Most Pd messages are just numbers or short lists of numbers:

```
┌5     ┌5 6    ┌5 6    ┌5
│+ 9   │+      │unpack  │pack 34 78
│0     │0      │0   │0  │print
```

If you send a list to an object with more than one inlet, the items in the list are spread out over the inlets, as seen in the 5+6 example above.

Unlike Max, in Pd all numbers are floating point. Numbers whose values happen to be integers are displayed without decimal points.

```
┌1.2 3.4
 │5 6
 │+
 │0
```
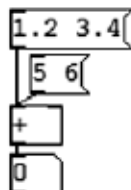
For more on messages, get help on any message box by right-clicking.

Pd as Open Source Community
Andrea Mayr

INTRODUCTION

Pd is a program developed by a community of electronic musicians in the style of an Open Source project.[1] The goal of this article is to make concrete the two central concepts of this general statement which in one form or another keep coming up in this publication. What are the aspects of an Open Source project which shape the development process of Pd and what does the community which supports this project actually look like?

PD AS AN OPEN SOURCE PROJECT

Pd is Open Source Software distributed under the popular BSD license, which permits but does not require the publication and modification of the source code. It is thereby possible that Pd code becomes incorporated into proprietary software. Eric S. Raymond named three essential points as characteristic for Open Source projects: self-motivation, the openness of the input, and flat hierarchies.[2] While large, increasingly professionalized Open Source software projects, such as the Linux kernel, no longer conform to this pattern, these points are still characteristic for the dynamics of development of the Pd project.

Many Open Source Software (OSS) projects begin with a programmer encountering a problem for which there still isn't an adequate software solution. There are then two possibilities. In case the problem cannot be tackled within an existing program, a completely new project must be started. Miller Puckette did this when he wrote the original version of Pd. It is often the case that already sizeable code segments from other programs can be used. If other developers are found who find the same problem urgent and consider the proposed method of solution sensible, the cooperation can begin.

The most common case by far is that the problem is solved by changing or expanding an existing OSS program. In this case, the most efficient strategy is to write the new function so that it

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[1]   This article is based on quantitative and qualitative surveys which the author conducted within the framework of a research project on virtual work teams in 2003. In the middle of 2005 some quantitative aspects were checked again and it was established that although the community had greatly grown, the core of developers had remained relatively stable. Thus the data from 2003 still permits a good insight into the structure of the Pd community.

[2]   Eric S. Raymond. The Cathedral & the Bazaar. O'Reilly 2001
      <http://www.catb.org/~esr/writings/cathedral-bazaar/>

can be added to the existing program. Since the same problem is often tackled by several people at the same time, it makes sense for them to cooperate with one another and not to develop everything by themselves. This is the crux of what the Pd community does. It expands the area of application of the core of the program originally written by Puckette. The individual needs of the members who want to use the software for their own artistic projects are crucial here. Their engagement also stems partly from the processes of group dynamics. Pd is perceived very positively in reflection within the group. Connected over the Internet, the group consists of people trained in very specific areas who help each other. The emergence of small local groups who meet each other in face to face situations has also been announced in the international mailing list. Beyond the engagement in solving purely technical problems, a great potential for identification with the group thus arises, which as a motivational factor ultimately has an impact on (artistic)production wit Pd. In other words, the development of Pd is determined by the individual needs, motivations, and interactions of the community members.

The openness of the input of OSS projects is reflected in the fact that all developers and users have the possibility to influence further program development. This can range from submitting a simple bug report to taking over the responsibility for the maintenance of a segment of the program. Open input has two advantages. First of all, mistakes are found and repaired more quickly since all users are (potential) testers and co-developers. A forum is provided for those who want to play this part actively, one within which their expertise can be of maximum use. In addition, new ideas can be introduced from all quarters and a collaborative learning process within the community of developers is encouraged. Both aspects are very important for the vitality of Pd as a program and as a community. In order that multiple contributors can be incorporated into the project, it is necessary for the software's architecture to have a highly modular character. This permits many people to work in parallel to one another on the pieces which interest them the most without extremely increasing the coordination effort in the community. Modularity in Pd is very highly developed. In Pd, it is possible to enlarge the core of the program with single external program parts and to provide it with the relevant function.

The possibility to be able to link these externals modularly in the operation of the program, and thus apply an experimental approach to programming without having to change Pd as such, excludes many grounds for confrontation which another program architecture would involve. If someone wants to have a certain Pd function which is available in an external at his or her disposal, this person can start the program so that it is available. Others do not have to do this. A modularity of this kind enables the offering of a nearly unlimited variety of externals, a variety which in the meantime already exists and which long ago surpassed the original estimations. However, the maintenance and description of these externals is in this respect problematic because there is no plan for naming them or for identifying their function. The suitable documentation and organization of the externals constitutes an important task within the project team.

The integration of externals on the one hand allows the community of developers to remain open and on the other hand provides for the integrity of the platform through a very flat hierarchy. Miller Puckette indisputably holds the highest authority within the community. He wrote the core of the Pd program and was significantly involved in the organization of the community. In the meantime, other programmers have also contributed to this core. The porting of the program to another operation system is an example of an addition which had to be made to the original Pd program itself. Miller Puckette was happy to incorporate these kinds of expansions. Despite Miller Puckette's authoritarian manner concerning the expansion of the Pd program, he enjoys the highest standing within the community. In hindsight, decisions in which he rejected suggestions are assessed as positive. The process of change and of the distribution of the core is clearly hierarchically incumbent on Miller Puckette. He comments regularly on the mailing lists relevant to development and collaborates with other community members to improve the program. Individual team members position themselves within the community depending on their specific capabilities, their achievements, and their communication skills.

The writing and the distribution of external program functions – which can no longer be differentiated from the inherent parts of the core of the program when the program is run – are available to everyone. This project architecture makes possible and permits a wild mushrooming of external program fragments while Pd as the core remains untouched. A similar structure is replicated in the larger externals, which usually have a "maintainer" who maintains the input.

Pd as Community

The next section attempts to answer the questions who the people now taking part in the development of Pd are, which factors can be appreciated for fostering motivation, and which further socio-demographic conclusions can be drawn from the individual surveys.

Pders as a Team

The Pd community consists of a large group of people adept at technology who communicate with each other predominantly via internet based media. They do this in order to exchange information regarding the use and further development of the Pd program and its expansions.

There is a small group of programmers who form the core of the community with a smooth transition to a comparatively large circle of users with consistently very high technical qualifications in the area of digital and/or analog signal processing. Most have already used the program over a long period of time, employ it experimentally, and often implement very specific applications. These users are in large part also those who point out specific ways of looking at

a problem in their applications and thus have a hand in an important part of the process of stabilizing the program.

What can be expressed well in numbers are the results of a survey of a mailing list that is a central means of communication pertaining to the further development of the program: Pd-list, the official mailing list for the Pd-Community. Pd-list was originally the only list which supported the community. Further distributors followed by the names of Pd-dev, Pd-announce, and Pd-off-topic. Three further communication channels were set up for topic centered work between February 2003, the time of the first survey, and the time of the second in August 2005: Pd-cvs, Pd-web, and gem-dev.

The first list was started in January 1998 at the Institute of Electronic Music and Acoustics (IEM) at the University of Music and Dramatic Arts at Graz. With support from Miller Puckette and those who were helping him with the development of the program at this time, access to the production of Pd and its applications was offered to the students at the institute at the same time.

The number of subscribers to the respective lists in February 2003

List name	Subscribers	Inactive Status
Pd-list: (main)	584	(90)
Pd-dev: (developers)	410	(70)
Pd-ot: (off-topic)	185	(17)
Pd-announce	440	(54)
Total minus overlap due to subscription to several lists	716	~ 16%
Email addresses of active subscribers (approx.):		600

The number 600 in June 2003 can thus be seen as an indicator[3] of the part of the community which accesses the mailing lists as a means of information and communication. According to research from this study, this applies to the majority of the members of the community. Up to August 2005, the number of subscribers to the community oriented Pd-list increased to 1273, whereas about a third is inactive, i.e. is not receiving any emails at the moment. In contrast, the programmers' list, Pd-dev, remained relatively stable. The analysis of the email addresses of the subscribers to all lists yields a quantity of 1536 unique addresses, approximately 30% of which are inactive. The total number of addresses of active subscribers is 1078 in August 2005. In relation to the 600 in February 2003, this is an increase of approximately 80%.

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[3]   It should be noted that there are factors which influence the upper and lower limits of this value. The possibility of the double subscription of a single person with different email accounts as well as the registering of email lists as single subscribers make this figure just an approximation. That a real person can be found behind each email address is naturally a supposition and must be accepted with reservation.

The following analyses were drawn up in the middle of 2003 and are based on the figures available at that time. Because they concern the core of the community, which proved to be relatively stable over this period of time, they can still be regarded as representative two years later. The survey on geographical variation is based on the analysis of the mailing list archives from 1998 to 2003.

Geographical Variation

As the central tool for communication, whose archive is visible on the World Wide Web, the mailing list provided good conditions to approach an estimate of the community in different categories. The number of several hundred community members diminishes greatly as one's gaze moves from the long list of the mostly passive registered subscribers to those who actively contribute to the group.

The archive goes back to the beginning of 1998 and right away in the first sporadic pages gives an impression of the dynamics within the Pd work group. Individual contributions to the archive are generally sorted by the date of their arrival; during the twelve months of the year, this chronological order is interrupted only by the summary of the main themes, or "threads".

The parameters for the sender of each message – the address of the sender, the date specifications, and the content – are included in the individual messages in the archive. Next to the time when a message was sent to the list of recipients, the date specification also reveals the time zone that the message was sent from. Along with the Top Level Domains (.at, .edu, etc) of the Internet addresses, this information helps sketch a geographical net that permits drawing conclusions about concentrations in particular areas in coordination with the frequency of particular country codes. It can be observed here that the geographical center of the community has shifted over the years to Europe, especially western and central Europe. The USA, above all the coastal regions, provides a further focal point. Australia and Japan are also represented, albeit relatively weakly. Thus Pd perfectly mirrors the global geography of electronic music culture.

Pders individually

Pd is not a tool which can be used intuitively. It requires above-average knowledge of information technology as well as an engagement with the operation mode and the application mode of the tool itself. These conditions create a picture of the community. It seems very homogeneous.

The attempt to understand Pders individually can naturally only tend to sketch a picture of the typical characteristics of people who belong to this group.
A questionnaire available at a password-protected, specially made web site was designed to approach this problem. The answers of 38 people were analyzed.

More than 60% of those who supported this survey had already been in the community for longer than two years. 13% had been there longer than the existence of the Pd-list mailing list, thus longer than four years. 23 of the 38 (60.5%) had been a part of other software development groups within the previous year.

Many artists, above all musicians, are a part of this group. Pd seems to provide a basis which picks out the fields of art and technology together as central themes. A differentiation in the interpretation of both of these fields concerning work with the program can be found here only in individual cases. The border between those who refer to themselves as artists with a good knowledge of programming and those who see themselves as programmers who use their code creatively is fluid.

The questionnaire asked for self-assessment on a five-stage scale between "user" and "developer". In the context of Pd, which is designed as a program with a target audience of musicians and artists, it can also be interpreted as a scale which can be understood between the use of Pd as a musical instrument and the programming of Pd. The evaluation revealed a great balance in the spectrum between user and developer with a slight surplus on the side of the users:

	user	< >	middle	< >	developer
%	18.4	21.1	26.3	21.1	13.2

The primary professional occupations in the group questioned does not seem to depart greatly from Pd relevant themes. In 29 out of 38 cases, it can be assumed that their professional work, which they could describe in an open field in the questionary, was related to the work they did within the community. In answer to the question of whether direct or indirect monetary income resulted from work with Pd, 36.8% of the respondents answered yes, 50% answered no, and 13.2% found the question inappropriate.

More than 65% declared their average age to be 20-29 years old. The rest are older. There was nobody under the age of 20.

Pders are predominantly male. The interviewed group was in fact 100% male.

What was emphasized strongly in both the survey and the participants' observations was the existence of a very distinctive group consciousness within the community. Get-togethers of the Pd community are similar on face-to-face meetings of local Linux User Groups. These kinds of opportunities exist in Vienna, Berlin, Ghent, New York, Cologne, and Barcelona. Instead of chatting comfortably in bars like the LUGs do, local Pd groups transfer/move/shift their meetings in clubs and use this to present their work to the public.

By this point it seems to crystallize that the dynamic of this program has a strong subcultural character. The factor of reputation, to which great importance is attributed relating to free

forms of collaboration on the net, also has an effect in the area of art as a sign of quality. This is similar in the local environment of small scenes. The increase in the value of an individual's reputation during a short face-to-face meeting naturally follows other rules than that of the development of a product online. Nevertheless, they enhance each other. Incidentally, a greater public presence through such regular meetings could offer the possibility to change the homogeneity of the group, for example in favor of changing the gender ratio. This seems to have begun to happen in the past two years.

COMMUNICATION

Communication takes place online and offline. 22 of the 38 questioned declared that they also spend their free time with other group members. In regard to Pd-specific themes, chiefly the mailing list Pd-list is consulted as a linking element. The flow of email from this list increased from 167 messages in its first year in 1998 to over 3200 messages in the first half of 1998 and to approximately 4500 in the first half of 2005.

Other tools are in use in addition to this list. In the survey, the following frequency of other forms of contact was indicated (data in %).

	Never / Not applicable	Less than once a month	About once a month	About once a week	A few times a week	Daily
Mailing List	5.3	5.3	15.8	18.4	31.6	23.7
Personal Email	13.2	23.7	15.8	21.1	18.4	7.9
Personal Telephone Conversation	63.2	15.8	7.9	7.9	0.0	5.3
Face-to-Face Interaction	31.6	26.3	15.8	15.8	7.9	2.6
irc (Chat)	92.1	5.3	2.6	0.0	0.0	0.0

Data in %.

An enormously wide spectrum of internet resources is set up to exchange information and data. Along with Community Platform, Wiki, and CVS (Concurrent Versions System) for the current version of Pd, the pages of Miller Puckette and the IEM play a great role.

The incidence of use of these tools turned out as follows (data in %):

	Never / Not applicable	Less than once a month	About once a month	About once a week	A few times a week	Daily
Community Platform	21.1	21.1	28.9	23.7	5.3	0.0
Websites	5.3	31.6	39.5	15.8	7.9	0.0
Wiki	39.5	31.6	18.4	7.9	2.6	0.0
Databases	13.2	42.1	23.7	15.8	5.3	0.0
CVS	39.5	21.1	23.7	7.9	5.3	2.6

Data in %.

There is a webring for networking at the individual website based information user inter-faces. In the past two years, this has more than doubled and now comprises 27 independent pages.

Motivation

Pders consistently work autonomously and are self-motivated. They go back to the most diverse resources in order to obtain the best possible support for their efforts in the further development of their work. They are rewarded to the extent they are esteemed not only within the group but outside it as well. The implementation of problems in commissioned work or in self-initiated artistic works through the use of Pd has an impact here. They gain esteem and a position within the group from a combination of their specific qualifications, social skills, and the amount of their effort.

An informal coordination of the field of activities distinguishes the project and a friendly mood characterizes the atmosphere of communication in the mailing list.

Satisfaction within the group is enormous.

Our group morale is high.

not applicable	strongly disagree	disagree	agree	strongly agree
13.2 (5)	0.0 (0)	2.6 (1)	63.2 (24)	21.1 (8)

I enjoy being a member of this community.

not applicable	strongly disagree	disagree	agree	strongly agree
2.6 (1)	0.0 (0)	0.0 (0)	52.6 (20)	44.7 (17)

I gain intrinsic reward from it.

not applicable	strongly disagree	disagree	agree	strongly agree
7.9 (3)	2.6 (1)	10.5 (4)	50.0 (19)	28.9 (11)

It's fun.

not applicable	strongly disagree	disagree	agree	strongly agree
2.6 (1)	2.6 (1)	0.0 (0)	44.7 (17)	50.0 (19)

It's fame.

not applicable	strongly disagree	disagree	agree	strongly agree
15.8 (6)	21.1 (8)	34.2 (13)	23.7 (9)	5.3 (2)

Data in % (Number of people)

Conclusion

Pd is a successful OSS project. The functionality is continually being expanded and the community is growing without losing its original character. In contrast to the stability of the list of developers, the strong growth of the community-oriented Pd-list suggests that a differentiation between Pd users and Pd developers is slowly beginning to emerge whereby the Pd users possess above-average technological know-how and are not pure users. This differentiation between users and developers, which is not codified in the program itself but which arises from individual practice, is quite typical of advanced OSS projects.

The community itself seems to be handling the growth well. The mixture of individual motivation (which determines the speed of development and the direction) and organizational consolidation (which provides for a certain stability and continuity) permits very productive and innovative work. The very availability of this publication is a testimony to and a part of the process of development of the community.