

Multiple TV program selection

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Institute for Perception Research
PO Box 513, 5600 MB Eindhoven

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Multiple TV program selection:
Rapid concept prototyping

R. Westrik and
M.D. Brouwer-Janse

Abstract

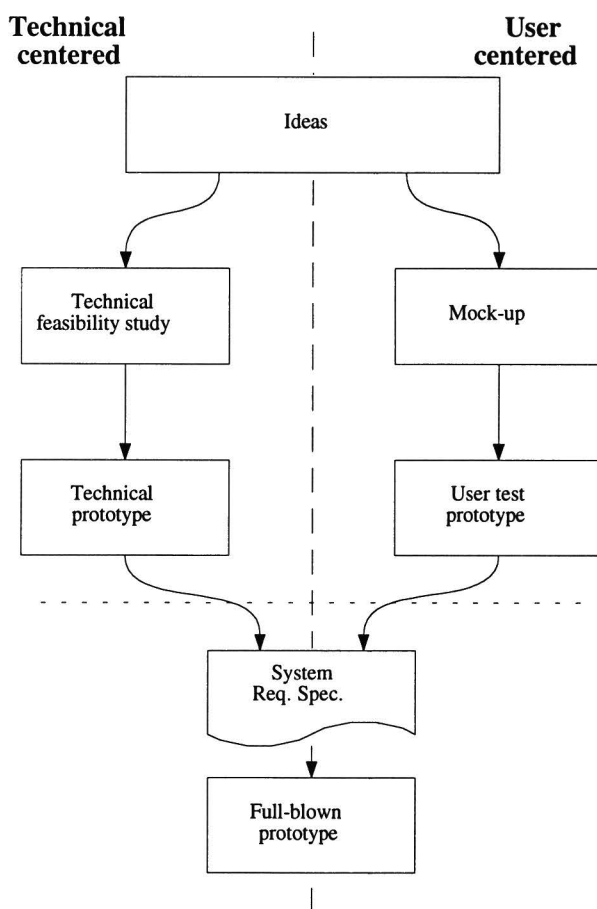
In this report a description of a prototype multiwindow TV that was built to conduct user tests in the context of the multiwindow TV project is given. The major results of the user tests with this prototype are presented. These results lead to recommendations for improvements to the developed system and requirements for a multiwindow TV. Furthermore, ideas generated during the development of the system, that were not (or could not be) implemented, are given along with some suggestions for future research. For a discussion on the overall user evaluation and user testing method we refer to the report *Methods and tools for TV user studies: exploring a new concept* [Brouwer&Westrik94 in progress].

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Introduction

This report describes a stage in the IPO activities performed in the scope of the multiwindow TV project. The multiwindow TV project was a multi disciplinary project with participation of several research groups from the Philips Research Laboratory. The following groups were involved: IST/IPA, IST/IT (Graphics), IPO and Video Processing. The goal of the project was to investigate the technology required to create a system that combines multiple video sources into one product and to build a useful application for this system. The following chart gives an outline of the project.



The IPO involvement in the project is on the user centred side, our goals were to develop user requirements and user interface concepts for a multiwindow TV system and to develop test methods and tools to verify these requirements and concepts. The current status of the multiwindow TV project is situated somewhere around the dotted line.

In this report a description and a rationale of the user test prototype, some results of experiments and recommendations for improvement of the prototype will be given. Further more suggestions for future research topics will be made, and also ideas generated during the development of the prototype that were not incorporated in that prototype will be discussed.

Description of prototype hardware

In the following paragraphs an overview is given about the prototype that was developed for user tests and evaluations concerning the multiwindow TV concept. First, some technical issues that concern the capabilities of the hardware used for the prototype will be discussed. Non-technical readers might want to skip this part and continue reading the next chapter.

The main requirement for the prototype hardware was flexibility. The most important parts were the video and audio outputs and the input devices. The video output should be able to display as many live video sources as possible, because little prediction could be made about the needed number of video sources. The video output should also allow displaying of computer graphics in combination with live video. The audio part should be separately controlled so no coupling of video and audio sources was imposed. With respect to input devices, the hardware should allow easy interfacing with existing remote controls. And last but not least the prototyping hardware platform should allow rapid and easy construction of application software.

In Figure 1, a schematic sketch of the prototype configuration is presented. The different key components will be described in the following paragraphs.

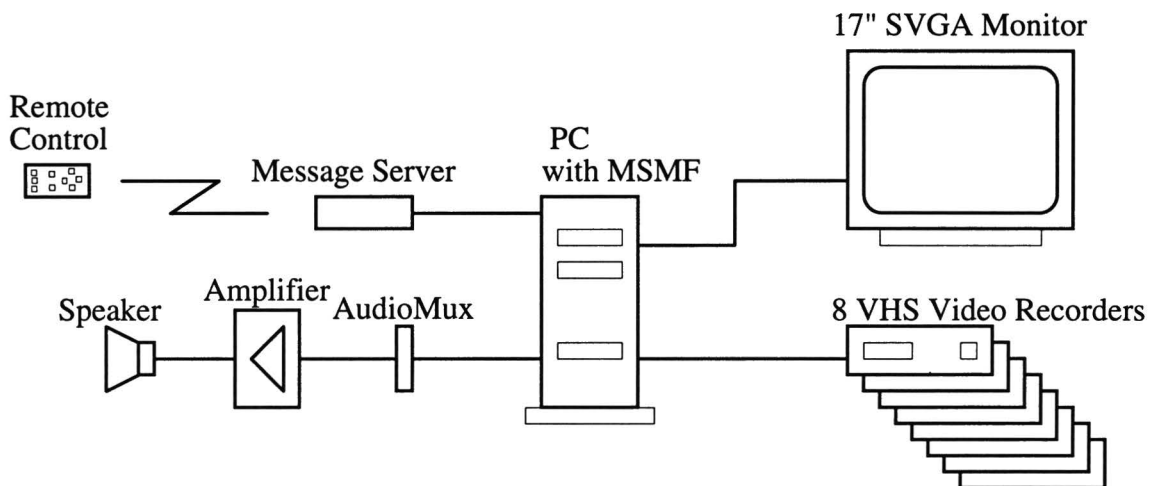


Figure 1. Configuration of the prototype.

Description of MSMF hardware

For displaying live video sources the PC-based prototype makes use of MSMF hardware built by the IST¹. This hardware consists of several ISA-bus PC extension-boards, each extension board makes it possible to display 2 live video sources on the PC monitor. The video sources can be the video outputs of a normal VCR (even S-VHS) or the video output of a TV-set. A total of 4 boards are incorporated in the prototype; that is, 8 live video sources (video windows) can be displayed concurrently. These video windows are always square windows.

¹For more information refer to the MSMF project of J.H.A. Gelissen et al.

Each of these video windows can be scaled in both horizontal and vertical directions. The maximum size of a window is according to the size of the input video signal (in case of normal PAL video this is about 680*512 pixels). Video windows can overlap with each other. There is one restriction, the MS-Windows mouse pointer is not visible in a video window. With some effort however, it is possible to emulate a mouse pointer by manually painting it. Manually in this case means that the pointer is fully controlled by the application software and should be repainted after every move of the mouse. Furthermore, it is possible to display graphics information in a video window (graphics overlay). This graphics information can be in the form of bitmaps or text. Semi-transparent overlays are not supported, they can be emulated by meshing; i.e., displaying the graphics by using a raster of video and graphics pixels.

For this hardware a Programmer's Interface [Pronk&Wolbers93] was developed at the IST. This interface enables MS-Windows application programmers to easily access and control the MSMF hardware. In addition, an intermediate interface can be written to control the hardware from Visual Basic to support an even easier access for (novice) windows programmers.

Other technologies for building a multiwindow TV prototype

Other technologies that were available for building multiwindow TV (or just future TV) prototypes for user studies were:

- Multimedia workstations; powerful multimedia workstations should be able to display a minimum of 2 live video sources.
- High-end TV-set with external computer control. If a computer can tap into the control bus of a TV-set and create text and graphics overlays on the TV screen, then a 2 window TV with several non-video windows can be simulated (the non-video windows can be used to access non-video services).

Compared to these technologies MSMF has the advantage with of displaying 8 live video sources. Two video sources, as offered by the above mentioned technologies, might not be enough for future TV and thus probably also not enough for user testing purposes.

Description of remote control interface hardware

To create the impression that the prototype was a TV-set, we used a wireless remote control. The easiest way to do this was by using the Infra Red Message Server [Jansen93] built by the Broadcasting laboratory of the ADC of Philips CE. This device can send and receive all kind of infrared messages used in Philips CE products (like RC5 and RC6). It can also be connected to a computer using a RS232 serial interface.

By using this message server, standard remote controls can be used to interact with the prototype. For our experiments we adapted a normal remote with respect to the layout and

labelling to satisfy our requirements (simple to use and logical layout). The remote itself will be discussed later on in this report.

Description of audio hardware

The hardware used for audio selections, is an AudioMux [Voncken93] developed at IPO. This device makes it possible to select one mono-audio source from a total of 8 sources. The audio sources cannot be mixed, a simple selection of one source is possible. The output of the AudioMux is fed into an amplifier to adjust the volume of the audio-signal.

Description of prototype application

One of the key issues in current and future TV watching is how to find the program of interest. The current situation is already challenging but in the future we might be able to receive or access hundreds of TV channels. Users will not be able to make their choices with the current channel selection method if a number that large is available. Multiple windows could be of help if the users want to pick out their favourite programs. First we want to discuss some multiwindow presentation layouts and how we came to these layouts. Later the channel selection supporting possibilities will be discussed. Our starting point was the viewing modes of the TV watcher. Jos Vissers [Vissers93] distinguished four different modes for watching TV:

- (I) Attention mode: Watching one program full screen (conventional viewing).
- (II) Inspection mode: Keeping track of content changes, such as the start of a program in a predefined window, while watching or zapping other programs in other windows.
- (III) Monitoring mode: Keeping track of specified events in a minor choice program while watching a major choice program.
- (IV) Multiplex mode: Keeping an overview of all happenings in the overall broadcast program at a particular time, i.e., reducing the need for zapping activities.

To support the user in all these modes several multiwindow TV screen layouts can be designed. As a starting point we designed three different layouts for our first experiments with a PC-based multiwindow TV prototype. The attention mode (I) does not need any special features but is simply a conventional TV, we call this presentation layout in the multiwindow context Fullscreen layout. The multiplex mode (IV) is also quite simple supported by displaying lots of small video-windows on the screen, this presentation layout will be called Mosaic layout (Dutch readers might be more satisfied with the term 'mozaïek-scherm'). The other two modes are more difficult to support and several display layouts can be designed to help the user. Two solutions were incorporated in the prototype to support these modes. The first one is fullscreen combined with multiple PIP's (Picture Inside Picture), the second is the use of a row of small video-windows on the top and right-hand side of one larger video window (this layout was called Tiled layout).

The prototype application for the MSMF hardware was developed at IPO in collaboration with the IST. This application was intended to simulate a future multiwindow TV as much as possible.

Presentation layouts

To support the 4 viewing modes, three basic presentation layouts were developed. These layouts are Mosaic, Tiled and Fullscreen see Figure 2.

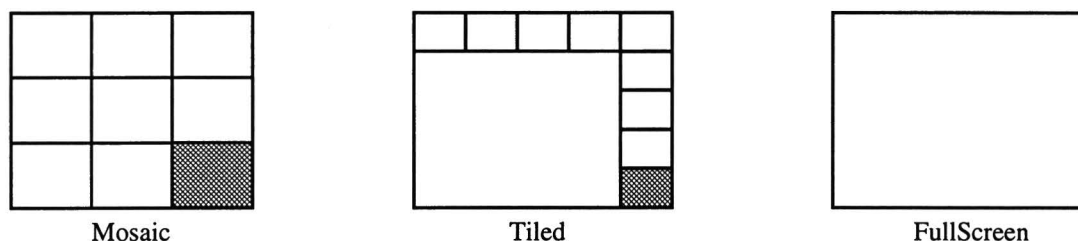


Figure 2. The three basic presentation layouts².

The aspect ratio's (4:3) of the windows were not changed. This means that scaling of a window is the same in both horizontal as well as vertical directions and no deformation of the picture takes place. As explained earlier due to hardware limitations only a maximum of 8 live video sources can be displayed on the screen. One of the video windows on the screen is always selected. The selection of a window is indicated by a 2-pixel wide white border around the window. The non-selected windows are surrounded by a black border.

Mosaic layout

The Mosaic layout is a static layout (i.e., the video source of the window cannot be changed, channels cannot be zapped) in which only one audio source is available and Tiled or Fullscreen layout can be selected. A total of 9 windows is the most logical choice when the aspect ratio and the maximum number of live video sources are taken into account. This number of windows is probably quite valid, as the number of frequently watched channels in the Netherlands is about 6 [Laar90]. However, this number depends heavily on the number of channels broadcasted in the native language of the viewer, and therefore it is assumed that this number has increased since the study in 1990. In the Mosaic layout the selected window is the source from which the audio can be heard. By selecting another window the audio also changes. This layout has benefits for the user: it gives a clear overview of a number of channels; it is possible to select a window and to hear and see the program. The selection is also useful when changing to another layout, this will be discussed further on.

Tiled layout

In the Tiled layout a large window is surrounded by 9 small border windows (POP's). This layout gives the users an overview of several windows and a special focus to one window. The border windows are static and the large window is dynamic this means that only the large

²The gray window was filled with a still-picture, the reason for this was the limitation of a maximum of 8 live video sources.

window allows channel zapping³. Since the focus of the user is directed to the large window, audio will always come from this window and cannot come from a border window. To make the control over this layout as simple as possible, selection always works on the border windows and zapping always affects the large window. The major benefit for the users is that they can swap⁴ a border window with the large window. They can pick a channel and take a closer look to decide if the program is of interest. In this presentation layout swapping may lead to a more dynamic layout of the display windows in the border. Figure 3 and Figure 4 show two possibilities for the interaction, in these figures for clearness only 5 border windows are drawn.



Figure 3. Pick-and-swap behaviour.

Figure 3 shows pick-and-swap behaviour, this might lead to a very confusing situation, because the channel arrangement of the border windows is constantly changing when a border window is swapped with the large window. Figure 4 shows pick-and-zoom behaviour, now swapping becomes actually zooming and the channels in the border windows will always stay in the same order. It was not possible to display one channel multiple times with the available hardware, so we decided to make the zoomed border window grey. Another option could be to freeze the picture of the border window.

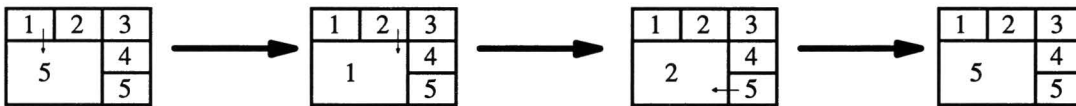


Figure 4. Pick-and-zoom behaviour.

Fullscreen layout

Fullscreen layout is the conventional layout for TV watching. Adding PIP's gives the user also a possibility to survey a few other channels while watching one channel. All windows in this layout allow zapping. In order to keep this layout as conventional as possible the user cannot close the main window (the fullscreen window) in contrast to the PIP windows that can be opened and closed. A maximum of 4 PIP windows was chosen, one PIP in each corner of the screen. (see Figure 5) More PIP's would obscure the main window too much. To open 4 PIP windows, the order shown in Figure 5 is followed. However, if for example 2 PIP windows are displayed, it is possible to select one of the PIP windows and close it (not necessarily deducing to the first picture of Figure 5).

³i.e., zapping is defined as switching channels within a window.

⁴i.e., swapping is defined as exchanging the contents (channels) of two windows.

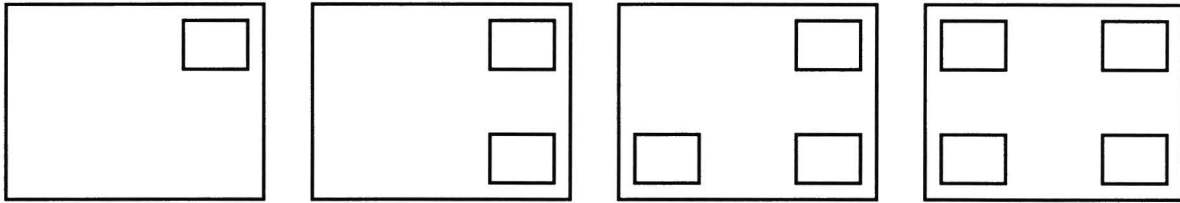


Figure 5. Multi PIP layout.

In this layout, all windows, PIP and Fullscreen can be selected for zapping. When the next channel to be displayed is already displayed in another window, that channel is skipped and the next channel is displayed. A selected PIP window can be swapped with the main window while the PIP window remains selected to reverse or undo the swap action. The audio is always linked to the main window as this window is the focus of the user. To keep this prototype as simple as possible, users could not move and resize the PIP windows.

Interrelation between the layouts

To fully support users in their TV program selection tasks, these presentation layouts should not stand alone. They should be related and compatible to each other. This relation between the layouts should support a smooth and effective channel selection process for the users. The most obvious relation between the layouts can be accomplished by zooming. This is also analogue to increasing and decreasing of focus. If a program displayed in one of the windows of the Mosaic layout seems interesting, the user can increase or zoom this window by switching to the Tiled layout (Figure 6b). If this program is really interesting it can be zoomed to Fullscreen (Figure 6c). A smooth transition has been made by narrowing the focus. The other way around is also possible. A losing interest in a program is supported by zooming out to Tiled layout or even Mosaic layout. Direct selection of a window in the Mosaic layout to full focus, i.e., Fullscreen layout is also possible. Figure 6 shows the relation between these different presentation layouts.

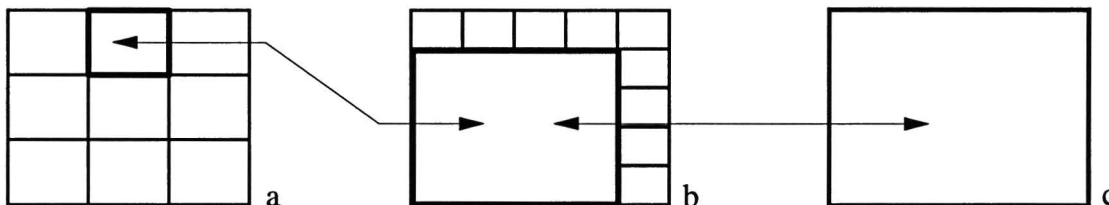


Figure 6. Relation between the presentation layouts.

Thus, the channel in the selected window in the Mosaic layout is displayed in the large window when switching to the Tiled layout or the Fullscreen layout and vice versa.

Remote control

Several requirements were important for the development of the remote control. That is, the remote should be easy to use, have a very limited amount of buttons (simple), and last but not least had to be build very quickly. Since the goal was to investigate the multiwindow concept and not to build the perfect remote control. We choose to adapt an existing TV remote control (RC5903) by removing superfluous buttons and adjusting the labels.

The focus on the multiwindow TV concept also made us decide to present all available functions on the remote control (as in the mainstream of the conventional TV-sets) and not to use any form of menu control. The functions that need to be supported are: selection of a display layout, selection of a window, swapping windows, zapping channels, open a PIP, and close a PIP.

Three options exist for the selection of a display layout this limited number of options is best supported by direct access to each option. So for every layout a separate button was implemented. The selection of windows was done by using a discrete cursor, i.e., the white frame surrounding a window. A discrete selection is best supported by a zero-order input device (cursor-keys or a joystick, mouses and trackballs are first-order devices). Given the available time we used cursor-keys. To keep the remote as simple as possible, channel zapping is done by using the program up and down keys (thus no direct access using number keys). The swap window and the open and close PIP window got separate buttons. And for experimental purposes an 'Einde Taak' button was added, this button was used to mark the end of the user's task during the experiments.

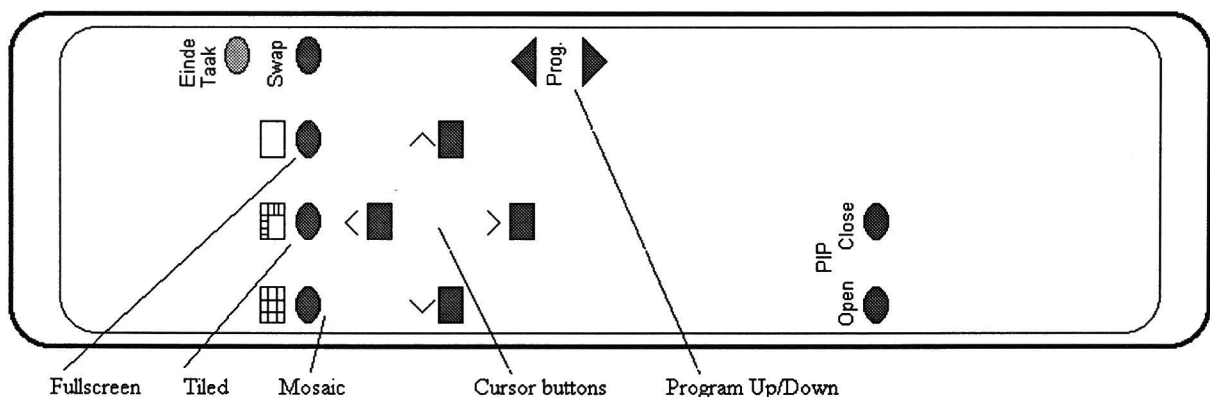
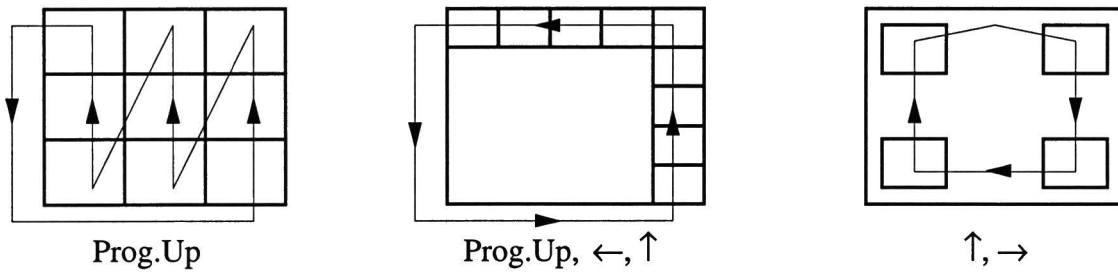


Figure 7. Schematic layout of the remote control.

For the program up/down and cursor movements within the presentation layouts natural mapping was used as much as possible. In the Mosaic layout the cursor keys worked as normal 2-dimensional cursor control, the program up/down keys were used for sequential selection of the windows (see Figure 8).



Prog.Up
 Prog.Up, ←, ↑
 ↑, →
Figure 8. Program up behaviour in each presentation layout.

In the Tiled layout the program up, left cursor and up cursor keys selected windows in one direction (see Figure 8). Program down and right and down cursor movements select windows the opposite direction. The difference between the program up/down and the cursor keys is that the program up/down selects the next window and at the same time swaps that window with the large window, while the cursor keys only select the next window.

The cursor keys associated with next window (up and right) in Fullscreen layout select the next window (the order is main window, 1st PIP, 2nd PIP etc.). As mentioned earlier the program up/down in this layout zaps the program in the selected window.

Results of evaluation

An user evaluation⁵ was conducted with this multiwindow TV prototype. A total of 16 subjects used the prototype to carry out several TV-watching tasks. The focus of the tasks was on selecting one or more TV programs. Video's of 8 prime-time programs from 8 different broadcast channels were offered to the users, i.e., a full prime-time TV program for all the channels was available. In the following paragraphs the most important results will be presented and discussed.

Indication of the preferred window layouts

During the experiment subjects used several window layouts. The Pie-chart in Figure 9 gives the ratio that a window layout was used out of a total of 103 changes in window layout.

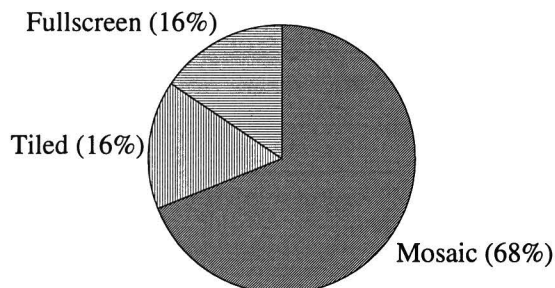


Figure 9. Use of layouts during the experiments.

The tasks in the experiments did not enforce the use of a specific layout during the execution of the tasks. Since the focus of the tasks was on searching and selecting a program of choice, this figure clearly shows that for this task the Mosaic layout is highly preferred. This can be explained by the fact that users are familiar to such a presentation layout, several cable providers offer a mosaic channel. But it also gives a clear overview (all windows have the same size) of the offered programs and it presented a simple way to change the audio source.

The use of PIP windows was limited to 1 or 2 PIP's at a time, only in one occasion 3 PIP's were used.

After the users carried out the tasks with the multiwindow TV prototype, a small study was conducted to investigate the user's preference for the several window layouts. Subjects (16 total) received 10 TV watching situations and 16 different layouts presented on cards. They had to select their preferred layout for each watching situation. The layouts consisted of several Mosaic, Tiled and Fullscreen layouts. The watching situations varied from "watching a single program" to "you want to watch TV but you don't know what program, out of an offering of 100 programs". The main results of this study were (the percentage of subjects that selected this preference is given in parenthesis):

⁵A detailed description of this evaluation can be found in [Littel94].

- To watch one program, the Fullscreen layout was selected (100%).
- To watch one program and switching to another, the Fullscreen layout with one PIP was selected (94%).
- To for watch a program while searching for an alternative program, the Tiled layout was selected (75%).
- To get an overview the Mosaic layout was selected. If the set of available programs is very large (100 or more), subjects selected zappable windows (69%). If the set of available programs is small (about 7), subjects selected nonzappable windows (69%).

These results match the four different TV watching modes that we identified. They also suggest that each watching mode requires a separate presentation layout.

Problems encountered

During the evaluation of the prototype, the participating users encountered several problems when using the system. The following problems were observed (the number of instances a problem occurred over the 16 subjects is given in parenthesis):

- Trying to close the large window in the Fullscreen-PIP layout (5 times). The users who encountered this problem certainly had the impression that they had more freedom over this layout than was presented.
- Getting the wrong program when switching from Tiled layout to Fullscreen (7 times). This was perceived as a problem when the users expected to see the selected program in Fullscreen instead of the large program from the Tiled layout.
- Trying to close a PIP window by pressing the Fullscreen button on the remote (18 times). This demonstrates that the icon used for the Fullscreen button was interpreted literally thus the icon for this button has to be redesigned.
- Opening more PIP windows than intended (5 times). This clearly is a flaw in the prototype design all keys on the remote control are auto-repeating. Only the cursor keys and program zap keys (up and down) should be auto-repeating.
- Pressing the wrong button on the remote control (14 times). In these cases the users pressed the button next to the intended button or pressed two buttons simultaneously.

Verbal comments

The most important comments made during the experiments are given here (the number of subjects that mentioned an item is given in parenthesis):

- It is difficult to attend more than one program (7 subjects).
causes:
 - Not able to hear the sound of the other windows.
 - Unequal size of the windows.
- Cannot identify which channel was displayed inside the windows (5 subjects).
causes:
 - The tasks referred to names of broadcast channels.
 - Users are familiar with number identification for channels.

Interview

In an interview session the subjects were asked to list advantages and disadvantages of the system and to give suggestions.

The following advantages (+) and disadvantages (-) were mentioned (the number of instances is given in parenthesis):

Multiwindow TV concept:

- + Multiple channels on screen (4 times)
- + Swapping windows (3 times)
- Difficult to see which channel is displayed inside a small window (4 times)

PIP windows:

- + Monitor a program while watching an other program (8 times)
- + Zap inside a PIP window (4 times)
- PIP window is too small (5 times)
- PIP window cannot be moved (4 times)

Tiled layout:

- + Small windows outside the main window (3 times)

Mosaic layout:

- + Better overview (6 times)
- + Sound moveable (3 times)
- + Quicker to zap (3 times)

The suggestions given by the users were:

- Watching more than one program is not necessary (4 times)
- A different remote control is preferred (5 times)⁶
- Allow more control for the user concerning size and place of windows (5 times)

Preliminary multiwindow TV requirements

The results of the experiments revealed several important requirements and guidelines. One of the most important aspects in multiwindow TV is that three levels of control can be distinguished:

- Layout control (select a layout ...).
- Window control (select a window, swap, activate sound, move, size ...).
- Program control (select a program, zap ...).

Sound control can be added as a fourth, separate, layer. However, it is also possible to incorporate the sound control into the other layers. At this point it is not clear which one is preferable or correct from a user perspective.

The experiments showed that the users also distinguish these levels, although most of the time it is subconscious. A multiwindow TV should thus present the user a clear distinction between these levels. This can be achieved, for example, by clustering the keys on the remote control.

For each level several guidelines can be defined. The experiments resulted in the following preliminary guidelines:

- Consistency within a layout. Each window in a particular layout should have the same possibilities, e.g., all windows should be zappable or not zappable, never a mixture of both.
- When changing layouts the selected window should be kept on the screen.
- The source of the sound should be the program displayed in the largest window. If there is no largest window the source should be the selected window. Selection of audio separate from TV program is not advisable.
- The user should be able to undo a window swap. This means that swapping may not change the selection of a window. That is, if the user invokes a second swap command the original state is again displayed.

⁶However in the remote control appraisal 75% appraised positive about its pleasantness, 74% positive about easiness and 56% about efficiency. Furthermore nobody gave a negative appraisal about the remote control.

- Give feedback about the channel that is switched on during program zapping.

Advises for improvement of prototype

In this paragraph simple suggestions will be given for a redesign of the prototype.

Several improvements can be made concerning the remote control. The keys should be bigger and have a little more space between them. The icon for the Fullscreen layout needs a redesign to make clear that it is not perceived as the key for closing PIP's. An other solution is to add a separate PIP layout (with one or two PIP's). Also the autorepeat should be disabled for all keys except the cursor and program up/down keys.

The Tiled layout as described here, violates stated requirements. There are several possibilities to solve this problem. Some might be equally valid and perhaps several should be incorporated in a multiwindow TV. At the least, they should be tested first. The first option is to enable selection of the large window and to play the audio from the selected window. A second option is to enable zapping in all windows. The third option is to keep the layout as it is and add audio selection (this however is thought to be too complex to be easily understood).

It is also advisable to at least give an indication about the name of the channel when switching channels, much like the current TV-sets have, e.g., the name of the channel is presented in the middle of the screen when switching channels during a short period of time .

More freedom regarding size en position of windows should be offered, however extreme care should be taken that this does not violate the simplicity of the control structure and of the remote control itself.

Suggestions for future research

Several ideas generated during the development of the prototype will be presented here, in order to give some direction to possible future multiwindow TV research. The attitude towards the multiwindow television concept indicates that the major advantages of the multiple windows should be found in getting an overview and in monitoring programs. That is, the multiwindow television concept as a tool for selection and browsing. But further research, especially in the field of the window layout needs, should follow.

Other presentation layouts

The Mosaic layout turned out to be very useful for searching and selecting an interesting program. The prototype implementation of this layout was quite successful in the sense that the subjects used it often and had little trouble operating it. However several questions concerning this layout need to be answered.

One of these questions is what is the ideal number of windows in the Mosaic layout. There is probably an optimum depending on the number of preferred channels of the TV viewer and also depending on the window size. It might also be the case that this amount should be user configurable between some limits. The upper limit is most likely determined by the visibility of the program in a window or on technical basis (cost might also be an issue).

Another question is how to structure this layout. It is clear that the Mosaic layout will not have enough windows to give the user a complete overview of all the channels but a stacked structure (see Figure 10, Shneiderman calls this Piles-of-tiles [Shneiderman92]) or a hierarchical structure (see Figure 11) possibly based on categorisation of the channels might be an aid to the user. Also a fish-eye view or a virtual-screen (Figure 11) could be used in these cases. The focus of the programs can be changed by navigating the view area of the virtual-screen. Another option might be moving rows or columns instead of moving the view area as with the virtual-screen. The initial set-up, i.e., which channel is displayed in which window, could be manual or adaptive and for different viewers who use the same TV-set personalised set-ups should be considered.

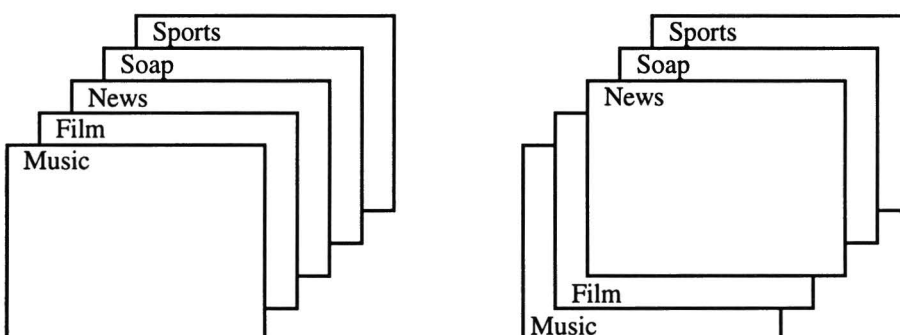


Figure 10. Stacked organised structure.

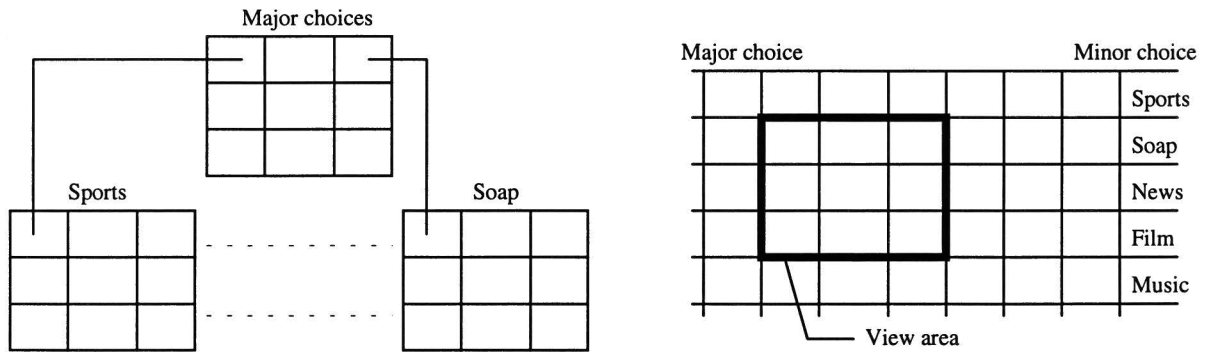


Figure 11. Hierarchical and virtual-screen organisations.

For the Tiled layout the same questions as for the Mosaic layout are valid. However, the layout itself can also be varied. These variations can range from the amount of border windows to placement of the border windows. The amount of border windows will depend on the number of interesting programs at a certain moment (ranging from 0 to the maximum available programs). This might lead to an interesting adaptive Tiled layout. The layout will rearrange itself depending on the amount of programs that the user wants to see. For example, the user is interested in one program and wants to monitor 2 other programs (see Figure 12a). If the user wants to monitor 3 programs instead of 2 the layout is changed to Figure 12b and so on.



Figure 12. Adaptive Tiled layout.

Some of the windows in these layouts can have different aspect ratios than the aspect ratio of the video source. This imposes the question how important it is for the users that the aspect ratios match and under what conditions this might be ignored.

The placement of the border windows is also a question that needs to be answered. Some options are on the left, right, top or bottom of the screen. Also a combination is possible, as in our prototype were top and right are combined. Several different layouts might be presented to the users.

The optimal size for the PIP's in Fullscreen layout and also the maximum number still have to be determined. The maximum number of PIP's to be used by viewers is probably somewhere around 2. The size and place of the PIP's might be left to the users to decide, this could be done during installation or during normal watching. Especially when size and place can be changed during watching, extreme care should be taken about the ease of operation and the feedback (since this is quite a complex operation). Another problem with movable and sizeable PIP's is that they can cause problems for selection. It needs to be figured out which window is most logical to select when for example pressing the up-button (also taking care that all PIP's must be selectable).

It is also possible to give the user complete freedom over the control and over the behaviour of the layouts, i.e., or offer a fully configurable layout. Some attributes of the windows that could be user configurable are: overlapping vs. non-overlapping, zappable vs. non-zappable, swappable, navigation etc.

Window selection

One important question regarding the window selection is whether the thick white frame is the best solution to indicate the selected window. The colour of the frame is chosen because of its visual brightness, but it is not clear whether it is the best colour (maybe a less bright colour is preferred). Other solutions could be the use of arrows to indicate the selected window or maybe lower the contrast of the non-selected windows a bit.

Use of sound

Audio is very important for TV watching. It is crucial for the selection process, that is why audio zapping was incorporated in the Mosaic layout. The audio support could be enhanced by mixing, using stereo sound or even 3 dimensional sound. With these enhancements it is possible not only to hear the selected window but also the audio of the surrounding windows. In this case it is not only possible to make a channel selection based on visual attractiveness but also on audio attractiveness.

Input devices

In order to select objects in a 2 dimensional space it is preferable to also have a two dimensional input device. Apart from the cursor keys chosen for this prototype there are probably better 2 dimensional input devices available, for example, joysticks and trackballs.

The Tiled layout, however, is not ideally supported by using a 2 dimensional input device because it would introduce ambiguity in the control. For example, which window should be selected when selecting a window on the right of the large window?. In the prototype this was solved by making the input device one dimensional for this layout. The easiest and fastest input device for one dimensional input is most likely a rotary dial also known as joggle. In the Tiled layout of the prototype this is a very natural input device. The usefulness of a rotary dial in the other layouts is not very clear. This shows that it is almost inevitable that a trade-off concerning the suitability of the remote control for the several layouts has to be made, e.g., a suitable input device for one layout might be less suitable for another layout.

In order to extent the natural mapping to a maximum the best input device might include a touch panel or touch sensitive screen on the remote control. The appropriate layout can be displayed on the touch screen and even direct manipulation of windows is then possible.

To support the stacked organisation of several screens some sort of 3 dimensional input device should be an interesting option to investigate.

Summary

Prototype application

The prototype used for the user tests has turned out to be quite suitable for browsing and searching TV programs. However, as always, improvements are possible and on some points necessary. The Tiled layout implementation and also the remote control caused several problems. Those caused by the remote control can be easily solved. The Tiled layout problems on the other hand are not so easily solved. These need a careful redesign.

Major findings

- The Mosaic layout was used most during the experiments (68% of the time). Fullscreen and Tiled layout were both used 16% of the time.
- The preferences in window layouts corresponds to the identified watching modes.
 - Attention mode - Fullscreen layout
 - Inspection mode - Fullscreen layout with one PIP
 - Monitoring mode - Tiled layout
 - Multiplex mode - Mosaic layout
- Three levels of control can be distinguished (layout, window, and program control).

Questions for follow-up

More research is needed with respect to, for example:

- Different window layouts.
- The remote control.
- The effect and relation of the number of windows.
- The relation between the number of broadcasts and the layouts.
- The optimal number of windows.

Abbreviations

ADC	Advanced Development Centre
CE	Consumer Electronics
IPA	Information processing architectures
IPO	Institute for Perception Research (Dutch: Instituut voor Perceptie Onderzoek)
ISA	Industrial Standard Architecture
IST	Information and Software Technology
IT	Information technology
LED	Light Emitting Diode
MSMF	Multiple Stream Multiple Format
PAL	Phase Alternating Lines, a video standard
PC	Personal Computer
PIP	Picture Inside Picture
POP	Picture Outside Picture
RC	Remote Control
S-VHS	A videorecorder standard
VCR	Video Cassette Recorder

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