastructure. Technologies such as visualization and grid computing fulfill this requirement, and they often come across as black boxes rather than sites of situated research facilitation. Furthermore, funding is much more likely if the infrastructure is associated with "new" research and "major" potential advances. There is also a push for interdisciplinary research endeavors. What I have described here is in fact an infrastructural template with which the humanities needs to engage.

## Academic Infrastructure for the Humanities

The discourses and practices of research infrastructure are strongly situated in science and engineering. While many funding sources are in principle

open to all areas of research (including the humanities), they have a strong tendency to fund science, engineering, and medical research. The humanities has not been seen as a significant player in these kinds of funding schemes apart from certain areas such as computational linguistics and digital libraries; consequently, observers rarely elaborate on the specifics of humanities infrastructures and engage in relatively little discussion of what humanities infrastructure could actually be.

However, the humanities in general and the digital humanities in particular have begun to acknowledge the importance of and push for a better research infrastructure. This process is strongly linked to a realization that material, tools, and culture are becoming increasingly digitized and that academic work is more likely than before to be carried out in a distributed and digitally supported fashion. Unfortunately, this realization often merely results in a transfer from known infrastructure, typically cultural heritage institutions, to the digital realm.

> The digital age is compelling us to introduce such physical collections onto the digital plane by digitisation and/or to construct new collections of digital objects as subjects of research in Humanities today.[17]

This European Science Foundation statement represents a fairly expected stance based largely on an analog mind-set. The risk may even be that such digital collections become decontextualized and that not enough resources are put into the interpretative layer. Moreover, while digitizing existing infrastructure is important, humanities infrastructure involves much more than this.

The background to the current interest in infrastructure is a relatively recent "infrastructure turn" (in the words of Geoffrey Rockwell) or even a revolution (a term often used by funding agency reports and other sources).[18] At least in terms of how it is presented, infrastructure in this sense is more likely to include human resources and other nontechnical aspects than were earlier generations of infrastructure. Nevertheless, the movement is essentially a science- and engineering-driven enterprise:

> The Panel's overarching finding is that a new age has dawned in scientific and engineering research, pushed by continuing progress in computing, information, and communication technology; and pulled by the expanding complexity, scope, and scale of today's research challenges.[19]

The use of *new* in this influential NSF Blue Ribbon Report is not accidental: the discourse of academic infrastructure prominently features *new*, *emerging*, and *expanding*. According to Christine Borgman, *new* appears 133 times in this report, and similar documents have similar language.[20] *New* appears 89 times in the 64 pages of the American Council of Learned Societies (ACLS) Report on Cyberinfrastructure for the Humanities and Social Sciences.[21] These figures suggest that "newness" may be a useful prerequisite for research infrastructure. It is not problematic or surprising that infrastructure discourse emphasizes what is new and what can be imagined, but these documents are often set in an overly positivistic and rigid infrastructural framework with limited connection to the subject matter.

This NSF report explicitly mentions the humanities only once (in relation to digital libraries), but there is evidently an interest in engaging with the humanities and social sciences despite the NSF's primary focus on science and engineering.[22] Similarly, many accounts of cyberinfrastructure include a note about the impact on these "nonprimary" areas:

> Although our focus is on e-Science, other research fields such as the social sciences, arts, and humanities will also require and benefit from this emerging cyberinfrastructure.[23]

Such statements are external to the humanities in that they often make outside assumptions about the field's needs, requirements, and priorities. For the humanities to control its own academic infrastructure, it needs to express humanities-driven needs and engage in constructive dialogue about our current and future infrastructure. As Andrew Prescott points out, infrastructure in science is often tied to specific research questions, while in the humanities, "our thinking about infrastructure is too often disconnected from research issues."[24] Prescott's statement may well be true, but it also exemplifies a tendency to take for granted the often implicit rationale for science infrastructure.

The close and complex connection between research issues, materials and tools discussed under the rubric of intellectual middleware in chapter 3 is highly relevant in relation to humanities infrastructure. There is no such thing as neutral access to content and the design of research tools encapsulates interpretative frameworks. Infrastructure projects should take this into account as there is considerable academic potential in allowing infrastructure to be inflected, integrative and intellectual.

## Risks, Strategies, and Models

Some risks of conceptualizing and building infrastructure for the humanities must be addressed. First, there is a danger that existing humanities infrastructure might be disregarded since we have no tradition of thinking about libraries, seminar rooms, and databases in terms of infrastructural framing. Second, the science-based and data-driven model might be imposed on the humanities (sometimes by humanists themselves) without careful discussion of its premises and consequences. Third, infrastructural needs or agendas most compatible with a largely science-based model might be inappropriately prioritized. Finally, new humanities infrastructure may be uncritically based on existing infrastructure, such as libraries, and associated epistemic commitments.

The current interest and investments in academic infrastructure for the humanities present an opportunity to think carefully about what the humanities may or may not need in terms of infrastructure. We cannot do so, however, without maintaining a critical stance and advocating a truly humanities-based approach to academic infrastructure. At the same time, we do not necessarily know what kind of infrastructure we will need, and we must simultaneously explore humanities-based research issues and challenges and technology and different kinds of infrastructure, including infrastructure that is part of what is seen as science and engineering infrastructure. Consequently, we must allow for combinations of technology- and humanities-induced visions and implementations.

Furthermore, we must be aware that any investment in academic infrastructure prioritizes resources and that certain parts of the humanities are more likely than others to be good candidates for such investments. We need to question such prioritizations, which are likely to privilege humanistic infrastructure based on a predominantly science and engineering template or on existing infrastructural traditions (such as libraries). Academic infrastructure is not neutral, as illustrated by the omission out of the humanities from much of the policy and practice on infrastructure.

In fact, the humanities has long used academic infrastructure in scholarly practice. Libraries and archives, for example, are often cited as an essential and historically important infrastructure to the humanities. Indeed, some writers claim that the humanities itself makes up vital infrastructure or that elements of cultural infrastructure can function as trading zones for technological, artistic, and humanities practitioners.[25] Humanities infrastructure

can also be tied to science models of infrastructure or to a sense that there is not much infrastructure. Three models for humanities academic infrastructure exemplify the nonneutrality of academic infrastructure: existing infrastructure, the lack of a humanities infrastructure, and a technology- and science-driven infrastructure.

## Model I: Extending Existing Infrastructure

One model of humanities infrastructure is based on the assumption that considerable humanities academic infrastructure is already in place and that this infrastructure is a very good candidate for becoming cyberinfrastructure or being digitized. The European Science Foundation's 2011 report, "Research Infrastructures in the Digital Humanities," traces humanities research infrastructures (RIs) back to the Musaeum in Alexandria, medieval libraries, and art collections—early databases that "provided material for subsequent phases of RIs in the Humanities."[26] Although the report calls for a move beyond the current model, a sense exists that the current infrastructural needs of the humanities primarily relate to this heritage.[27] This picture is also evident in a report by the American Council of Learned Societies:

> The infrastructure of scholarship was built over centuries. It includes diverse collections of primary sources in libraries, archives, and museums; the bibliographies, searching aids, citation systems, and concordances that make that information retrievable; the standards that are embodied in cataloging and classification systems; the journals and university presses that distribute the information; and the editors, librarians, archivists, and curators who link the operation of this structure to the scholars who use it. All of these elements have extensions or analogues in cyberinfrastructure, at least in the cyberinfrastructure that is required for humanities and social sciences.[28]

This fairly accurate description of existing infrastructure largely omits infrastructures outside of libraries, archives, museums, and publication systems and accentuates only some aspects of such institutions and systems—for example, by overlooking the idea of the library as a social infrastructure and a place for knowledge production.

We are thus concerned with a library- and collection-based model. Such a model accords well with a large part of the humanities but also brings a set

of epistemic commitments pertaining to structure, delivery, material types, retrieval systems, selection procedures, the relationship between researchers and library institutions, and other issues basic to the humanities. Any major new investment in academic infrastructure should therefore not be uncritically based on these existing structures and descriptions. This model distinguishes fairly strongly between the collections (institutions, distribution systems, professional functions involved, and so forth) and the researchers and research community. But as Johanna Drucker notes,

> The design of new environments for performing scholarly work cannot be left to the technical staff and to library professionals. The library is a crucial partner in planning and envisioning the future of preserving, using, even creating scholarly resources. So are the technology professionals. But in an analogy with building construction, they are the architect and contractor. The creation of archives, analytic tools, statistical analyses of aggregate data in humanities and social sciences is work only possible with the combined expertise of technical, professional, and scholarly personnel. . . . Modelling scholarship is an intellectual challenge, not a technical one. I cannot say this strongly or clearly enough.[29]

In contrast to much of the discourse of academic infrastructure and digital humanities, Drucker focuses on the scholarly challenge rather than on the technology or technology-induced visions. However, the terms on which this analogy is constructed reinforce specific roles, and the terms *contractor* and *architect* mark clear institutional positions. Will new institutional roles develop, and if so, will they blur the roles described by Drucker and the ACLS report? Along these lines, Christopher Blackwell and Gregory Crane call for institutional change:

> We need new institutions to provide access to the results of our work. Neither the libraries nor the publishers of the early twenty-first century serve the needs that emerge in this collection. While libraries may survive and indeed flourish as an institution, they will do so by subsuming and transforming the functions that we entrusted to publishers in print culture.[30]

It is true that both publishers and cultural heritage institutions are under considerable pressure and that functions will shift and develop over time, although often in directions we might not anticipate. When new generations of

infrastructure are based on traditional infrastructures, we have to be sensitive to the complexities and changing dynamics of those traditional infrastructures. For example, there is an assumption in the above quote that providing access has been and remains a primary and unchanging need not only for libraries and publishers, but for any new institutions in this domain. But is access really the most productive or interesting way to think about the future of these institutions and contemporary stakeholder needs? Cultural heritage institutions as a model is thus not static, and if we are going to model tomorrow's research infrastructure on past or current infrastructure, we must do so critically and with a mind to what tomorrow's intellectual-material needs will be.

## Model II: The Lack of a Humanities Infrastructure

The sense that traditional humanities has very little need of academic infrastructure is illustrated by the way funding is allocated for students in higher education in Sweden, where the price tag for humanities students is much lower than that for students in most other areas. Similarly, the humanities receives little funding for research infrastructure in most countries. In some cases, the humanities does not see itself as technological and retains a "pen and paper" conception of itself. At the same time, some members of the (digital) humanities community realize that needs may be changing:

> Despite a slow and uneven uptake of digital technology in some areas of the Arts and Humanities research, the discipline is no longer based on pen and paper. Specific individual needs of research that relies on the use of advanced technologies must be better understood and matched by a level of support that is already enjoyed by the scientists.[31]

Such reasoning to some extent reinforces the sense that basic humanities relies primarily on technologies such as pen and paper, which is by no means a new argument.[32] This construction shows the humanities as not only relatively free of technology but also hesitant about it or even Luddite.[33] This account also connects to the overall tendency of mainstream humanities to engage with the digital as a study object rather than as an interpretative tool or an expressive medium.

Given this view, the digital humanities often takes on the role of helping or educating the humanities, thus reinforcing the view of the humanities as

nontechnological. Emphasizing slow uptake is a rhetorical strategy for demonstrating the infrastructural needs of the humanities and is commonly used by representatives of digital humanities centers:

> Equally important, digital humanities centers are key sites for bridging the daunting gap between new technology and humanities scholars, serving as the crosswalks between cyberinfrastructure and users, where scholars learn how to introduce into their research computational methods, encoding practices, and tools and where users of digital resources can be transformed into producers.[34]

Such rhetoric plays up the gap between humanists and technology, creating a problematic frame by discursively depicting humanists as technology novices and technology as something very complex. It implies that humanists need to learn and will have to be changed from users to producers, and that teaching them is the job of the digital humanities. Similarly, according to a website for a digital-humanities-related organization, "We show researchers and students with little knowledge of advanced computing how to use new technologies in their work."[35] These statements increase the gap between the humanists and technologies and impose an instrumental connection that does not acknowledge digital humanities work as an iterative intellectual and technological process.

More broadly, the view of basic humanities as having little or no significant infrastructure not only assumes a science- and technology-based idea of what makes up infrastructure but also imposes a pen-and-paper construction of the humanities. Pen and paper, while inherently communicative and collaborative, is also linked to the assumption that humanities scholarship is to a large extent a solitary endeavor (the individual scholar in his or her study):

> Humanities scholars often work alone without collaborators or assistants. In contrast to the cooperative efforts common in the sciences and social sciences, humanities scholarship is the result of solitary research and thought.[36]

As Anthony Grafton points out, most humanities research is not at all solitary, even though authorship is often attributed to one person.[37] One possible con-

sequence of construing the humanities as lacking infrastructure and being a solitary enterprise is a greater tendency to adopt science and engineering models of academic infrastructure simply because there is nothing already there.

## Model III: STEM Notions of Infrastructure

When a science, technology, engineering, and mathematics (STEM) framework is transferred to the humanities and social sciences, attempts occur to align specific STEM tool sets and technologies with the subject areas in question. The starting point is often the research material or the technology rather than the research question. We also need to distinguish between STEM-based infrastructure and STEM-based infrastructure as it is understood by the humanities. In particular, the humanities does not always seem to see the complexity or layering of STEM infrastructure and therefore runs the risk of basing infrastructural efforts on simplified models.

Big data is an example of such a domain being tackled by the humanities. Because of the assumed access to big data, humanists are expected to engage with it, as exemplified by a 2013 call for project proposals issued by the United Kingdom's Arts and Humanities Research Council.[38] Projects under the more costly funding strand

> would need to take a more in-depth approach to their proposed research. They could possibly include visualisations and analysis of big data, creation of new tools and workflows for big data, the assessment of use of high performance computers, creation of artworks and other objects with big data, and may generate new big data. These projects may involve greater collaboration with both academic and non-academic partners and within or between disciplines.
>
> [More generally, proposals should] produce innovative, collaborative projects that add value to the Digital Transformations theme, can potentially have a big impact in the Arts and Humanities, and also raise enthusiasm about the potential of big data to facilitate and support innovative research in the Arts and Humanities.[39]

On the one hand, this call is quite attractive in that it is open-ended, encourages exploratory work, and seeks innovative research in the arts and humanities. I would be delighted if the Swedish Research Council dared to propose

calls of this type. On the other hand, though, there seems to be little substance to the conceptual foundation articulated in the call and the guidance document. The documents offer little intellectual rationale for why this investment would lead to innovative research or even why it is important. Why might such projects have a big impact? The expectations in relation to the more expensive projects (up to £600,000) seem almost naive, and there is little focus on the scholarly challenges or on a deep conceptual rationale.

Furthermore, the call is clearly based on a science model: the first paragraph of the guidance document states that some of the best-known examples of use of big data come from the sciences. The document gives statistics from the Large Hadron Collider, which is said to produce 15 petabytes of data every year and points out that a grid consisting of 140 centers in more than 35 countries analyzes these data.[40] The call, however, contains very little discussion of what the collider does in terms of facilitating research or tackling research challenges. It gives corresponding numbers for other humanities-like datasets: the George W. Bush e-mail archive, for example, consists of 200 million e-mails (80 terabytes).[41] But what, if anything, do these statistics mean?

The call also fails to discuss the perceived objectivity of data or relevant work done in science and technology studies on data. Lisa Gitelman and Virginia Jackson remind us that objectivity, as situated and historically specific, is the result of "conditions of inquiry, conditions that are at once material, social, and ethical."[42] Despite the importance of encouraging exploratory work and engagement with technology, the call has significant weaknesses that come from a combination of starting out with the material, assuming a science model (through a humanities lens), failing to focus on research challenges, and failing to incorporate the critical modality that we associate with the humanities. This is where the digital humanities and the humanities more generally should be involved in discussions with funding agencies, making sure to connect scholarly needs with infrastructure.

Grid computing exemplifies starting from technology rather than the material or data.[43] Questions asked in this context may include: What can grid computing do for the humanities? What large humanities datasets are particularly suitable for grid computing applications? The gap between high-performance computing (HPC) perspectives on grid computing and humanities-based research issues and questions can be very large, and facilitating meetings between the two requires creating a common discursive

space and allowing time for dialogue. A good example of deep thinking about this process is provided by "Mind the Gap," a report arguing that the main gap between HPC and research in the humanities relates to research culture and support:

> On the one hand we have to find ways of training and preparing humanities research teams to be able to imagine using existing HPC facilities, and on the other we have to develop the ability of HPC consortia to be able to reach out and support.[44]

The report recommends that humanists become involved early in the process (as well as in management and decision making). A balance must clearly be struck between discipline- and technology-driven issues and questions, and finding this common ground is not trivial. We also need to acknowledge that technology competence can be very diverse, research-intensive, and complex. Since the discourse of research infrastructure tends to take place at an aggregate level in relation to complex and internally diverse entities such as the humanities or science and engineering, real, grounded encounters can be particularly valuable.

On a more abstract level, concerns arise about aligning academic infrastructure as a project with the humanities and social sciences, as the ACLS report outlines:

> Humanities scholars and social scientists will require similar facilities but, obviously, not exactly the same ones: "grids of computational centers" are needed in the humanities and social sciences, but they will have to be staffed with different kinds of subject-area experts; comprehensive and well-curated libraries of digital objects will certainly be needed, but the objects themselves will be different from those used in the sciences; software toolkits for projects involving data-mining and data-visualization could be shared across the sciences, humanities, and social sciences, but only up to the point where the nature of the data begins to shape the nature of the tools. Science and engineering have made great strides in using information technology to understand and shape the world around us. This report is focused on how these same technologies could help advance the study and interpretation of the vastly more messy and idiosyncratic realm of human experience.[45]

Again here, there is a risk of adopting a science- and engineering-based model for humanities infrastructure in such a way that it significantly constrains and shapes possible research enterprises and directions. Is it possible to discern "the point where the nature of the data begins to shape the nature of the tools"? If so, that point might occur very early, and more may be at play here than the nature of the data. The alignment described in the ACLS report is simply not feasible. As Jonathan Sterne notes, "Disciplines never fully constitute their objects; they fight over them."[46] He argues that these fights are partly what make disciplines maintain their intellectual vibrancy. If the range of data and the study objects are in question, it may be difficult to "process" data up to a certain point and to use generic tools without early involvement from researchers. Furthermore, as Geoffrey Bowker contends, any data would already be part of the information and knowledge infrastructure that is relevant to knowledge production and the creation of tools and technology:

> Information infrastructures such as databases should be read both discursively and materially; they are a site of political and ethical as well as technical work; and . . . there can be no a priori attribution of a given question to the technical or the political realms.[47]

Moreover, the ACLS report seems to advocate a notion of infrastructure very much concerned with incorporating as much data (basically the entirety of our cultural heritage) as possible. Asks Andrew Prescott,

> Is the vision of large quantities of university-created digital content requiring central curation still the most pressing issue? Isn't this a vision more appropriate to 1995?[48]

Academic infrastructure is intertwined with various institutional, social, cultural, and historical layers inside and outside the disciplines themselves. This is the realpolitik of digital humanities. Because research infrastructure often but not necessarily supports interdisciplinary work, it seems particularly important to situate data structures, standards, technologies, knowledge structures, and tools in a broad epistemological context. This is even more important given that infrastructures have a tendency to become invisible over time and that scalability is a commonly assigned property of research infrastructure.[49]

There is a risk that external pressure on the humanities, including the digital humanities, will lead to a positivist, results-driven approach. Here the need to provide motivation for funding agencies and university administration unsurprisingly plays an important role, as Melissa Terras points out:

> I'd just like to chip in and say this is what the funding councils are calling "Evidence of Value"—and are asking us to show evidence for the value of digital humanities research. Its important, as funding cuts in this area (such as the withdrawal of funds for the AHDS) are based on the perceived lack of evidence of value. Unless we can articulate, as a community, the better/faster/more nature of digital, we will struggle even harder for funding in years to come.[50]

Terras's use of *better/faster/more* suggests a view of the digital humanities and associated infrastructure that is in line with the positivist discourse of science and technology-driven research infrastructure. Terras's short, informal statement does not provide arguments that bring in research issues or current disciplinary challenges, which would seem indicative of the methodological and technological focus of traditional humanities computing. A tendency exists to fail to connect humanities infrastructure to research issues, and there is a substantial risk that humanities infrastructure becomes an issue of data and funding rather than research and conceptual grounding.

## Implications

At the same time that external pressures push us to specify infrastructural needs for the humanities, humanities-based interest in academic infrastructure and the digital is growing. Furthermore, the ways that we articulate and implement academic infrastructure for the humanities have strong implications. What happens if we fail to explore multiple visions, focus only on digitizing existing infrastructure, or let the agenda be set through a technological focus or a model strongly based in the sciences?

An overly narrow vision of academic infrastructure will limit the players and participants to those who match the epistemologies embedded in the new infrastructures. Similarly, a singular focus on extending current infrastructure may result in a kind of epistemological conservatism that would foreclose potential new ways of knowing and legitimizing knowledge. And allowing a

science- and technology-inspired model to drive the agenda could result in academic infrastructure for the humanities without a strong grounding in the disciplines, humanistic knowledge production, or the needs and interests of the humanities.

There is also the risk of "epistemic double-binds,"[51] where humanities researchers who want to use the new technologies are caught between the commitments of their academic disciplines and those of engineering, computer science, and science more broadly. Matt Ratto cites an example from computer-supported visualization and modeling in classical archaeology: three groups of scholars and scientists—for different reasons grounded in different epistemic commitments—rejected a project where an immersive 3-D environment was used to question the traditional understanding of the use of terra-cotta materials in a particular form of pre-Roman temple.

> Acknowledging these commitments can help us develop appropriate technologies that help rather than hinder existing research practice, add a layer of reflexivity to researchers' choices and decisions, and ultimately, facilitate productive cross-disciplinary collaboration.[52]

Acknowledging and managing different sets of epistemic commitments is important to big digital humanities, and Ratto's work more generally helps explain why certain practices and modes of expressions meet with resistance in different disciplinary contexts.

Given the infrastructural push and the considerable interest in establishing new initiatives for the digital humanities, a window of opportunity is currently open for articulating and implementing a humanities-based notion of infrastructure. This opportunity needs to be combined with a critical engagement to establish good practice, explore possible models, and have an infrastructural dialogue across the humanities. Building infrastructural platforms is partly a matter of creating alliances and working with other institutions. Libraries and humanities centers would seem to constitute important potential partners. Another possibility is work between other intersectional areas within or outside the humanities, such as environmental humanities, ethnic studies, and urban humanities. The only way such alliances can work over time is if the fields in question share a sentiment, a conceptual grounding, and a willingness to negotiate.

## Sketching Out an Alternative Model

A critical factor for creating humanities infrastructure involves connecting the conceptual level of infrastructures—the underlying ideas—with actual infrastructure in a way that is not too reductive. Doing so can be accomplished using a framework that incorporates three levels of description and analysis. This model draws on existing infrastructure and sees STEM as a possible infrastructural partner, but in contrast to the models discussed earlier, it acknowledges the need for a new conception of humanities infrastructure and the importance of connecting humanistic thinking to material configurations. The model presented here partly overlaps with the notion of intellectual middleware (chapter 3), but is focused on infrastructure and a design perspective.

The first level in this model, conceptual infrastructure, refers to the underlying ideas and visions behind an infrastructural project. Above this conceptual level is the level of design principles, which connect the ideational level with material academic infrastructure. The design principles provide a means of discussing and articulating infrastructural projects without getting caught up in only detailed infrastructure or the abstract visions typical of the discourse on academic infrastructure. The third level is the surface—the actual, material infrastructure.

In this way, actual infrastructure—including space, technology, digital platforms, encoding systems, support and expert functions, research facilities, and low-level material installations—can be implemented with the support of the immediate level of design principles, which, in turn, draw on the level of conceptual infrastructure below. While this model may seem overly ambitious for small installations and for conventionalized infrastructure, such as a traditional classroom intended to be used in a default way or a standard query system for a research database, it can be quite useful when thinking about learning platforms, research spaces, or new ideas for access to digital materials. It encourages us to be clear about the conceptual underpinnings and epistemic scope and to think carefully about how they can be translated into design principles and operationalized in relation to existing infrastructure and planned academic infrastructure.

If successful, such a process would help us articulate our requirements, visions, and ideas in a broad, contextualized sense as well as in relation to conceptual issues and physical and digital implementation. Furthermore, it may help us create an interaction point for people from the enterprise (department, university administration, users) and for people involved in the creation

of new infrastructure and space (architects, hardware and software specialists, contractors, property owners, and sometimes also funding agencies).

Arriving at a conceptual foundation and implementation is often a complex and exploratory process, and it can take many possible paths. In practice, the flow will be iterative, new space and infrastructure can never be built without constraints imposed by existing systems, architecture, and infrastructure as well as existing funding regimes and policies at the administrative level. Such constraints and possibilities need to be presented and negotiated throughout the process. To illustrate this three-layered structure, I use HUMlab at Umeå University as a case study. This is a lab-based example, which means that material space is more important than would be the case for a digital platform and that we are concerned with a specific institutional setup and context (a relatively well-funded comprehensive university in the North of Sweden). However, much of the principal thinking would apply across different types of infrastructures.

HUMlab is a meeting place for the humanities, culture, and information technology and came into being the late 1990s. This meeting place is enacted through physical and digital spaces, technology, and programming as well as through people and through collaborating extensively inside and outside the university. The operation currently incorporates a series of joined lab spaces on the main campus of Umeå University as well as a newer lab space (HUMlab-X) on the Umeå Arts Campus. HUMlab has had a long engagement with virtual worlds, social media, and different kinds of digital environments, including a series of digital platforms built on a concept called faceted browsing. Activist engagement and regional outreach have always been important, but the Arts Campus location has made it possible to scale up this broader engagement.

## Conceptual Infrastructure

A set of conceptual underpinnings has shaped HUMlab's emerging infrastructure from the beginning, although some of them may not have been articulated until quite late in the process. Other parts of the conceptual foundation have developed and changed over the years.

*Meeting place.* The notion of a meeting place is central to HUMlab as an idea and space and was clearly articulated in early vision documents as well as in practice. The design principles included translucence (encouraging contact and having a sense of what other people are working on), flexibility (support-

ing many different kinds of meetings and technological platforms), and intensity (a space and endeavor that attracts engagement and interest). HUMlab has plenty of social spaces (both inside and outside the labs proper), meeting tables, an "outward" design that makes many computer screens visible to others, many large screens, coffee (often free), and a range of software, hardware, expertise, and activities that attract people from different parts of the university and from outside it. The lab is also available to users twenty-four hours a day every day.

A well-functioning lab space can help create a platform for managing and supporting academic infrastructure in that a range of competencies and skill sets is always available, as is (ideally) a willingness to help and share knowledge. The sense of meeting place extends outside the physical lab space, and there are a strong dispersed community, ongoing distributed work, and shared datasets, materials, and tool development. Practices such as curatorship and empowerment channel the power of this infrastructure.

*Multiple modes of engagement.* Another conceptual and epistemic baseline for HUMlab is the interest in multiple modes of engagement with information technology and the digital. The lab has been set up to support work with technology as a tool, an object of study, and an expressive medium—essentially the description of big digital humanities laid out in chapter 3. Although there was no early explicit commitment to these particular modes of engagement when HUMlab was started, there was an openness and flexibility (both in terms of technology and content) that allowed for very different kinds of projects and activities. Much of the early inspiration came from open-ended educational projects. Over the years, cumulative practice and reflection on this practice—also in relation to other international initiatives—resulted in a model of modes of engagement that is part of the conceptual infrastructure of the lab.

This commitment to a range of different kinds of engagement has very direct implications for design and infrastructure. For example, a multiple-mode focus is not compatible with a traditionally instrumental computer lab setup because the space needs to work for activities such as seminars and meetings and must relate to various study objects (digital and nondigital). These elements are also important to bring in researchers and students from different disciplines, not only because familiar elements may be attractive but also because they perform basic epistemic functions such as allowing intellectual exchange and visual enactment of materials.

A commitment to multiple modes of engagement also calls for a varied

technological setup, and HUMlab offers a wide range of technologies for analytical work, visualization, creative work, screenings, and physical computing. The downside may be that it becomes more difficult to allocate substantial resources to single areas (as in a specialized lab environment). More generally, the humanities often seems to need a more diversified and multiplex infrastructure than the kind of science and engineering infrastructure described in policy and vision documents. This a necessity for big digital humanities.

*Multiple perspectives and rich context.* The humanities provides rich cultural and historical context as well as multiple viewpoints and critical perspectives. But visualization technologies and setups often are not designed for such richness, and the humanities needs infrastructure that does not promote only single viewpoints. A simple example would be the single-screen model that prevails in most university spaces. Here the primary associated design principle is multiplexity, and the most obvious implementation would be the screenscape in one part of HUMlab and the underlying technological infrastructure. This screen and interaction space (with eleven screens) has different functions in relation to different projects, activities, and modes of engagement, but the underlying principle is to support critical discussion based on heterogeneity and contextual depth. Another relevant installation consists of an angled screen setup (two screens set at an angle) in what could have been a traditional cinematic setup with a single screen, but is now an environment where one screen can be used to "speak to" or critique the content on the other screen. Imagine for example an immersive 3-D installation being flanked by a critical analysis of the underlying ontology. More generally, the mixed setup of the lab caters to multiple perspectives and epistemic traditions (for example, through different screen configurations, a range of software and digital platforms, artistic installations, physical making stations, tables, and integrated performance space). The implemented infrastructure is intended to stimulate ideas, experiments, and uses, and in this sense the infrastructure is just the beginning.

## Design Principles

One way of approaching an infrastructure such as HUMlab in a more structural and systemic manner is to look at how the infrastructure has been designed and implemented in relation to the ideational underpinning and to

identify overarching design principles. A number of central design principles emerged in the course of the development of HUMlab. While these principles are situated in a specific context, they also have some more general applicability. These design principles can, in turn, be related to the level of conceptual infrastructure.

Design principles are a way of connecting the ideational level with material infrastructure and of facilitating a means of discussing and articulating infrastructural projects without getting caught up in only detailed infrastructure or the abstract visions typical of the discourse on academic infrastructure. The principles are anchored on both these levels. Design principles can be seen as a design-driven operationalization of intellectual middleware as discussed in chapter 3.

Here I discuss four suggested design principles for HUMlab as an infrastructural project: translucence, flexibility, multiplexity, and intensity. While HUMlab had other design principles as well and while these have changed over time, they suggest an anchored and systemic-level foundation for HUMlab as infrastructure and illustrate how infrastructure for big digital humanities can be conceived and implemented. All the design principles discussed below also relate to distributed environments.

### *Translucence*

Translucence has been an important principle in designing the space and operation of HUMlab. This principle relates directly to the digital humanities as a meeting place (conceptual infrastructure), and the basic idea is that it is important to see what is going on in the lab while not resorting to having one large and totally open space. In optics, translucent materials allow light to pass through them diffusely. The constraints and affordances are not only visual, of course: for example, an awareness of whether one can be overheard by other people is an important factor. In a studio (or other) environment, this translates to having a space that that has divisions and separations that allow subspaces to maintain spatial, auditory, and conceptual integrity (to different degrees) at the same time that a sense of what is going on in other parts of the space is retained. This affects possible interactions in several ways.[53] One of these ways is that participants have access to concurrent activities, processes, and dialogues. For example, when the lab or a project is presented to a visiting delegation in the inner glass room, there is a good visual sense of activities and people outside the room. Similarly, people outside this room have a sense

of what goes on inside (and will, for example, be prepared to act when the delegation prepares to leave the inner room). Paul Dourish and Sara Bly's notion of awareness and their porthole system are based on a similar idea, although they emphasize the distributed nature of the system:

> Awareness involves knowing who is "around," what activities are occurring, who is talking with whom; it provides a view of one another in the daily work environments. Awareness may lead to informal interactions, spontaneous connections, and the development of shared cultures—all important aspects of maintaining working relationships which are denied to groups distributed across multiple sites.[54]

HUMlab takes as its point of departure the organization of collaborations across physical-digital boundaries. Seminars, for example, primarily take place in the physical space, but they are almost always streamed live, and there is often a Twitter channel for questions. HUMlab-tagged tweets appear on a secondary screen in the physical space. For workshops and conferences, remote participants are often "beamed in" on separate large screens, giving them individual presence. A more recent development has been to think carefully about the feedback given to remote participants and about their perspective. We therefore use extra cameras to give them multiple points of view and to allow them to see themselves and other remote participants. Designing for awareness and translucence is also quite important in physical space, and many current spaces are "mixed."

In the physical lab, screens (both public and semiprivate) play an important role in representing ongoing work and in bringing in external worlds and materials (portholes). Both HUMlab on the main campus and HUMlab-X on the Arts Campus have large display walls, and they can be connected via cameras, thus creating human-sized digital portholes between the labs. In both labs, many simultaneous activities can take place in such a way that there is a sense of what is going on in other parts of the lab, but there is also separation, thus enabling a sense of copresence and collocation without unnecessary disturbance. Moreover, this arrangement opens up space more generally and helps coordinate collaboration. Translucence is supported through many separate, semiprivate sections as well as through the way screens are positioned to allow a sense of ongoing work. The translucent nature of dividers (e.g., half-height bookcases, hanging absorbents, pillars, screens, and an aquarium) allows dialogue, copresence and some overhearing between sections.

Done correctly, an appropriate balance can be maintained between seeing and not seeing, between collaborations and individual work, and between mutual engagement and individual intensity. With a platform such as HUMlab, it has been critical to create opportunities for continuously connecting these extremes.

### *Flexibility*

Flexibility is connected to the digital humanities as a meeting place and to a multiple-mode engagement with the digital (conceptual infrastructure). A wider range of activities and initiatives can be supported by allowing flexible use of an infrastructural resource such as HUMlab. Work on the design of learning environments and studio spaces often emphasizes flexibility.[55] Simple examples would include the ease of reconfiguring the space and changing furniture around, allowing many different kinds of activities, flexible distribution of media, and a multiplex technical implementation. In short, a flexible setup allows more change in pedagogical, scholarly, and technological practices.

A fixed setup, conversely, has a stronger investment in a particular model or framework.[56] A tension arises between what is flexible and what is fixed, and total flexibility is probably not possible because decisions will always constrain the level of flexibility. A totally flexible space would probably have to be a compromise. Also, some degree of fixedness can be part of good design practice and of deliberate choices to encourage certain kinds of use and activities. In the case of HUMlab and probably many other similar environments, a rather delicate balance exists between flexibility and fixedness. Some of the fixedness comes from a set of basic underlying ideas about what a space is and how it should be used and can be seen as part of the conceptual infrastructure.

In some of the virtual spaces associated with HUMlab, similar tensions can be observed. For example, an art installation and artist (with assumptions of exhibition and controlled space) coexisted in the same Second Life space as people who are continuously doing experimental building, and who fly through the asserted space of the exhibition with, for example, spaceships. Negotiation and curation are often needed to resolve these clashes. More generally, flexibility is a relevant category for analyzing and creating digital environments. Maximum configurability and general access are often thought-after properties in digital humanities systems and tools. However, superficial flexibility can conceal the hard-coded epistemic, aesthetic, and technological

fixity that is often part of such systems. Furthermore, interpretative tools often need to be specific as well as flexible.

### *Multiplexity*

*Multiplexity* is a parameter that interrelates with translucence and flexibility and that goes back to the investment in multiplex perspectives and rich context (conceptual infrastructure). The humanities, richly engaged with a multiperspective, complex, and multilevel subject matter, needs an academic infrastructure that supports these multiple perspectives, complex datasets, and heterogeneous contexts. In HUMlab, multiplexity in this sense is facilitated in particular through the screenscape in one part of the lab. It allows simultaneous engagement with many types of materials, ideas, and perspectives through the screens, interaction technology, sensor technology, and audio. Furthermore, multiple screens can have a more empowering function than single screens. Where there is just one main screen, it is traditionally controlled by a teacher, who thus holds all power over how that screen is used. With many screens, as in HUMlab's screenscape, that control can be held by a single user or by many, and in either case, many screens can be used at the same time. A fundamental difference exists between, one the hand, having eleven slides presented on eleven screens in the space and moving among these slides (and screens) physically in the lab and, on the other hand, doing a series of eleven slides on one screen. The multiplexity of this system is not only dependent on the physical screens, but also on the software layer and on digitally based content.

Other related infrastructural projects in HUMlab are more wholly software-based. Multiplexity is a central design principle for the faceted browsing system developed in HUMlab, which enables navigation of complex data sets. This web-based system allows users to select and show many facets (variables) at the same time. The resultant view or views depends on the selection of facets. The facets are displayed in the web interface, which makes live interaction with complex data sets possible without losing track of the complexity and heterogeneity of the material.

HUMlab also supports multiplexity through the many different kinds of meeting spaces, technological implements, and workplaces in the studio space and through digitally supported spaces. The mix of workstation setups, couches, private nooks, glassed rooms, almost insular furniture, and different types of studio spaces is a critical component for the operation. The fact

that the two main labs are quite different (although built using similar design principles and conceptual foundations) is a clear asset. However, they have also been shaped and inflected by the hyperlocal context and conditioning. Another factor that plays into the difference between HUMlab and HUMlab-X is the historicity of the spaces. HUMlab was built in the early 2000s in an old exam hall below the university library, quite literally shaped by the rotunda outside the library, with alcoves adding to the complexity of the space. HUMlab-X, in contrast, was built around 2012 in a complex where new structures were juxtaposed with repurposed industrial space. In some ways, allowing multiplexity in the new space, which had to be created from scratch, proved more difficult than in the old one.

In addition, the technology setup is multiplex in that it includes a variety of technologies, systems, and software. Students commonly give this varied setup as an important reason for working and studying in HUMlab. Most technology-rich labs at the university are either generic (basically providing browsing, word processing, and printing) or program- or department-specific (and highly restricted, such as 3-D–modeling labs in the computer science department). One idea underlying HUMlab is that a varied technological setup can facilitate exploration and many different types of activities and crossover effects.

### *Intensity*

Intensity involves the importance of having infrastructure that is not too linear, orderly, or sterile—that is, academic infrastructure that stimulates engagement. This is an important property of digital humanities as a meeting place (conceptual infrastructure).

William Mitchell has discussed the importance of supporting intense and exciting experiences through designing appropriate spaces. One key parameter mentioned by Mitchell is variation and diversity (which basically relates to all the design principles discussed earlier).[57] It is, of course, impossible to pinpoint exactly what combination of features gives a space such qualities, but nonsterile and heterogeneous spaces seem more likely to evoke this kind of sentiment, and a sense of energy can be derived from having many (different) people share the same space, from ongoing creative work, from a sense of process, and from a culture that supports collaboration, community, and dialogue. Although I focus on physical space, intensity is also a property of distributed environments and media ecologies.

Architecture is set up around a typology of spaces, and a standard type for higher education is the classroom. Traditional classrooms tend to have a fairly low degree of intensity. They do not normally reflect ongoing work to a large degree and tend to be nondescript and standard. When the class is over, the norm is typically and understandably that the room should be left tidy and organized (and thus fairly devoid of rich context). Traditional learning spaces are also often horizontal in the sense that floors and ceilings are rarely used beyond their obvious core functions; they are not seen as important design elements in a nonlinear space.

Another architectural type of space is the lab, which can have many different configurations. Labs associated with the domains of digital media, visualization, and associated methodology tend to appear somewhat sterile, particularly because they are large, rectangular, and fairly monofunctional. They are often organized around specific sets of equipment such as visualization walls. Studio spaces, conversely, typically reflect ongoing processes and are hence more contextual and untidy. As Daniel Fällman stresses,

> While each and every piece of among the multitude of material objects that appear in a progressive design studio seldom by itself has a strong or even explicit link to an aspect of the project at hand, they as a collection seem to conspire to create the rich environment needed to stimulate creativity and create novel ideas.[58]

Design studios often contain sketches and prototypes that provide a sense of process as well as points of display and discussion. Daniel Buren similarly emphasizes how artistic studio spaces can contain a collection of visible materials that creates a sense and understanding of process.[59] As a set of disciplines, the humanities are much concerned with rich historical and cultural context, which would seem to be well in line with a highly contextual space. If this space is also flexible, it may allow for shifting contextual landscapes (for example, through dynamic screens) as well as a more static or semistatic context.[60]

People are the most important reason why any space or digital platform is experienced as being intense and engaging—for example, through flows of people gathering for project meetings and other activities or for doing their own work as well as through a constant influx of new people such as visiting postdoctoral fellows and guest speakers. Most digital humanities operations and spaces will benefit from including undergraduate and graduate students, which is probably one of the best ways to enable intense and productive work.

Exciting exchanges of ideas also come from careful programming, which often both depends on and enables active space. Programming for intensity can involve facilitating many simultaneous activities, or condensing time by asking everyone interested to be present for a couple of hours every week on a given day. Intensity is not a constant and it is important to give time and space for different paces, processes, and work practices.

Furthermore, integration of external materials and distributed presence is important in this context. Physical elements can clearly play a significant role here—HUMlab has a neon sign outside the lab, beanbags, inviting couches and tables for meetings and coffee drinking, tall immersive couches for individual work, pictorial mats, an oriental rug, a pink lamp, designer wallpaper, whiteboards, plants and a plant wall, and a large aquarium. These elements can be just as critical as computer workstations and visualization walls in supporting a collaborative, engaging technology-rich environment, but their meaningfulness is also contextual and situational. Beanbags and designer couches will not automatically produce an attractive studio space.

## Material Infrastructure: A Screenscape Further Explored

Lev Manovich has explained how having access to the visualization environment HIperSpace at CALIT2 at the University of California at San Diego has made new ideas or directions possible:

> HIperSpace is the reason why I am able to think of being able to map and analyze global cultural patterns in detail. I would not ever think about it if I just worked on my laptop screen.[61]

While facilities such as HIperSpace and HUMlab are very flexible and generate ideas, uses, and experiments beyond what could be envisioned at the start, users and uses are also constrained by the way these infrastructures have been conceived and implemented. That is part of the conceptual infrastructure. HIperSpace is a very large tiled display made up of many small screens—basically a large rectangular screen with internal boundaries caused by the frames of the individual screens. It is the front end of a large computer resource, an optiputer, and the main overarching goal is to "examine a 'future' in which networking is no longer a bottleneck to local, regional, national and international computing."[62] The boundaries are seen as eventually becoming reduced and perhaps disappearing altogether, thus creating one large seam-

less display. This is not just a technological development but an aesthetic-technological ideal that strongly suggests that one screen is better than many frames making up a large screen.

HUMlab, conversely, has invested in allowing both big display walls and smaller visually distinct screens. The frames of the screens are thus quite important, as is the positioning of individual screens at the periphery of a large space. On a very large screen, such as the HIperSpace installation, a number of different materials, sources, and windows can be displayed, so the individual bits will be framed on the screen, but this framing is internal to the screen. This relates to what Anne Friedberg calls "multiplex frames" and Manovich's earlier discussion of computer windows and is rather different from having separate screens with "heavy" frames.[63] This difference is equivalent to someone working on a laptop screen showing a word processor window and a web browser window (showing a secondary source) versus someone working on a laptop showing only a word processing document while a web browser appears on a separate tablet computer. This change is more significant than just organizing the "same" content differently; it is about the two arrangements affording different kinds of interactions regarding and relations to what is inside the computer/s.

A somewhat related paradigm for visualization is virtual reality (an earlier generation of privileged infrastructure), which often tries to remove the frame altogether:

> The visual (and aural and haptic) displays that immerse the user in the virtual world and that block out contradictory sensory impressions from the real world.[64]

In some ways, the distributed screenscape of HUMlab is the opposite of such virtual reality manifestations. In HUMlab, sensory impressions from the "real" world are quite important, and the screens are integrated in a lively studio environment, potentially making the screens less "aggressive" than in many other visualization environments.[65]

This part of HUMlab borrows elements from visualization spaces as well as from traditional seminar, studio, and exhibition spaces, and the collaborative affordances (whether or not in relation to technology) are quite important. In addition, the screens have their own identity and framing. The epistemological stance thus differs radically from that of many virtual reality environments where the users, as Dan Sandin, coinventor of the CAVE (Cave

Automatic Virtual Environment), points out, "in a sense, view things from inside the scene."[66] In other words, there is arguably no frame:

> There would be no screen between the user and the information and no way for the user to step back and contemplate the screen at a distance, because she would be wearing the screens as eyepieces that completely covered her field of view.[67]

This is reminiscent of the discourse surrounding recent products such as 3-D TV sets and the Oculus Rift headset, which is said to allow one to "seamlessly look around the virtual world just as you would in real life."[68] In contrast, HUMlab's screenscape installation seeks to bring together multiplex frames (digital screens that contain separate elements such as windows) and multiple digital screens in a held-together screenscape. Each screen can be run individually in the screenscape, be part of a large "computer desktop," or be part of a video-signal level desktop or extended space (which can include video, computer, and other sources). The screenscape as a whole is situated in a large studio space with a seminar table in the middle of the room, supporting a range of practices and uses—traditional seminars (using no or little technology), individual researchers using their workstations with one or several screens, research groups using the large high-resolution touch screen collaboratively and in a distributed fashion with remote datasets and researchers, students using three screens to discuss different solutions to an assigned problem, and even large interactive art installations using screens, sensor technology, and spatial audio.

As digitized material becomes increasingly available, a screenscape can help philologists and art historians display and interact with manuscript pages or pictures. Researchers in environmental archeology can pull together large datasets, diverse materials, and visualized data models and use a large, high-resolution screen to work with the data model (zooming, modifying, interrelating the model with data sources), locally or together with remote research centers. Site-specific art installations can be created in the space. Students who have built virtual exhibitions in Unity can show their individual or their group's slices of their virtual world on screens. Events such as indie game evenings can use the screens to allow people to interact with a range of games, and in an associated presentation, individual games can be moved to the large screen and juxtaposed as part of a comparative and analytical process. Other events may bring in remote researchers through different types

of virtual environments, Skype sessions, and visualized datasets. Thematic screenings of films can be facilitated. An upcoming seminar with an international guest speaker can be contextualized through a curated selection of images, video clips, texts, and web pages.

More generally, complex scholarly environments for humanistic research can bring together analytical tools, distributed materials, representations, and ways to tackle central research challenges in a studio space as well as in associated online environments. One example is a research project that explores the Virgin Mary as a role model in medieval Sweden through a multiple-place installation built on experience and a preromantic sense of aesthetics.[69]

An interesting interrelation exists between the humanities and technology-supported visualization and representation, and the associated academic infrastructure comes with certain epistemic commitments. However, uses also grow from implementation and experimentation. Multiplexity and framing are critical factors in the conceptual infrastructure associated with the screenscape installation in HUMlab. HUMlab differs from virtual reality manifestations where there is ideally no frame (from the inside) and from installations such as the HIperWall (basically very large multiplex frames). Friedberg suggests a taxonomy of variables based mainly on a cinematic perspective, but her examples are limited to cinematic representations (such as Charles and Ray Eames's *Glimpses of the USA* exhibition at the 1959 Moscow World's Fair). Friedberg's discussion of computer screens seems to suggest a one-screen (multiplex frame) paradigm:

> The Windows interface is a postcinematic visual system, but the viewer-turned-user remains in front of (vorstellen) a perpendicular frame.[70]

This view is challenged by the increased use of many linked but individual screens (available on Macintoshes from the late 1980s and on Windows since the mid-1990s). Beatriz Colomina's analysis of the Eameses' multimedia architecture shows how separate video screens, although not one screenscape in a technical sense, can create a thematic and performative whole.[71] With seven enormous screens and seven individual images per screen plus one final image, *Glimpses of the USA* included a total of fifty images. They were presented in thematic bursts in a highly coordinated and very carefully planned installation. Although this arrangement does not make the individual frames visually multiplex at any given time, frame-internal multiplexity is achieved temporally.

The HUMlab setup explores the importance of having multiple screens and multiplex frames at the same time and how it relates to the essence of the humanities: rich cultural and historical context, heterogeneous qualitative and quantitative materials, different modes of representation and presentation, shared presence, and multiplex perspectives. Multiple screen environments of this type are rare, and HUMlab exemplifies how the humanities can marry a conceptual foundation (an idea) with a technological implementation in a way that is not very likely to happen elsewhere.

Nevertheless, while screens can be seen as interactive surfaces that serve as interfaces to computational worlds and bring in nonvisual modalities such as audio and touch, these display solutions exemplify a visual bias that is common in the digital humanities and research infrastructure. One way of counteracting this bias is to actively engage infrastructurally with other modalities. HUMlab is also investing in new screen- and performance-based experiments, partly because of ongoing research on screen infrastructure, including a tripartite display wall that shares space with a church organ.

This installation draws on much of the rationale for multiplex screens, but it is one screen (built by modules), and the three parts are demarcated by the shape of the display. The screen's triangular shape is partly inspired by the triptych form commonly associated with early Christian art and altarpieces as well as with Northern Renaissance painting.[72] A triptych screen allows experimentation with center and periphery in a way that cannot be done on a regular rectangular screen. When bringing in remote participants, for example, active speakers can appear on the main part of the screen while "silent" speakers can appear on the side parts. Also, the setup supports three-part storytelling, with, for example, the side parts supporting the main narrative.[73] If immersive virtual environments were the antithesis of the eleven-screen screenscape, the corresponding frame of reference for the triptych screen would probably be large-scale cinematic display walls.

## An Infrastructural Agenda for Big Digital Humanities

Big digital humanities, with its multiple-mode engagement with the digital and interest in serving as a meeting place, seems to align well with the infrastructure turn. Building academic infrastructure is partly a matter of channeling resources, and the digital humanities can offer a platform for pulling together technological, intellectual, and personnel resources. Such platforms are material, whether mostly physical or mostly digital, and their materi-

ality matters. If they start out from a humanistic sensibility and intellectual challenges as well as from technological engagement, then they can enable, stimulate, and enact the humanities as a scholarly and educational endeavor. They have to be critical in the sense of embedding critical perspectives and interpretative capacity, but also in the sense of enacting critical perspectives on themselves, including environmental and equality dimensions.

This endeavor obviously cannot succeed without people, and infrastructure constitutes more than just devices and cables. Postdoctoral programs, residency programs, technological expertise, methodology workshops, teams of doctoral students, and high-quality support can be as important as technology. Whether such human infrastructure can be packaged together with the technology is a matter of the framing of infrastructure and funding agency constraints. However, provisions must be made for such costs within a given initiative or project. In some cases, universities can provide such resources as matching funding. In other cases, it might be worthwhile to package infrastructure as one part of a larger bid that includes, for example, residency programs and high-level technology support as well as the infrastructure proper.

Since infrastructure is so institutionally, culturally, and politically embedded, discussions of academic infrastructure necessarily tend to be fairly strategic. But offering a more nuanced and multilevel argument for infrastructure enables us both to engage with building infrastructure and to think carefully about the conceptual underpinnings. What is the intellectual rationale for having this type of infrastructure? Why should proposed infrastructures make us excited as scholars, educators, and students? Do we even need such infrastructure? What is the environmental impact? Does humanities infrastructure only relate to humanities, or would it make sense to think about infrastructural platforms more broadly and work with other areas?

One advantage of thinking of digital humanities labs as infrastructural platforms instead of focusing on more specific instrumentation or operations is that labs can be more versatile and can accommodate a range of technologies, groups, and uses. This strategy also makes it easier to include components that can be important to the humanities but that may be difficult to immediately classify as infrastructure. Simple examples include a seminar table, cheap technology, flexible workshop space, or new methodologies for digitization. It is increasingly likely that the diverse infrastructural repertoire of the humanities will include layers of distributed resources, physical computing devices, and material sites for the purpose of play, learning, research, collaborative work, individual projects, and ex-

change within and outside the humanities. Such infrastructure must have an ideational grounding, be maximally available, and support education and research in the humanities. In some cases, it might be advantageous to also have strategic collaboration with existing infrastructure such as libraries and humanities centers or with platforms such as environmental humanities and urban humanities.

Academic infrastructure is about material installations, people, staffing, programming, and ideas. Material infrastructure ranges from mostly physical to mostly digital and will almost inevitably play out in digital and physical spheres at the same time. This said, we need to acknowledge the considerable difference between a digital humanities operation centered around a lab or center and an infrastructure that consists mostly of databases, digital tools, and web services. Digital humanities labs can be very useful as an infrastructural platform, particularly if they are broadly conceived, technologically experimental, and intellectually heterogeneous. They allow integration of many different resources (physical, digital, and intellectual). Labs (or studios) do not have to be large, heavily technological spaces, and some of the most convincing operations, like the Transcriptions Center at University of California at Santa Barbara, are fairly small-scale with high intensity. This does not mean, of course, that the physical lab or studio is the only possible model.

Alternative models include EU-funded infrastructures such as Dariah and Clarin, the thematic humanities laboratory model employed at Duke University, authoring platforms such as Scalar, and online publishing initiatives such as *Debates in the Digital Humanities* and HASTAC, a very powerful, distributed network for intellectual discussion and work.[74] The key factor is to link ideas and a conceptual foundation to material infrastructure. Doing so is not as easy as it may seem, but it is crucial.

Humanities infrastructure includes labs, libraries, software systems, networks, academic programs and projects, publishing and distribution systems, humanities centers, staff, faculty, and students. The humanities has been unwilling to see itself as infrastructural for several reasons. First, infrastructure is assigned to the domain of science, technology, and engineering both in the sense of being located there and as an object of critical inquiry separate from the humanities. Second, the humanities has been reluctant to engage with its own modes of knowledge production critically, which has contributed to inscribing it as a place without infrastructure. Third, the humanities is locked into a construal of itself as institutionally underprivileged and threatened, which is not compatible with acknowledgment of existing infrastructure.

Finally, it can be argued that the humanities as a whole lacks the capacity to imagine and implement intellectually driven infrastructure.

The landscape is changing, however, and institutional actors such as the digital humanities and humanities centers can be transformative agents. There is an opportunity for the humanities to think about infrastructure as an opportunity to create intellectual agendas, a multivalent humanistic platform, grounded outreach, and new modes of material engagement and interpretative frameworks. Making academic infrastructure is ultimately an intellectual challenge.

## Conclusion

Academic infrastructure is culturally, institutionally, and technologically situated. The humanities needs to shape not only its own infrastructure but also the frames and discourses associated with it. Neither existing humanities infrastructure nor science and technology may be a useful model.

It would be sensible to think carefully about the ideational underpinning for the humanities in relation to what may be subsumed under the rubric "infrastructure." Such conceptual infrastructure can be related to design principles that in turn can be translated into actual built infrastructure. The humanities must engage critically with academic infrastructure while being involved in conceptualizing and building infrastructure. This is a key challenge for the digital humanities, and big digital humanities is well placed to serve as a powerful and suggestive infrastructural platform. This challenge cannot be met, however, without intellectual drive, scholarly and educational interest, and a multilevel investment in making the digital humanities.