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Evolving Interactions: Agile design for networked media performance

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ABSTRACT

Network Jamming systems provide real-time collaborative performance experiences for novice or inexperienced users. In this paper we will outline the interaction design considerations that have emerged during through evolutionary development cycles of the *jam2jam* Network Jamming software that employs generative techniques that require particular attention to the human computer relationship. In particular we describe the co-evolution of features and uses, explore the role of agile development methods in supporting this evolution, and show how the provision of a clear core capability can be matched with options for enhanced features support multi-levelled user experience and skill develop.

INTRODUCTION

Live media performance with computers has been a growing cultural trend, especially with youth, over several years. Our project has tried to understand how these experiences can be made accessible to young people, what the social and educational benefits of media performance might be, and how a media performance system should be designed to best achieve these outcomes.

Based on our previous experience as musicians we began the design process with the assumption that collaboration and social interaction was an important catalyst of engaging performance experiences. A software system called *jam2jam* was devised that allowed collaboration via generative digital media applications connected over a local network or the internet. To ensure ease of use for young people few assumptions about prior musical experience were made and control was limited to simple parametric changes of the generative processes. Generative systems are used to semi-automate the content creation processes and when these are combined with human collaborations the understanding of cause and effect can become a complex interaction issue. On this conceptual basis a series of *jam2jam* software systems has evolved. We will draw upon several *jam2jam* software iterations as case studies in this paper. These studies serve to describe the journey toward

understanding the experiential requirements for performing with collaborative media systems; a practice we call Network Jamming.

We believe that Network Jamming provides a great vehicle for young people to develop media literacy and “for children it potentially provides a way of making sense of the complex world of media that they are immersed in through collaborative improvisational performance” (Dillon, Adkins, Brown & Hirche 2008). This seems particularly important in the 21st century where an emphasis on numerical and text literacy continues to distract educational systems from the significant role of media in contemporary communication. Lawrence Lessig draws a parallel between this modern representational discrepancy and an age where the Latin language dominated educated activities while English, French, German and other languages were in common use by almost everyone for day to day communication. For him, “Text is today’s Latin” (Lessig, 2008:68) and media literacy’s are being overlooked. Our research has explored how generative media systems can assist to provide access to experiences that help people make sense by improvising with expressive media.

The original *jam2jam* system was designed as an innovative feature of a children’s music festival in 2002. The objective of providing access to rich media performances, unheeded by geographic bounds through internet connectivity, has remained true throughout the development of the system.

At the heart of the *jam2jam* software is a generative media engine. This provides a constant music and visual stream which is controlled by users. It is the collaborative ‘remixing’ of the generative media stream through the control of algorithmic parameters that occupies the network jammer. Remixing has become recognized as a valuable activity, especially for younger people. Palfrey and Gasser, in their examination of the generation they describe as ‘digital natives’ because of their immersion in digital culture, comment that “remixes allow Digital Natives and others to interact with cultural objects in a way that effects how cultures develop and are understood” (2008: 115). While Lessig argues that “there are two goods that remix creates, at least for us, or for our kids, at least now. One is the good of community. The other is education” (2008: 77). He argues that it is in the contexts of community arts, where people remix with and for one another, and education, where it is a strategy to excite interest-based learning, that remixing has greatest

value and it is these contexts where our trials of jam2jam have been directed.

A single user can interactive with the generative processes in a jam2jam client, and jam2jam clients can communicate over a network such that any and all changes made are reflected on every client system; the creative responsibility is shared between system and all users and there is no escaping the implication and responsibility of the synchronous relationship. In some ways Network Jamming is like a media instant messaging chat where everyone messages each other in parallel. The jam2jam software started as a music jamming applications, but has recently added real-time video and image remixing, and Network Jamming activities have acquired overtones of DJ/VJ night-club remixing culture that resonated with a youth audience.

An additional complexity in the development of jam2jam was its use in community arts and educational settings that bought with them their own sets of expectations and demands. We observed a tension between social and musical/ media knowledge outcomes that was also played out in the perceptions of the interface, function, and usage design. The blending of these formal and informal cultural contexts provided a rich experience topology for the design team to navigate.

There have been several distinct versions of jam2jam. These occurred when the flow of design iterations became too turbulent to maintain a logical consistency. At these times a fork of the project occurred, often coinciding with simultaneous changes in technology, media and user contexts. This version history is outlined in figure 1, and more details of the journey are provided later in the article.

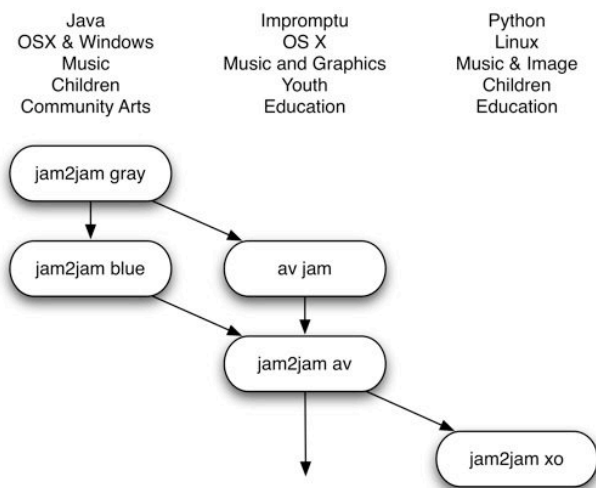


Figure 1. The jam2jam family tree of development.

BACKGROUND

At one level the jam2jam system is a musical (now media) instrument, and shares in the benefits and frustrations of a history of instrument making that is much too broad to consider in any detail in this context. Suffice to say that, like most musical instruments, jam2jam has undergone consistent refinement and

modification. As an instrument, development of jam2jam has not been bound to satisfying specific functional goals, but rather development has responded to feedback from people using jam2jam in creative situations.

Unlike most musical instruments, jam2jam is a semi-autonomous media machine, that offers a unique partnership with and between the performers. The generative media processes in jam2jam provide a set of rules that when imposed on media through a simple interface can affect expressive changes in the output. The approach is to embed in the software a range of musical and visual attributes and culturally-specific media transformations, that will become understood by users through engagement with them. In jam2jam, a user chooses a musical and/or visual feature, such as volume or density in music or crossfade or Kaleidoscope visual effect, and controls the level of these features as their contribution to the performance. Interface gestures facilitate these changes in the parameters. These gestures can be controlled by any number of physical or virtual interfaces ranging from dragging a graphical slider or icon with a mouse to waving around a Wii controller.

Network Jamming performances involve improvisation rather than reproduction of a ‘score.’ In looking at the idea of Network Jamming as improvised performance we claim that “the network is the ensemble”, to co-opt a marketing phrase from Sun Microsystems. As a computational device, the jam2jam system provides discrete control over media parameters, such as pitch, rhythm, colour saturation, rotation, and so on. The ability to treat these parameters distinctly and in coordination is significant to the pedagogical potential of the system. This is enhanced by the ability of jam2jam to record and reply video clips of performances. Jam2jam provides an opportunity to demonstrate embodied knowledge through exploration in performance and, when recorded, provides an artefact for sharing and reflecting.

There is also, of course, a technical aspect to the design and development of the jam2jam family of Network Jamming software systems. The project team approached development as they would a performance, providing themselves with hard deadlines in front of real audiences, and ‘tours’ where development processes were road tested to new audiences in rapid succession. This approach shares many characteristics with what is now called agile, or lean, software development. It also spurred a dynamic research approach, that has been characterized as software development as research (SoDaR) (Brown, 2007).

This approach has had the effect of drawing genuine user input into the design and redesign of the interface and the implementation of features. Alongside this agile development approach we have also considered the Network Jamming environment as a system that includes users, teachers/coaches/facilitators, a physical and virtual venue, and a wider community. So, alongside software development as research, we have simultaneously developed pedagogical frameworks.

The learning opportunity of Network Jamming is to help 'making sense' of 21st century media production through participation. The Network Jamming project has been guided by an approach that seeks to understand creative experiences that we call 'meaningful engagement'. The theory of meaningful engagement considers the psychological and cultural commitments of participation in the arts, design, and other creative activities. It is often visualized as a matrix, as shown in figure 2.

	Appreciate	Select	Direct	Explore	Embody
Personal					
Social					
Cultural					

Figure 2: The Meaningful Engagement Matrix

The meaningful engagement matrix uses the following terms for modes of creative engagement and the types of creative meaning.

- Appreciate – attending carefully to or analyzing a creative work
- Select – judging the value and appropriateness of materials or outcomes
- Direct – leading a creative activity
- Explore – searching through possibilities for creation and manipulation
- Embody – being engrossed in and fluent with a creative task
- Personal – intrinsically enjoying the activity
- Social – developing relationships with others
- Cultural – feeling that actions are valued by the community

The meaningful engagement matrix provides us with a lens to examine how participants interact during music making experiences. It also allows us to identify the location of meaning in the experience.

Having laid out some of the important intellectual territory this project seeks to navigate, we will now turn our attention to the more concrete matter of the jam2jam version history as a series of design case studies.

CASE STUDIES

The evolution of jam2jam development involves a series of related case studies (versions) that show how design choices support Network Jamming experiences. The case studies also describe the co-evolution of designs and uses. Through this study it becomes clear how different contexts and audiences draw out the creative affordances of particular features and how they prompt the inclusion or suppression of design elements. The role of agile design approaches in managing this evolution becomes clear through the extended case study exploration that

includes changes in computational algorithms, interface, development environment, and delivery platforms.

The evolution of the jam2jam software versions tells a story of the development of our ideas and understandings about interaction principles for media performance. An overview of feature changes is provided in figure 3 and includes shifts in graphical user controls, dropping of text-reliant features, addition of video and image capabilities, refinement of networking connections, support for several input-output protocols, and rebuilding from scratch on different platforms with different technologies.

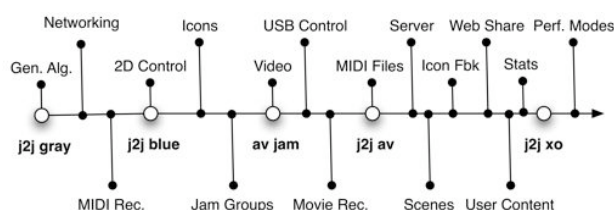


Figure 3. A timeline of the jam2jam feature evolution

During this project we have used a number of methodological strategies. We have already mentioned theoretic frameworks and agile development. For data collection we have extensively used videos of user trials and interviews. We will now examine how each of these strategies is part of our research approach.

We have been concerned to provide users with meaningful engagement with creative media making and each other through Network Jamming. It is our contention that a rich creative life is one that includes experiences that cover a wide range of meaningful engagements. In a practical application, we use the meaningful engagement matrix (figure 2) during data analysis to check to what extent this breadth is present in any particular activity. We then look to understand how the pattern of engagement may be enhanced through changes to either the software or experience design.

In many cases the pragmatic, collaborative and responsive practices that characterize agile software development have been used since the advent of computer programming. In particular, dynamic coding environments that have been used for many decades by the Lisp family of languages, and are cases in point. However, in contrast with this, an orthodox practice of waterfall development has been well established where a complete specification precedes coding on the assumption that this will save time overall. In a partial reaction against this orthodoxy the Agile Manifesto (Beck et al. 2001) was developed with a focus on constant feedback and adjustment and on collaboration rather than clear separation of duties and lines of communication. Curt Hibbs and his colleagues provide the following summary; "The agile approach combines responsive, collaborative people with a focus on demonstrability, concrete goals (software that actually works). That's the spirit of agility" (Hibbs et. al 2009:2). This approach to software development is particularly appropriate in a research context where the speed of design and testing iterations is critical.

Throughout the development of various jam2jam versions we have regularly relied on analysis of video from field trials as a core of our research data. This became most sophisticated when we were testing a range of interface alternatives during trials of jam2jam blue. For this we employed the use of ‘Kid-Cam’; a multi-camera set up that recorded several streams of data including audio recordings of the performed sounds, a video of screen activity, and an overall video camera directed at capturing the group’s activity. In order to manage these multiple streams we use the Interact software to synchronise, code and meta-tag these multiple streams of audio-visual data. This method provided a breakthrough that enabled us to track detailed observations of interaction and to analyze users conceptual development and interactions. These processes are more fully described in previous publications (Adkins et al., 2007). Data was also captured from video recordings of interviews with stakeholders including users, teachers and facilitators, developers and researchers.

Recently we have added the ability to capture network data traffic to create statistical mappings and visualisations of session interactions; all gestures and network traffic during a session can be captured. There has yet to be significant analysis of this data, but we are excited about the possibility of using this for further triangulation of our qualitative data.

In the following sections the evolution of the system will be unfolded. We will provide some details on each version of jam2jam, including their features and what we learned from them.

Jam2jam Gray

The first version of jam2jam, now known as jam2jam gray was a music-only system developed as an internet-focused activity for a children’s music festival.

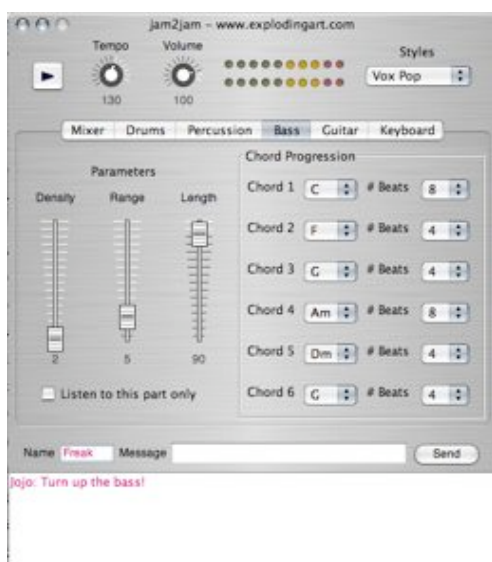


Figure 4. The jam2jam gray interface

The objective of jam2jam gray was to create an engaging ensemble music experience for children with little formal musical training. From the outset this first version of jam2jam established the basic features of user-

controllable real-time generative music processes and synchronisation of state over a network. Jams involved real-time improvisation, the results of which could be saved and rendered to CD for users to take with them after the session. Musical styles included in jam2jam gray focused on popular music genres identified as favorites amongst the target audience.

The interface (see Figure 4) consisted of a fairly standard graphical user interface for the time (early 2000s), that included a series of tabbed areas, (one per instrument) with sliders, dials, and popup selectors that mapped to the various algorithm parameters. The controls were labeled, with the intent that the names of parameters and their associated musical effect would be learned as users played with the system. The interface included a text-chat area with simple instant messaging capabilities between networked systems.

The target audience were young children, ranging from about 4 to 8 years of age, with an unknown (assumed to be minimal) formal musical training.

The system was first used as part of a week-long children’s music festival. Data about the trials was gathered through observation, video documentation, written questionnaires and informal interviews with children, parents and educators. There were many more workshops conducted with the jam2jam gray over several years involving hundreds of children.

The interest of children in the activity was quite apparent and the immediacy of producing a significant musical result from the generative system was the main contributor. Typically workshop sessions were about 30-60 mins in duration and user focus was easily maintained over this time. Inter-generational collaboration between children and their parents was surprisingly high. The interface was found to be generally too complex for the target audience, but the level of detail probably assisted with parent’s interest in participating. Younger children lacked the dexterity to easily control the slider and dial interface elements with a mouse. On many occasions parameter adjustments were too subtle to be easily heard, and so a ‘solo’ button for each part was added during the trials in an attempt to alleviate this. The text chat feature was attractive to users but was eventually deemed to be both a distraction from music making and often required literacy skills beyond the target audience. An option to hide the chat window was added as a result.

In this first version a fundamental design pattern was established, that musical knowledge could be embedded within a generative algorithm, the learning design could revolve around drawing this knowledge out through control of algorithmic parameters, and users would develop a language around this understanding.

Jam2jam Blue

In an attempt to make jam2jam more compressible to the young users we conducted trials with three much simplified interfaces, one of which is shown in figure 5. Simplification was deemed necessary both conceptually and gesturally.

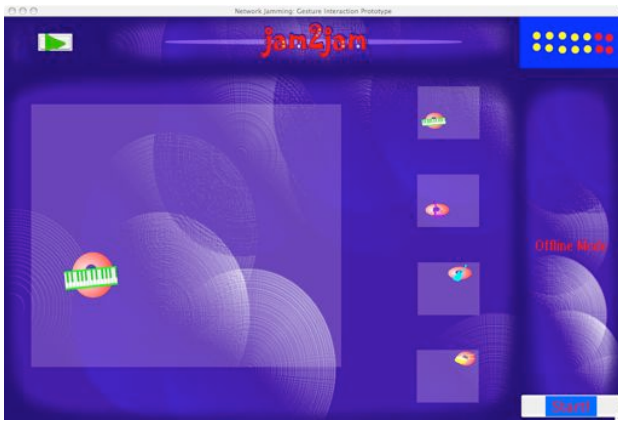


Figure 5. A jam2jam blue interface prototype.

This interface replaced text with icons and employed a simpler, more game-like, appearance. There was significant remapping required to link the restricted gesture set and the algorithm's musical parameters. The parameters were limited to between two and four depending upon the interface version. This allowed experience design to be focused around a limited set of musical concepts.

Language development was provided through discussion with workshop facilitators and musical knowledge was gleaned from free play and semi-structured ensemble performance. Finally, the networking was rewritten to easily support 'buddy' lists and small groups of users on the one network. Musical content remained the same as for jam2jam gray. A variety of interfaces were designed and implemented for trial. All these included one screen, without tabs because these were often not understood in previous trials, and large icons were used rather than conventional sliders and dials. Text labels and instant message features were removed from the interface because it was decided they were more of a distraction than an assistance to young users engagement with music making.

The target user audience was primary aged children, from ages five to eleven years of age, slightly older than the previous trials in recognition of the skills the system required. A comprehensive video documentation process was set up as previously described.

As with jam2jam gray, user engagement was immediate and attention was easily maintained in the hour long structured sessions, using any of the new interfaces. A session-based pedagogy was emerging that supported this engagement. It started with individual play, then play in pairs, then in small groups and concluded with a 'public' performance by the group. The simplified interface and remapping resulted in clearer understanding by users about what they were controlling and how musical results were achieved.

Of the different interface prototypes, the two-dimensional surface version was considered to be the best balance of ease of use and number of concurrent dimensions for control. Also many users of this interface imagined

themselves moving on a 2D 'stage' which was unexpected, but usefully concrete. This interface spawned comments such as, "It's like I was running around the stage" and the icon representation of instruments triggered friendly user rivalry as two players competed to control the same instrument. Ease of use in the absence of text showed that text labels was not significant for children's engagement and created the potential for intercultural communication amongst participants.

AV Jam

While the interface of jam2jam blue was found to be more suitable for young children than jam2jam gray, we also wanted to engage older school children. There were some major technical hurdles to achieving this. The audio quality of jam2jam gray and blue was limited by the development environment (Java) and was not sufficient for a more sophisticated audience who were imagining being old enough to go to night clubs and who regularly listening to mp3's. As well, music for them was rarely isolation from video elements which were seen as integral to contemporary media culture.



Figure 6. AV Jam at the Powerhouse Museum in Sydney.

The audio visual (AV) Jam system was a more direct descendent of jam2jam gray than jam2jam blue in its use of sliders and dials (real this time). It was a more technically sophisticated and was developed from scratch to emulate electronic dance music styles and added video remixing to fully acknowledge the DJ/VJ culture. Video material came from a live web camera facing the performers. Video changes and effects could be synchronized with musical beats, and video clips of the resulting sound and video could be captured. Andrew Sorensen of MOSO corporation wrote the AV Jam software using the Impromptu development environment he had created (Sorensen 2005).

To make the experience more tactile and to allow the screen to be used for the video elements, rather than as a control surface, the interface to AV Jam was a series of MIDI control surfaces. These controllers were much more tactile and easier to use, also several controls could be moved simultaneously allowing more sophisticated interactions. An additional advantage, was that the cost of a system with one computer and five MIDI control surfaces was considerably less than five networked

computers, and was easier to set up and transport to workshops. Lacking from AV Jam was any notion of networking with people at remote locations, hence the absence of jam2jam in the name.

AV Jam was used in a series of trials including several community arts workshops for children and a two month installation at the Sydney Powerhouse Museum in early 2008 where it was open to the general public. Data collected from these activities relied mostly on extended observation and photography.

The museum installation was particularly challenging from a technical perspective, given that the site needed to be running for extended periods of time and usable without supervision. These demanding factors tested the agile development processes and contributed to a robust interface and software design.

The user experiences from AV Jam were very positive and video manipulation was a big hit. However, the 'installation' aspects of the hardware setup (relying on MIDI control surfaces) was limiting with regard to wider adoption into contexts that may not have the equipment and the loss of network jamming capability excluded some the more interesting use cases. We wanted to have our cake and eat it too, so we decided to integrate features of AV Jam and jam2jam blue.

Jam2jam AV

The jam2jam av version integrated many of the interface developments from jam2jam blue with the more sophisticated media capabilities of AV Jam that were enabled by developing in the Impromptu environment.



Figure 7. The jam2jam av interface

The target audiences for previous versions had been primarily community based. With jam2jam av the audience focus shifted quite deliberately to education; in particular, arts education in lower to mid high school years. It was clear that an interface with more options than jam2jam blue was required, but less confusion than jam2jam gray or AV Jam. A new design exposed parameters on the interface as transparent icons. The educational focus promoted the development of deliberate processes that supported sharing and reflection. Thus the capturing of performances on video became more prominent, and a social networking web site was built to

enable sharing and commenting on captured performance clips (<http://www.jam2jam.com/>).

A limitation of previous versions was that the production of new musical content required the development of new generative music algorithms, and there were a severely limited number of people with the required skills to create these. In order to better facilitate the development of new musical styles the music generator in jam2jam av used standard MIDI files that were algorithmically transformed. New transformational algorithms were written for this purpose (Brown and Kerr 2009). Video material sources were also enhanced. Video could either come from a live camera input, as in AV Jam, or from looped video clips provided with the application. Two video sources could be in play at once, allowing cross fading and overlays, techniques prominent in VJ performances.



Figure 8. Jam2jam av scene selection.

Six 'scenes' were provided in Jam2Jam AV, each providing unique music and video content and each scene also presented a space, equivalent to a chat room, for networked jamming, allowing users to share a 'scene' in which to collaborate.

Interaction with other users across a network is a key aspect of Jam2Jam. Jam2Jam av enabled networked jamming across the internet and within local area networks. When users enter Jam2Jam av, they are presented with a visual indication of other users are already online in each of the scenes, whether or not they are jamming on an internet connection or local area network. The scenes in Jam2Jam av allow users to form 'bands' by selecting the same scene to collaborate on musical performances. This approach also allows a class of students to divide themselves up into several groups, each allocated to a different scene.

The selection of musical parameters that users could control was organised with a view to highlighting elements typically identified as significant in music education, such as pitch, timbre, texture, tempo, and articulation, and in media education, such as cross fade, colour saturation, blur, frame rate, and so on. External controller support, that was a feature of AV Jam, has been maintained and extended and standard control from mouse and keyboard is also supported.

In conjunction with the development of jam2jam av was the development of a jam2jam web site (<http://jam2jam.com>) where users can share and comment on video clips of jam2jam performances. This supports the development of a network jamming community and adds social media and social networking facilities to

extend meaningful engagements beyond those arising from ensemble performance.

Trials of jam2jam av have been quite extensive. The project has established several trial sites around the world, each comprising a school, teacher and arts education researcher. Trial sites are located in Australia, New Zealand, USA, Sweden, Norway, and the UK. Data and analysis from these sites is shared and some of the jams from these trials have been made public at the jam2jam web site.

The outcomes of the field trials of this version have shown that the initial engagement of controlling generative processes is maintained, and that the sophistication of the older target audience is somewhat satisfied, but often extended features are not obvious and options for more direct control have been requested. Every opportunity for more sophisticated control and customization are exploited by these older user and each feature spurs requests for even more, mainly in support of greater levels of individualization and integration of jam2jam with other aspects of their digital lives.

The focus on educational contexts has clarified our thinking about where the learning opportunities are for Network Jamming with generative systems. In interviews with teachers and by examining feature requests a picture has developed of the features that most support student learning. These include:

- Integration of musical and visual media
- Discrete control of individual musical or visual parameters
- Creative collaboration, both locally and remotely
- Recording of performances for sharing and reviewing
- Digital media production of source material for jamming
- Opportunities for new kinds of cultural relationships

The opportunity for young people to not only see media art but to interact with it resonates with popular remix culture.

Jam2jam XO

The One Laptop Per Child project provides a unique opportunity to provide jam2jam as an education tool for children in countries all over the world. The OLPC laptop, dubbed the XO, equipped with a variety of networking and multimedia tools offers a platform sympathetic with the pedagogical philosophies of jam2jam. As such it presents an ideal platform on which to develop a version of the jam2jam system. Responding to a suggestion from staff of the OLPC program we developed jam2jam ox.

This version functionally returns to the feature list of jam2jam blue. This is largely because the very limited capabilities of the platform mean that concurrent generative music and graphics are unlikely. As a result the system is music focused. Programming for the XO using the Sugar interface is done in the Python language and we have built upon some open source projects available on this platform, in particular the audio engine is Csound and the graphical engine is Pygame. The current

version of jam2jam xo can be downloaded from <http://wiki.laptop.org/go/Jam2jam>.



Figure 9. jam2jam xo running on the OLPC XO laptop.

An important consideration when developing jam2jam xo was the context in which it would be used. It was designed to be usable without instruction, to follow patterns of operation already familiar to XO users, and to exploit the features of the XO platform. Like other versions of jam2jam this version can be used as a solo instrument, for jams between remote users online, and in classroom situations with numerous users in close proximity. The mesh networking technology of the XO provides a useful infrastructure for Network Jamming because mesh networks work in peer to peer mode, connecting even where there is no internet or wifi hub.

The same two dimensional control surface from Jam2jam av is used on with Jam2Jam xo. However further thought has gone in to how to physically interact with the system. Users of the XO can find the use of its trackpad frustrating. Nor are specialized controllers such as MIDI or BlueTooth devices readily available. So, jam2jam xo augments mouse control with keyboard shortcuts and it uses some of the additional 'game' buttons available on the XO. In keeping with the user interface convention of the Sugar window manager used by the XO and to minimize graphics processing, control parameters are selected from menus.

Jam2Jam XO is still very much a project in development. A 'pre-release' version has been presented to some veterans of the OLPC community, who have provided valuable tips and advice for further development. An early version has been made available to the OLPC community and we look forward to detailed reports about jam2jam xo activities 'in the field' especially since this version is likely to be used extensively in non-Western cultures.

FINDINGS AND DISCUSSION

Across all versions the functionality of jam2jam has remained consistently focused on collaborative real-time interaction with rich media (music and image) - media jamming. The jam2jam family of applications support this performance practice and the features, interface and interaction design have evolved to enhance the user experience while maintaining the engagement with live performance.

Around this stable core competency, there have been small and large feature changes, those that are obvious and others that are behind the scenes, some have involved reductions and others enhancements.

One important aspect not yet discussed is user awareness of other's interactions. In jam2jam blue and early versions of jam2jam av the position of instrument icons on the screen did not always reflect the current system state, nor was it apparent in the interface when others in the jam made contributions; even though they were evident in the changes in media output. For a long while this did not emerge as an issue and confusion was indeed further compounded by the fact that the generative algorithms were also effecting the output. The issue became apparent during development of jam2jam av in feedback from an older audience who had more sustained use at the various International school trial sites. As part of providing a greater sense of interaction with others in the jam, the icons were made to highlight when moved by others and the icon locations changed when parameters were selected to always reflect the current state of the system. The interface needed to be consistent and help users understand each others' actions even though they were remote. These developments support three aspects of Don Saffer's (2006) characteristics of good design, that a system should be 'trustworthy', 'smart' and 'responsive.'

At its heart jam2jam is a generative media system, and through this project the appropriate design for the use of algorithms and generative processes has become apparent. In addition, many algorithms underwent constant refinement, both within versions, and across implementations. The addition of video effects engaged participants immediately and directly, however at times this was at the expense of them engaging the musical controls, which by comparison seemed much more subtle, or even unclear in their response. This highlighted a need for the musical algorithms to provide clearly audible and controllable transformations to participants actions.

Another change which required a modification of the design of the algorithms, was the move towards user created content. This led to a simplification of the requirements for the provision of new content, but required revised algorithms to handle the material more intelligently in order to achieve a similar level of interest and control.

Latency and responsiveness can be big issues with networked applications. However, latency and bandwidth are less problematic for jam2jam than other network multimedia applications such as video chat software. This is because jam2jam doesn't transferring audio and video media, only parameter change data. Jam2jam communicates comparatively small instructions to ensure the local experience for each person is virtually the same.

Different physical interfaces were used in different versions of jam2jam. We think there is little doubt that Network Jamming experiences are enhanced by effective gestural control and that the mouse and keyboard are far from ideal controllers, but they are omnipresent.

Interfaces to control Jam2Jam have been implemented for various hardware control surfaces using MIDI and for custom gestural tools and various iPhone applications the using the Open Sound Control (OSC) protocol. By documenting the messaging protocols, other research teams have been able to design their own interfaces to control jam2jam and in the users are also be able to map their own controllers to jam2jam if they wish.

While the agile development process focuses particularly on the flexibility of feature inclusion and software architecture refactoring, this project has also shown that development platforms are also significant enablers (or disablers) and that agile development can also include being prepared make significant technical changes such as a change in programming language, development environment, or system libraries. The history of the jam2jam project shows that these tool considerations need to be secondary to design motivations and user experience requirements when the objective is to innovate and engage. In the earliest version of jam2jam the basic elements of generative media support and real-time networking were apparent, but fidelity and media richness was found be compelling, especially to more discerning user groups. The inclusion of video remixing, high quality sound, and external controllers in the AV Jam version took the project to a new level even while maintaining the earlier innovations. While Alan Kay noted some decades back that changes in concepts are more significant than those in fidelity, the experiences from this project is that both shifts in media type or interaction, and increases in fidelity, can be tipping points to the engagement with previously untapped user communities.

As we have discussed throughout this paper, in this project we have attended to what media means to children and how they engage with it through technology. The development of the Meaningful Engagement Matrix emerged as a conceptual and evaluative tool that allowed us to document user experiences and asses what design changes were required. As a result, many questions have been identified. They include;

- How can technology allow media to be present in the conversation about media?
- How can we identifying the experiential affordances of generative technologies?
- What are the opportunities for expression and meaningful engagement?
- How can humanly organized society best expresses itself in sound and visual media?
- How can media improvisation promote relationships between individuals, groups, and communities?

Most interestingly, jam2jam is distinctly a multi media instrument for Network Jamming. It bridges audiovisual domains in a way that provides access to improvised media experiences, and for children it can provide a way of making sense of the complex world of media that they are immersed in through collaborative jamming.

CONCLUSION

In this paper we have presented an overview of a large research project rather than a detailed analysis. This was necessary because we wanted draw conclusions about what has been learnt about interaction design and development across that time scale. What emerges is an understanding that we can evolve the design of a generative software system that facilitates engaging and meaningful experiences for users of many ages where they can participate in creative ensemble performances with relatively little artistic expertise. The human computer partnership that arises with generative systems requires particular attention to the communication of state and clarity or opacity, as required, between the generative and human contributed elements.

We can summarize the ways in which this project has developed its interaction design through co-evolving the jam2jam software and its use, with reference to the four design values specified by Cooper, Reinmann and Cronin (2007).

Ethical design has been achieved through a focus on access and equity to meaningful engagement with media art. As well, there have been trials in a number of different cultural settings and facilities for cultural customization have been developed. Finally, as these activities are being undertaken by children using the internet, we are mindful of their safety and anonymity. It is a deliberate design choice that no media is transmitted between clients that might compromise this privacy and that the inability to directly text chat limits potential abuse or bullying.

Purposeful design has been achieved through a consistent focus across the project on maintaining the integrity of the network jamming experience. All design decisions have been made with this in mind, and their effectiveness in use has been repeatedly checked and analyzed against the meaningful engagement matrix.

Pragmatic design has been achieved by adopting agile development practices that stress working prototypes and user feedback. In addition, at several stages in the development radical software and hardware changes have been made in the interests of achieving practical outcomes when it was clear that the research team needed to reskill and change direction in the face of changing user contexts and demands. Finally, software features were never unnecessarily added when changes in facilitation strategies or accompanying resource materials provided a suitable alternative.

Elegant design has been achieved through the refinement of a simple to use interface, and maintained through decisions to provide extensions and elaborations as options that are kept in the background until required. Also, the interface design has progressively improved feedback to the user about system state and other user actions. This has enabled users to have a sense of confidence in the system and to feel a closer connection with others they are jamming with.

The Network Jamming project is ongoing and we have a number of areas that we feel the project can contribute research insights in the future. These include:

- Enhancing the sense of embodiment through increasingly direct gestural control, both with existing interfaces and through the design of custom controllers.
- Expansion of use contexts and applications through user-led innovations.
- Allow the full range of engagement opportunities to unfold by examining Network Jamming experiences pursued over longer periods of time, weeks and months, if not years.
- Find the best ways to reveal hidden opportunities and functions through interface enhancements, exemplar videos, and supporting materials.
- Support integration with existing musical, visual and media arts activities through enhanced content input and output facilities.
- Focus our attention on the group experience rather than the individual's engagement with the interface, which now seems to be well established.

The agile evolution of jam2jam's design has been able to incorporate significant technological and design variations while maintaining or enhancing user experiences. As a result the software has been able to provide an abundance of challenges, learning opportunities and enjoyment through Network Jamming.

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