Upgrade

Aharon Charnov

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Upgrade
By
Aharon Charnov

Submitted in partial fulfillment of the Requirements for the Degree of MASTER OF FINE ARTS

MFA Imaging Arts/Computer Animation
SCHOOL OF FILM AND ANIMATION
ROCHESTER INSTITUTE OF TECHNOLOGY
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Howard Lester
Howard Lester, Chair
Professor
Chair
School of Film and Animation

Howard LeVant
Howard LeVant
Professor (Retired)
School of Photographic Arts and Sciences

Tereza Flaxman
Tereza Flaxman
Assistant Professor
School of Film and Animation
Upgrade

A computer animated movie by

Aharon Charnov

Original Music by: Nicholas Salve

Length: 8 Minutes 30 seconds

Color

Stereo Sound

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e-mail: aharon.charnov@gmail.com
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"UPGRADE"
By Aharon Charnov
MFA Imaging Arts/Computer Animation
School of Film and Animation
College of Imaging Arts and sciences

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Thanks also to Howard Lester and Malcolm Spaul for all the advice, instruction, and for giving me many, many opportunities.
Introduction to “Upgrade:” Focus and Methodology

By deciding to focus on the story as the primary element of my thesis I knew that I would have to employ the technologies of computer animation as expertly and efficiently as I knew how, in order to have the ability to adapt the models, animation, texturing, lighting, and other elements to the needs of the evolving narrative in the easiest and most flexible way. This was done in order to allow the ability to make changes as they were needed, and was meant to cut as little as possible into animation time while still helping to maintain the high level of visual quality needed to create a successful story. The goal of this thesis, therefore, was to create a visually acceptable story that was enjoyable and coherent, and to do so without the benefit of substantive collaborators. Unlike student work at the School of Film and Animation, some large animation studios divide the creative process among several departments. Story is handled by a development department. Technical aspects such as modeling, rigging and lighting are governed by a second group, and a third unit is called upon to actually animate the characters (PIXAR, 2005). For the aspiring filmmaker who is singly responsible for all of these elements, computer animation is a dynamic tool that is often the source of great internal tension. On the one hand, the technical aspects are so varied and difficult to master that they often demand a great deal of time and attention and there is little room to concentrate on story. Conversely the needs of linear film making often force the animator into neglecting and ignoring various technical challenges so that there will be enough time to actually create the story. My goal was to use the technology intelligently and place it in the service of the narrative; thereby attaining a degree of limited expertise in matters technical while preserving the conditions necessary to engage in good story telling.
Narrative as a Concept

Enjoyable narrative was therefore the primary goal for "Upgrade," my thesis film. The reasons for this were twofold: audiences like good stories, and linear narrative is a natural and normal means of thinking about reality. So it makes sense to create a visual experience in this manner.

Everyone sees life as a story, usually as his or her own tale, thus it behooves a filmmaker to craft a compelling story with which the audience can identify. "Casablanca" is not "Snow White" and neither is "Kill Bill," but all are good stories centered on characters with which people could identify. That was why audiences have loved them. PIXAR's own employees have attributed the company's success thus far to the fact that its top priority is to create good stories. PIXAR's director of photography Sharon Calahan has said, "That everyone at PIXAR is committed to making the best story possible... No expense is spared to that end, and that is what... has made PIXAR so successful, and profitable (Hill, 2003)."

Many people have argued that experimental filmmaking is more creative or more artistic insofar as it is bound by no rules. This school of thought holds that mainstream narrative methods of filmmaking are corrupt as an art form due to their commercial aspects. Thus many "experimental" films lack any narrative elements. If these films employ a symbolism it is often esoteric, understood only by the creators and left for the viewer to puzzle out if he or she can do so. Again, the proponents of experimental films argued that engaging in this deciphering of the cryptic is the purpose of the experimental film. They reasoned that in teasing meaning out of garbled and often non-concrete visual presentations, one was intellectually engaged in the art and thus came to appreciate the piece. Appreciation rather than enjoyment, they argued, was the desired ends to the film viewing process. It was to this ideology that the playwright/director David Mamet said, "Oh, grow up (Mamet, 60)."

Mamet contended that linear story telling is the most natural means of presenting visual imagery. He believed that it was best told through the contiguous presentation of discreet uninflected beats and that a story was best told simply. Linear structure or a
narrative format worked best for film because it was the way in which the human mind organized reality. As he put it:

The Job of the film Director [was] to tell the story through the juxtaposition of uninflected images – [emphasis his] because that [was] the essential nature of the medium. It [operated] best through that juxtaposition, because [that was] the nature of human perception: to perceive two events, determine a progression, and want to know what [happened] next (Mamet, 60).

It was precisely when there was no discernable progress between two shots, argued Mamet that neurosis resulted.

Moreover he maintained that one wanted to “tell the story in cuts. Which [was] to say, through a juxtaposition of images that [were] basically uninflected (Mamet, 2).” Essentially Mamet argued for giving the audience the necessary components that told a story, but to let the audience perceive the relationships between those components without help from the director. This, he claimed was the nature of comprehension and thus it should have been the means of visual story telling. The audience, in other words, was equipped by means of being human to perceive. Thus the filmmaker should simply present the story as simply and correctly as possible. The story telling/perception would attend to itself in the conscious and unaided mind of the viewer.

Mamet claimed that in order to tell a story in cuts one had to break a scene down into its natural and necessary beats. A beat was one cut in which one emotion or point was clearly made. Additionally, he argued that one should only film these natural and necessary moments. His principle of Keep It Simple Stupid (K.I.S.S.) argued that if one “always [did] things the least interesting way... you will make a better movie (Mamet, 20).”

Mamet’s argument coupled to my own experience as a person who enjoys good stories convinced me that his way was right. Narrative story would be the most natural thing to present visually. I thought that I would try and tell a story that was both interesting and succinct and I would attempt to do so in the clearest and most interesting
way possible. Fine. But what was my story? I didn’t know. I just knew that I wanted to tell it well.

Story was all important. I had previously tried to make good stories and while my skills at film making were growing none had truly satisfied me by the time I had reached my thesis. With this last film I wanted to nail it. After all, it was my last chance as a student. My previous films had perhaps been good ideas, but they had suffered as poorly made animations for many reasons: my animation technique wasn’t very good, my editing needed improvement, my story telling was arrhythmic and poorly structured etc. Worst of all, they all represented an ambition not commensurate with my skills and the time allotted to me. I wanted my thesis film to be acceptable in terms of quality. Thus I adopted three basic guidelines to help me create my thesis. My first concern would be to tell a story as Mamet instructed and PIXAR’s success demonstrated. The story I ultimately made would be a simple one. I decided that I would not get too technically ornate in the creation of this animation. Also I would take as much time as was needed to craft this story, even if it meant postponing the completion of my Masters Degree.

The Story as Evolving Concept

I therefore had to address myself to creating an interesting story. In my earlier films, my stories became needlessly complex. I maintain that the more complexity I put into my stories the worse they became. My second film, “Ooga Chakka” was supposed to be a tale about the caveman who almost discovered fire. In order to show his ineptitude I moved my character through a sundry of historical periods where he always caused calamity with fire. While amusing in concept, this necessitated the creation of many set pieces, props, and costume textures. I might just as easily have created one set and played out his getting singed and incinerated in as many variations as possible. Indeed that might have been better, as it was unclear to the audience how or why my caveman was moving through time.

In response to this needless complexity I resolved to keep my thesis’ story as simple as possible. But I still didn’t know what to write about. At first I tried to write a story that served as a metaphor for some of the current issues I found relevant. My first
draft was a bizarre tale that took place inside a computer. It was about a program breaking into a computer to steal another program with which he was in love. After kidnapping the object of his affection he had to race over the Internet in order to escape two bungling anti-virus police programs. This story cumbersomely titled, "Natalie, Merchant Protection Software and the Corporate Raider," was set up to let me tell many jokes about the vagaries of computer use in the internet age. I had hoped it would ultimately serve as a foil to expose some of the points in the debate currently raging about computer piracy and illegal file sharing. When I pitched it I described it as "TRON" on crack. It seemed funny at the time, but didn't really seem to add up as a story. Also it was very, very complicated and I didn't know if audiences would accept its premise.

Clearly this broke all the principles for good and simple storytelling. It was complex beyond belief: calling for four characters, a myriad of sets, and untold numbers of props. Moreover, it wasn't that good a story. I therefore went back and rewrote the script, again and again. Each draft tried to hone the story down into something both manageable and interesting. I worked with both Howard Lester and Howard LeVant in the creation of many drafts. But ultimately it was recommended that I work with two live action professors in an attempt to create a better story. Naomi Orwin and Adrianne Carageorge were good enough to meet with me unofficially and their help proved invaluable. They helped me focus on one story that contained elements any viewer would find resonant. Their instruction helped me tell a story about things an audience would immediately understand in ways in which it would identify instantly.

As the story writing process progressed (ultimately culminating in twenty three distinct drafts and re-writes) many elements were discarded. The cops and robbers component was scrapped, as it was ultimately a long chase scene. It wasn't interesting as a story and so I deleted it and its two unnecessary characters. A world in the computer was hard to convey. I dropped it although it did comeback, albeit in a mitigated fashion.

Each version focused more on human elements that were easily recognizable like love, romance, and conflict. The story slowly evolved into a love triangle between a real-world man, the computer he has used since the day he assembled her and the newer, younger laptop that invades her world of happiness to threaten its stability. This version of the story seemed natural. Love conflicts and revenge are universal, and the story
points seemed to flow intuitively. They just needed to be worked out simply in order to tell a good story. I did not work these elements out all at once. They were created a bit at a time, usually as a result of weekly story meetings with Howard Lester, my thesis committee chair and with Naomi Orwin who helped me find the problem areas and cut away the chaff. Their input during the writing phase helped me clarify many issues. With their help I began to hammer out the rudiments of a story. Further refinement was necessary of course, and I was excited to tweak my idea into a useable form.

Under the assumption that bad stories could be refined into good ones, every element I considered was carefully examined and refined. At first the human was going to be the main character, but as I thought about the needs of the story it became clear that the computer would have to be the sympathetic focus. The audience would understand how hurt she felt at being betrayed by her user/lover and would sympathize with her revenge. In that case this computer character would have to be emotionally convincing in order to elicit audience support.

Similar refinements were considered in every step of the story's development. The laptop was initially going to be an anthropomorphic character much like the desktop computer (who would have a congenial human face displayed on her monitor). But ultimately that idea proved to deliberately symmetrical and a bit forced. It required a mid-second act introduction of a character whose only purpose was to be present. Could not the same point be made merely by showing the laptop and the user's devotion to it?

Also, why would the user, now named Bob want a new computer? This was a short film after all; the progression of events had to flow from one beat to another but also had to relentlessly and succinctly drive the story to its conclusion. What if, I surmised, Bob's continued use and feeding of software caused the computer to become full, slow, and fat? Would not that diminished utility or reduced capacity cause him to replace his lover? Was that not similar to men in the real world leaving their aged wives for younger women? Having a lover leave in favor of something more exciting provided the necessary emotional calamity for the desktop to seek her revenge. It seemed to come together very nicely. I had a story and it seemed simple and organic.

"Upgrade"
“Upgrade” would begin when Bob assembled his new computer. Upon turning her on he would immediately start coming on to her. She, would at first, be incomplete. She would initially be a human-like head made of polygonal faces that had many holes in it. She would be uncertain of how to take his advances. Bob would begin to install software by feeding her compact disks. At first she’d be afraid of the input from the CDs. After all she’s never installed software before. Very quickly she realized that new software makes her more robust by filling in the missing pieces in her face. Moreover she found the installation process to be pleasurable. After a while she came to like and perhaps demand more from Bob who willingly gave. Soon her face was complete but Bob kept giving her more; the computer physically grew as a result. She realized that Bob’s input had made her larger and stronger. She came to love him as he initially loved her. With her mouse she stroked Bob’s hair giving back pleasure that he had given to her. All seemed well as the first act closed.

The second act began sometime later. The computer had accepted too much input and had become bloated. Bob tried to install one more CD in her but she was just too slow and too full. She rejected his advances and refused to install the software thus frustrating Bob. As a result he became bored with her and began to search for a replacement computer. He searched the Internet looking for a new laptop and wouldn’t let the Computer OS see what he was doing. Only after he left to find a new lover did she uncover his plan. When she realized that he wanted to replace her she became horrified. Later, Bob returned with his new object of affection: a slender, sleek laptop. He took this new computer to his bed and the old computer was helplessly forced to watch the two interact. The OS tried to call Bob back by printing him a love letter, but he crumpled it and ignored her. As Bob continued to work with the new laptop, the computer became so enraged that she attacked it. She grabbed the laptop with her mouse and dragged it toward her with malicious intent. Seeing this, Bob rushed to save his new love. The OS then separated the two, threw the laptop out the window in a jealous rage and morphed her monitor into a giant mouth. She swallowed Bob in one gulp. Once inside her, the computer knocked Bob about between the multitudes of icons he had
installed. She compressed and fragmented him, and ultimately threw him in the trash, exacting her revenge.

The story was a simple one. Its plot points moved necessarily from one to another and little effort was made to explain the progression on the assumption that audiences would organically comprehend the relationship between beats and want to see what happened next. Audiences could easily understand a love triangle between a man and his two lovers. A subtext could easily be read into this story. One might have surmised that my underlying intent was either to preach against the disruption of stable relationships by cheating or to make a statement about how modern people treat relationships in the same disposable way that they treat their computers and other appliances.

In modern society people entered and maintained relationships while they were convenient. When those arrangements ceased to be so, or when something more convenient came along, people would dump their old commitments and acquire new ones just as if they were upgrading to a newer computer. Many of these thoughts occurred to me while I was writing the various scripts. While these ideas and some of the clichés they embody did factor into the visual imagery I sought to create, they were not the guiding basis for the story. Though the subtext was there, the story came out of the flow of events. Thus the story came before concerns of embedded subtext. I wanted the audience simply to see what happened irrespective of any message implied or otherwise.

**Preproduction**

Once I had the story, now called "Upgrade," fully realized in script form, I had to turn to various development issues. This phase incorporated pre-visualization in the form of storyboards, designing and refining characters and sets, refining story points, assembling initial sounds, and creating reference-ready computer files. The goal during the development period was to plan as much of the animation as possible before committing time and effort to the tasks that, if modified, would require starting all over again. Additionally I went into development trying to anticipate which elements would require further research or experimentation. I tried to devise methods that would allow
me to proceed apace and still be able to tweak these elements as alterations were required or unacceptable results were reached.

**Storyboarding and Design**

Storyboarding and design were the necessary first steps in the development process. Storyboards are comic book-like pictures that detail, in visual terms, every shot and sequence in one's film. The storyboard's purpose is not to tell the story, but rather to help the animator decide how he or she would structure and order visual imagery. Because “Storyboards also assist in the timing of a sequence, experimenting with camera angles, movement, and continuity amongst the elements within the frame (Tumminello, 11),” they are an invaluable tool in planning out an animation. With little more than an aspect ratio field guide, paper, and pencil the animator can try out many different camera angles, scene compositions, and lighting arrangements. These boards can be scanned and used in compositing software to create a story reel or animatic. “Creating the story reel allows the creative team to experiment with pacing of individual shots to see how the story flows before resources are committed to animating (Tumminello, 160).” With a story reel, the animator can change the length of time a given board is shown, or change the order in which the boards are shown. With these quick modifications he or she can get an early sense of the editing choices he or she will make when the shots are done. Storyboards also directly help the animator because “these sketches [guide the animator] for how the action should move within each scene (Tumminello, 18).” Storyboards are similarly inexpensive to create. A single scene can be tried out many ways expending
nothing more than time, paper, and graphite. Indeed as Tumminello points out, “as films became more expensive to create, many directors took note of the efficiency that storyboards provided (Tumminello, 22).”

It was with all of these advantages in mind that I committed myself to the creation of detailed boards covering every shot I planned to use in my thesis animation (See Appendix C). In total I kept one hundred and fourteen storyboards. Of these, seventy-two were used for the final cut of “Upgrade.” Storyboards were drawn and re-drawn with an eye toward good camera framing, competent composition and continuity between shots. They allowed me to visualize what each shot would look like and how it would fit within a given sequence. Several times throughout the process I discovered incongruities within a shot, or found that my script as written would create an eye jarring jump cut. I was thus able to correct several mistakes before I ever began animating. I used the scanned storyboards to synch-up an animatic. I projected a running time of four and a half minutes for my thesis film. This was before sound had been completed and it was before some unexpected re-shoots became necessary. The four and a half minutes was therefore a mere estimate. As my final film had a running time of eight and a half minutes, I clearly misjudged my timing. Nonetheless, I believed that I would have been much worse off had I not had at least the storyboards and animatic to guide me.

In storyboarding I had developed a basic idea of the environment and the characters. With the boards as my guides I next turned to fully designing every item that would have to be modeled. Caputo claimed that, “it is the artist’s job to make deliberate choices that will communicate the concept (Caputo, 165).” He argued that the artist/designer is constrained to use design in service to the purpose of the script. In other words design should not have been based on aesthetic concerns alone, rather form followed function or purpose. In my case I didn’t really know what that meant.

I merely wanted 3D CG characters. I had no
high concept. I just needed fully realized models. I firmly believed that stylization was acceptable. I believed that sparse sets and suggestive rather than fully formed characters could be used effectively. Moreover, there was a long standing body of surreal design in cartoons. One needed only to look to the Chuck Jones' "Duck Dodgers in the Twenty Fourth and Half Century" for creative and odd designs that, while out of reality, clearly worked. I wasn't shooting for photorealism in my models. But I also did not want to have strayed too far into experimental or loose stylization. I executed drawing upon drawing in order to let the character designs evolve. For example Bob, who was initially more professorial, went through several iterations before I accepted an image for him. Again, Mamet's "keep it simple stupid" principle came to my aid. I decided on a look and feel for my world which was just off of real; it was slightly cartoon-like but clearly and simply recognizable as analogous to the real world. All computers and electronic devices were based on right angled, slightly rounded, cubes. The room's four walls were all at normal right angles and the other props would be instantly recognizable as simplified versions of the objects found in the real world. Wacky design was avoided. I merely simplified everything, retaining the parts needed to read as the object in question and discarding any ornate or extraneous design elements.

For Bob, I designed a character that was a parody of me. Bob was a spindly, thin-necked geek who wore his shirttails out and a PENN t-shirt. He wore blue jeans and scuffed up biker boots. He wore glasses and had bad hair. Essentially he was me, only exaggerated to look more cartoon-like. His feet, head, glasses, and hands were atrociously large. He looked very cartoon-like but also fit in with the more realistic though simplified environment I designed for his room.

Since I was parodying myself for the design of Bob, I similarly designed his bedroom to resemble my own. His desk was a warped slab of Formica covered wood held up by two sawhorses, just like in my room.
Likewise, his bed and work area were cramped together as were my own. Also far too much of his furniture was cheap and plastic. The furnishings of my own student-bachelor apartment were just like that.

The operating system’s face was a different matter altogether. She had to change over time. At first she needed to appear as the face of an attractive girl. Later she had to appear older, heavier, more motherly and perhaps a bit disheveled. For the young girl's head I used a set of sketches by the comic book artists J. Scott Campbell (Campbell, 22-23). Extrapolating on that I next created sketches that seemed to age and add weight to the younger face. These drawings were based on each other because I hoped they would help me create two characters that while different, believably bore some resemblance to each other. It was my intention that this design would clearly show that these two different faces were in fact the same character at different points in her life.

The character designs were carefully created and drawn in orthographic perspectives, usually from a front and side orientation. These drawings were executed in this manner to help with computer modeling. Other props like the desktop computer and its peripherals, the laptop, or other items in Bob's room were drawn up, but not in nearly as much detail. Sometimes a prop was deemed simple enough and clear enough from the story boards that further design wasn't necessary.

A counter intuitive element of design was that while the script and storyboards did influence the character and prop designs, the design elements went back and forced
me into a new round of editing and helped me refine my script even further. Bob, for example was initially thought of as wearing a lab coat. The final design made his top more shirt-like and this allowed for the computer to more dramatically swallow him at the end of the film.

Audio

Once visual design was completed I began assembling the sounds I would need to create an advanced scratch track for each individual shot. Sound was very important for animated stories. It was often said that “a truth whispered among animators is that 70 percent of a show’s impact comes from the sound track (Laybourne, 85).” In my last film every viewer had said that the score was very, very powerful; so I knew that sound could help sell the visuals at presentation time. My own needs for a sound track that was better than a scratch track, however, were more basic.

A scratch track was the equivalent of a rough draft for the soundscape being created for an animation. It culled the basic aural elements needed for each shot and greatly aided the animator in the timing of the sequences to be animated (Laybourne, 86). I had been having trouble timing my animations in the past. Typically the character animation was either too slow or to fast. I felt that if I created a robust track that helped me place character motion in time by means of synchronizing it to either dialogue or precise Foley, I would get a very detailed basis upon which to build the character’s motions. I therefore needed a nearly complete soundtrack in order to help get a feel for the timing needed for each shot.

Gregory Madore was good enough to record for me as I lacked the needed equipment and expertise. He recorded both myself, doing the voice of Bob and the very talented Rena Schrier, my friend who voiced the computer operating system. I asked Rena to do the voice work because she is an accomplished actress and vocalist. Her years of training and performing in local theater gave her an excellent command of voice. I needed her talents as her character went through many emotional states and even had to fake an orgasm at one point. Rena voiced all her material very professionally and my faith in her talents was confirmed.
Data Storage Architecture and Asset Management

Once the first phase of sound work was done, I turned to the last aspect of the development for my thesis, which was the creation of an organized file storing system on the computer. I needed files to be easily findable, and I also wanted completed asset files to be stored away from animation files so that I would not accidentally overwrite them or mistakenly alter them in any way. In order to accommodate this need for protection and good organization I created a series of directories within the default structure set up by MAYA. In these, I tried to separate assets from actual animation files. The asset folders were again divided into two directories, one for all the props in the set and one for the characters. Thus I had three folders for my 3D files: “Set,” “Characters” and “Upgrade” (the name of the film). The “Upgrade” directory would come to contain all the animation files for my thesis film, but it had no actual assets within it.

It was my intention to have modeled everything I needed and to have saved off finished files in the appropriate directories. When the time came to animate a shot I referenced all the pertinent files into the animation scene. Referencing was a means of “[bringing] the same file into multiple scenes simultaneously (Riddell, 21).” Referencing was advantageous for several reasons. It allowed one full access to all the attributes in a given file, but preserved the original without any changes. For example, I was able to reference a fully rigged character and animate it, setting permanent keys in the file’s timeline. The original file however, remained pristine and could be referenced into yet another file at any time and would not have affected the first reference.
Conversely the originals could be edited and updated. Any change made to an original asset would filter down to every referenced scene. By using these referencing I could edit and change assets if they proved to be lacking necessary attributes or functionality but would not lose animation files even if they were already in progress. For instance, I referenced in the OS character and in the course of animating, found that the character lacked a needed facial expression. I saved the animation file, opened the original character file and added the missing blend shape target for her face.

Once the original was saved I then went back to the animation file I had been working with. Not only were the keys I had already set still there, but the new attribute would automatically be there as well. Moreover any new scene in which this character would be referenced would benefit from the added attribute as well. Also, if I were to go back to any old animated files that called this character as a reference, they too would have the attribute even though they had first been animated without it. Referencing therefore provided a great deal of flexibility upon which I intended to capitalize.

Modeling

With development completed I began production in earnest, starting with the modeling of all the 3D characters and props. I had prepared many of the designs in orthographic views so that I could directly import those designs into Alias Maya and use them as blueprints. The modeling itself was directed by my knowledge of Maya and the capabilities and liabilities of its modeling tools. In Maya there were three types of surface generation techniques available to the modeler: polygons, subdivision surfaces, and Non-Uniform Rational B-Splines (NURBS).

"Polygons... [were] n-sided shapes described by vertex position data. Connected, they form[ed] polygonal objects (Kundert-Gibbs, 9)." Because they were merely the connecting lines between the vertices, Polygons were easy to model. One merely appended polygon primitives together or took existing polygons and by means of either arranging the vertices or extruding edges and faces, coaxed out new forms and shapes. In addition polygonal texturing was very versatile as one was afforded the ability to map out the structure's internal local surface coordinates (UVs) as needed. Due to their faceted
composition, however, polygons were resolution dependent and could not create true curves. This sharp and faceted look was too obviously computer generated and looked very primitive. As a result polygons were, for a long time, shunned and excluded from use in high-resolution animations. Recent upgrades however, have allowed polygons to
smooth down far more satisfactorily by subdividing every face, but they were still faceted to a degree.

While Polygons were always resolution dependent, subdivision surfaces were not. Subdivision surfaces were “polygonally derived surfaces... They offer the animation advantages of low polygon surfaces combined with the smoothness of highly tessellated NURBS surfaces, thus combining the ease of use of polygons with the organic quality of NURBS surfaces (Kundert-Gibbs, 9-10).” Subdivision surfaces used all the advantages of the easy to use polygon but resulted in a NURBS-like, smooth, resolution independent surface. Additionally, they allowed for the creation of low-resolution polygon proxies. These proxy cages could be dealt with separately even though they drive the surface properties of the subdivision surface. Indeed, a polygon proxy cage could be used to layout UV coordinates for texture mapping on a subdivision surface. They could also be bound to a rigged skeleton and used to drive the smoother surface’s deformations during animation. This was advantageous because subdivision surface topologies were computationally heavy. Merely displaying a heavy subdivision surface on the monitor tied up the computer’s graphics card and slowed down the ability to navigate in MAYA’s interface. Animating with subdivision surfaces displayed, in an otherwise heavy scene became almost impossible due to the time lag. Moreover, subdivision surfaces could not, at the present time, integrate fur or paint effects. Thus while they were easy to use in modeling and acceptable in terms of appearance they remained limited in application.

NURBS on the other hand, had long been considered the workhorse of 3D graphics and design. Many of the early 3D feature films and effects movies used NURBS based models exclusively. Jurassic Park, Terminator 2, and Toy Story all used NURBS surfaces for their 3D characters. Historically, NURBS came into wide usage after polygons and before subdivision surfaces. Indeed NURBS were viewed as a workaround to the limitations polygonal facets posed to high resolution imagery. NURBS were considered more useful than polygonal geometry because they were "A type of geometry that [included] curves, patches, surfaces... They [were] particularly suited for modeling in 3D, because they [provided] excellent continuity with a minimum number of control points (MAYA, online help documents)."
Moreover, NURBS surfaces were resolution independent. That is, they could display curves that would appear smooth and organic, irrespective of the viewer's proximity and angle to the surface in question. Because they were spline based, NURBS surfaces also deformed fairly organically and they allowed for the generation of complex organic curvatures that were useful in anything from human character design to automotive styling.

In the last few years however, NURBS based modeling had been in competition with subdivision surfaces for several reasons. As Chang pointed out: "Trimming a [NUBRS] surface [was] expensive; it [was] difficult to maintain smoothness or even approximate smoothness, at the seams of the patchwork as the model [was] animated (Chang, slide 8)." NURBS models, which had to be split up into patches\(^1\) became very difficult in terms of across-patch texturing and often split seams when stretched too far during the course of surface deformation in animation.\(^2\) Subdivision surfaces, on the other hand could be made of one piece by defining "rules for creased edges and vertices (Chang, slide 21)." By doing this, the modeler could create robust forms out of single pieces of geometry where detailed tangency (or deviation from the same) was maintained by the pre-set creases. Deformation of these objects would not ruin them. Moreover because they had no seams, splitting could not occur. For these reasons companies like PIXAR had already decided to only use subdivision surfaces for their characters.

Taking this into account I decided that since the majority of automotive, industrial and product design was still done in NURBS I would create all my props and sets from NURBS surfaces. In deference to the expertise of PIXAR, (a company I greatly admire) I would model the Bob character in polygons and convert him into a subdivision surface. The operating system character was also intended to be a subdivision surface but as I created her, her rough, faceted and polygonal look really enhanced the perception that she was an artificial anthropomorphic version of a computer so I decided to let her stay a fully polygonal structure.

\(^1\) Given that the endemic base structure of a NURBS surface was a rectangular patch it became nearly impossible to create an entire complex structure out of just one. Thus NURBS models were almost always the result of "[attaching] several surface fragments together and [adding] a tangent line to the seams so that [they looked] like one smooth surface (Choi, 227)." These patches were stitched together to maintain tangency and texture alignment.

\(^2\) A problem I encountered too frequently on my second film "Ooga Chakka." I was determined not to make the same mistakes in my thesis.
During the modeling phase I created many props from NURBS surfaces. These included a room, a desk, a computer monitor, a computer CPU tower, a fully functional keyboard, a computer mouse, an articulated and detailed chair, a bed, bedroom furniture shelves, various nick knacks and eighty two books. All of these NURBS models were created from photo references and sometimes orthographically laid out blueprints. Using NURBS surfaces allowed me to quickly create basic forms and then trim and patch them into the more complicated and interesting models suggested by the reference materials.

Many of the NURBS props were created deliberately to allow for ease of modeling. This required that they have as few control vertices as possible. This was done not because fewer control points made less robust objects but because lower parameterization allowed me to model quicker than would surfaces that were denser. Speed was of paramount importance. I knew that I was willing to take as long as was necessary to finish my thesis film but I did ultimately want to finish it. Efficiency therefore was a major priority.

As has been stated, NURBS were unfortunately a work around created to solve the polygonal faceting problem. Oddly MAYA's "renderer only knows how to render triangles and volumes, not NURBS surfaces (Berndt et al, 185)." At render time
MAYA's rendering engine converted NURBS surfaces into triangular polygons based upon the density of the given model's parameterization. Early on I noticed that the supposed universal smoothness touted to be the reason for NURBS was not showing up in my rendered scenes. My NURBS surfaces looked faceted, polygonal, and useless. To defeat this problem I increased the basic, render, and advanced tessellation settings of given objects, as it seemed necessary. Increasing the tessellation allows for these polygonal triangles to better approximate the surface described by the underlying mathematics of the NURBS surface. Thus increased smoothing occurred irrespective of the numbers of control vertices in the surface's isoparms. Therefore a "light" NURBS object could retain very few control points and yet could look very smooth, but only when highly tessellated. Once this was implemented my NURBS objects looked fine and modeling continued at a quick pace.

All of the models created were instantly recognizable although they were by no means photo-real. It was never my goal to reproduce photo-quality analogs to real world objects. Rather I wanted to create a world that was recognizable as based on reality but clearly a fanciful cartoon. Thus every object created looked good but didn't need to be an exact replica of some real world product.

Once the set was created I next turned my attentions to the main characters. Just as the world was not meant to be photo-real neither was Bob. He was meant to look very cartoon-like. The polygon proxy cage that drove his subdivision surface skin was fairly light geometrically speaking. Bob had only four fingers per hand and his design was highly stylized. He was very angular. Bob's head could be thought of as a triangle atop another triangle. His body was lanky, had a too thin neck that was inserted into a slim torso with a bit of a paunch and his oversized feet and hands radiated outwards like four triangles.
I had executed orthographic designs for Bob based on an earlier version of the script. In that version he wore a lab coat. Once he was more of a caricature of me I very quickly turned the lab coat into his open shirt. Very few other changes were made and his modeling proceeded apace and in conformity with the design.

The operating system, on the other hand, went through several iterations. None of the designs I had created for her body were satisfying. I honestly had no driving aesthetic behind her body and every attempt was passable but ultimately didn't gel with any of the story elements. The final body I had modeled made her look like a young girl in a tennis outfit. It just didn't fit and so I decided to make her a disembodied floating head whose face would at times dominate the computer screen. I needed a face to make the computer seem more alive. A body however, pushed the metaphor too far and scrapping it really helped. During the design phase I decided that the OS' face also had to be created in two forms, one thin and the other fat. It was at this stage that I turned to the designs of noted comic book artist J. Scott Campbell. His "Danger Girl" comic uses designs that accentuated a character's youth by coupling very smooth and slight facial features with big wide eyes and high arching eyebrows (Campbell, 29). I built polygonal facial features to match these attributes and came up with the young/thin face that suggested a new, young and naïve computer. Her hair was comprised of simple polygonal planes that suggested a hairline. The overall effect was clearly anthropomorphic but retained a simulated feel. In order to drive home her artificiality I let the OS remain an un-smoothed polygonal model. Faceted polygons look computer generated and I felt that look was right for the face that appeared exclusively on a computer monitor.
Rigging

Once the models were created I began to set up rigs for any character or prop that required built-in articulated motion. At its most basic, rigging was the driving of a surface through the use of an underlying hierarchy of a set of deformers called joints.

Joint hierarchies are used when you are building characters. When you create joints, the point pivots act as limb joints while bones are drawn between them to help visualize the joint chain. By default, these hierarchies work just like object hierarchies. Rotating one node rotates all of the lower nodes at the same time (Dwelly, 7).

In theory then, a character would only need the careful placement of a few joint chains throughout its surface. Properly placed and then bound the character should be ready for nuanced performance driven animation. Would that it were so simple.

Since the Bob character was human in basic appearance and function, he was given a skeletal rig that suggested a human being. He had an "s" shaped spine with ribs coming off of it. Similarly, he had collarbone/clavicle joints and then rotating shoulders. His skeletal legs were joined from the hips to the slightly bent knees, to the ankles and then to the balls of his feet. His shoulders extended to elbows, forearms, and then to wrists and fingers. A separate reverse foot skeleton was created to drive the functionality of the foot's rotations and simulate a realistic foot roll.

Once the joints were in place all that remained was to bind the skin to the skeleton. Smooth binding was the binding technique I preferred to use. In smooth binding, "the bound skin points [were] weighted across many different joints, with each joint having a different weight of influence depending on the joint's hierarchy and/or distance from the particular skin point (Dwelly, 176)." This method allowed for a more organic deformation since real skin and cloth on a human stretched and deformed beyond
the immediate joint about which it bended or rotated. For example when one turned his 
wrists the whole of his forearm from wrist to elbow twisted relative to the changing 
positions of the ulna and radius bones. Smooth skinning helped to better simulate this 
 twisting by allowing given skin points to be driven by multiple joints. In theory this built 
in very organic deformations but in reality it had to be tweaked by hand and meticulously 
tested. Moreover, joint influence levels had to be carefully refined before the rigged 
character is ready for animation. This was required for several reasons. 

Firstly, joints were indeed driving surface deformation after that surface was 
bound. But how the joints deformed the surface was not always predictable. MAYA 
determined which joints drove certain surface points algorithmically, but that did not 
guarantee that they were the right points. Initially Bob's elbow joints caused points in his 
ears to shoot off and away from his head. Additionally, the smooth binding did not 
always ascribe the right level of control for a surface point to a given joint. "Each skin 
point [had] a total weight value of 1.0, but that weight [could] be spread across many 
influences (Dwelly, 192)."

Clearly the smooth binding needed to be tweaked. One was afforded two means of smooth bind modification. One could call up joints or skin clusters in the component editor or one could use the 
paint skin weights tool. The component editor allowed precise numeric control but 
calling up clusters or joints was often tedious and unintuitive. On the other hand 
painting skin weights was very intuitive as it showed one the influence levels in visual 
terms (in this case a grayscale image where black denoted no influence and white 
indicated total and exclusive influence). Painting skin weights, however, did not allow 
absolute numerical precision and in the course of modifications the brush would 
occasionally paint through one surface onto another behind it. With the wrong surfaces 
controlled, deformation was even worse. For both Bob and the OS' head I used smooth
binding and tweaked with both component editor and painting tools, as they seemed most efficient.

A priori one would have assumed that once smooth binding was accomplished rigging would be done and animation could begin. Here too, one would be wrong. A bound skeleton was rigid and often lacked the abilities needed to easily simulate organic motion. Should the model’s ability to perform be hampered, the ability to tell the story would be greatly diminished. For example, as pointed out above: when rotating joint hierarchies, a higher node’s rotation cascaded down to all subsumed nodes. That meant that all motion proceeded from the skeleton's root joint (usually the bottom of the spinal column). But realistic characters don’t move naturally from the base of their spine. When walking for instance, one usually lead with one’s foot. The leg and body followed. Similarly, when gesturing one typically moved the hand as the arm and torso followed slightly later in time. Animating this sort of naturalistic motion where, out of necessity, had to begin the motion at the top of the joint hierarchy’s chain (e.g. starting with the rotation of the hip and working down to knee, ankle and toes) was difficult at best.

Additionally simply bound characters could not conform to certain real world phenomena and as such could not be easily used. For example, the feet of a bound character did not remain planted when the root was moved. That is, because the root node’s state drove all other joint nodes’ positional and rotational data they would not remain in place when the root was moved. Therefore if a character walked forward he would seem to slide along the ground because it was nearly impossible to re-pose his feet every time the root moved such that the feet absolutely matched their initial positions.

To defeat this rigidity and account for these properties it was advantageous to institute a new level of control where applicable by adding Inverse Kinematics Solvers. Inverse Kinematics (IK) was developed to be a method of defeating the deformation order of the joint hierarchy. Thus IK chains allowed the animator to grab the end of the joint chain and move the foot. The knee and hip would then follow normally. Similarly, if one moved the root joint, the end joints of the IK chain would not move.\(^3\) Because of

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\(^3\) Strictly speaking, this was not necessarily true. IK chains could or could not be made to anchor on an arbitrary point. This functionality was governed by a Boolean attribute humorously called “stickiness.” I created all IK chains with stickiness turned on and so they did stay anchored in all cases.
this, a character's feet could stay anchored even if the root joint was moved. I gave the Bob character IK chains on his legs, feet and arms.

The IK handle is a transform node devoid of meaningful rotational attributes. It could not rotate a given piece of geometry. Moreover, if a key was inadvertently placed on the handle's target joint the IK would cease to function altogether. I therefore created NURBS curves to drive the IK in Bob's legs and feet. Because the IK handles were parented to these curves they allowed for keying both the IK's positional data and allowed for joint rotation as well.

These NURBS curves allowed for the placement of both the joints and IK chains on reference layers in MAYA thus rendering them untouchable during animation. In computer animation one wanted to divorce user control from model functionality. The reason for this was as obvious as it was hard to attain: one wanted to keep the functional parts of his or her models from breaking. And breakages could occur all the time. The less the functional parts could be touched, the fewer were the chances for breaking them. For example, once smooth binding and skin weight tweaking was accomplished an animator could still ruin the rig by accidentally translating or scaling a joint when he or she meant to rotate it. Therefore access to the joints was restricted.

By building many more functional aspects and then constraining them under objects that were intuitive, easy to use, and are separate from the actual structures doing the controlling one was reasonably well assured that models would not break during animation. Additionally one could modify existing attributes and add new ones to give a more succinct and yet comprehensive tool to the animator. For example, the controls for Bob's feet allowed only translation and rotation. I removed the scale attribute so that during animation the controllers and/or feet joints could not accidentally be resized. Scaling them might have changed Bob's feet size. Conversely, I added attributes to the feet controller such as ball and heel rotations that could be accessed merely by selecting the controller with the mouse. These attributes allowed Bob to do things like realistically tap his toes, kick with his heels, or roll on the sides of his feet. They were created with these attributes to encompass the normal range of human foot motion. They allowed all applicable functionality to be gathered under one controller.
NURBS curves also allowed me the ability to change underlying functionality in bound joint, functioning IK chain, or deforming cluster without altering animation control. This allowed the most flexible means to animate and make changes as needed. To that end I created more NURBS curves to act as controllers. I parented the entire rig including IK chains under a global controller that allowed me to position the Bob character anywhere in a scene and keep his feet and hands moving with the body. A local control just under the global curve allowed me to refine Bob's placement but left the IK driven arms and feet anchored so they remained in place even though Bob's body moved. This helped with good knee and elbow bending for poses with very little effort. Similarly Bob's elbows were further constrained to point at two NURBS curves so that elbow placement could be done quickly and effectively. His hands had controllers that governed vertical, horizontal and twisting rotation for the wrists and forearms.

While many of these controllers had functional aspects like the IK chains parented directly to them, it was not always desirable or possible to do so. In cases where parenting was not possible, the controllers governed motion by means of point and aim constraining. "A point constraint is used to make one object move to another object (Dwelly, 70)." Bob's wrist IK handles were point constrained to the hand control curve. Wherever the hand controller was moved, the IK chain had to move with it. An aim constraint was used to make one object face another. Bob's elbows were pole-vector constrained at controllers. Wherever these controllers were moved the elbow always pointed toward them. This use of constraining was advantageous because it allowed the controlling object to influence functional structures without being bound or a part of the joint/IK hierarchy. If changes in functionality needed to be edited the controllers would remain unaffected and retained functionality.

This is not to say that animators would necessarily break models. Indeed, for "Upgrade" I was both rigger and animator; it followed that in being intimately aware of the rig's inner workings I would avoid breaking its functional underpinnings. Nonetheless I maintained that at rigging time the rigger was aware of the delicate nature
of his models whereas during animation the animator would seek to push the model farther than the rigger might have intended. That the same person worked in both capacities did not assure similar attentions would be paid during different phases of production. After all, during animation and its required mindset one was rarely thinking about accidentally keying attributes that weren't supposed to be keyed. Therefore I created a control structure so that my rigs would avoid later problems.

This attempt at control mostly worked. From time to time the Bob character's wrists would evaluate rotation poorly and appeared to revolve in an unmotivated way. I tried to eliminate this by fixing the rig and by hand keying problem frames. Mostly, it did get fixed but there were still a few scenes in "Upgrade" that simply would not behave. When it was fixable I removed the bad rotations. Where necessary, I cropped the scene so that the viewer did not see it happening and very occasionally the shot's requirements forced me to simply ignore the problem and render with the bad rotations.

Additionally I added attributes for mechanical tasks that were repetitive. They were added to the controller curves and given functionality through set-driven keys. "Set-driven keys [were] used to define a relationship between one parameter and another (Gould, 479)." In the case of the Bob character I created attributes on the hand controllers that would drive finger rotations. The numeric parameters of these attributes would affect the joint rotation parameters for each of his fingers. Had this not been done, it would have been laborious to animate fifteen individual joints spread across five fingers each time they needed to be moved. Instead, the set-driven keys drove all the rotations in any finger with only one numerical input. In this way I had one controller that allowed me to move any of Bob's fingers in natural and organic ways with a minimum of effort. In addition to Bob, set-driven keys were used to automate the opening and closing of the scanner, laptop and printer models.

The final aspect of rigging involved the creation of blend shapes for all the necessary facial animation for Bob, the OS' head and the computer monitor. Blend shapes or multi-target morph shapes are a procedure by which "one object assumed the

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4 Rotational miss-evaluations were (and are) endemic to the computational nature of computer-generated inbetweening. Rotational values were merely numbers and the computer would move from one key frame to the next in what to its algorithms were the most efficient ways. This was done without considering the animator's intentions. Often degrees of freedom would be lost and rotations would seem to double back on themselves. This stuttering rotation problem was known as gimbal locking.
shape of another (Maestri, 142)." Blend shapes were typically used with facial animation. They were very useful in creating mouth positions used with lip-synch. I have found that many students rarely use blend shapes as well as they could. I was determined to correct this in order to get a better performance out of my characters.

Whether used well or not, morph targets needed to be created if they were to be used. In the case of my models, I took the model in question and made many duplicate copies. I then selected each of the duplicates as morph targets and the original head as the recipient of those targets and created a blend shape connection between them. At this point each of the faces was identical but their surface point arrangements were feeding into the original model.

Creating blend shapes automatically created a set of sliders allowing the animator to give the recipient between 0.0 and 1.0 amount of influence from the morph target. When each slider was raised to 1.0 the animator could see the target's full influence on the recipient. With all of them raised to 1.0 the full and often interdependent effects became obvious. Often further editing was needed to tweak the morph targets so that they worked well together.

Once the targets were connected to the recipient surface I began modifying the target faces to match necessary expressions. Because blend shape connections were history dependant, changes made to the target after the connections were made still affected the recipient. As I made changes to the targets, the recipient began to change. Many people created the different faces first and then applied them as targets. I liked to get the connections done first just to be sure nothing had yet changed. Occasionally in the creation of these targets mistakes were made early (e.g. a vertex one did not intend to move got shifted radically); I liked to see the modeling as it happened to be sure no such errors occurred.
In creating morph targets I differed from many other animators I have seen. Most starting or student animators created blend shapes covering a basic range of mouth positions. They gave the recipient face targets that could smile, frown, look passive and attain the nine phonemic expressions specified by Preston Blair (Blair, 186-187). They next built blinking into the eye lids and created forehead arrangements for a furrowed brow, raised eyebrows and a passive straight brow.

These targets allowed the animator an astonishingly broad range of expressiveness given the number of combinations available when mixing and matching target influence levels. Nonetheless I felt that this method of blend shape creation was entirely limited and that it ignored some important features needed for good facial performance. Firstly, I took half the faces I create and scaled them in the horizontal to a setting of -1.0 this effectively reversed the face’s orientation. I then took all the inversely scaled duplicates and put them in exactly the same location as their positive counterparts. I next selected both surfaces and pushed and pulled identical points to create new facial expressions for half of the face. Because half the target models were inverted the expression was then independently available to either half of the face. For example I could have the right side of the face smile while the left side could frown. I did this because realistic performance was rarely if ever fully symmetrical. Characters smirked or half-smiled, they spoke out of the sides of their mouths or sometimes half of their face remained flat for some reason. Even when characters did move facial features symmetrically they rarely moved both sides of their face in absolute synchronicity. Thus by allowing for asymmetrical control a greater level of subtlety could be imbued in the facial performance.

Additionally I tried to create blend shape targets not for pat expressions but instead to cover the full range of muscular motion available to the human face. Rather than create a frown for example, I created a blend shape target that could depict the full pull of the Triangularis muscle between the lower lip and the jaw. I tried to do this for all pertinent facial movement. Thus all my characters had built in motion in their mouths, cheeks, eyes, brows and foreheads. The mouths could cover a range of motion from

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5 Indeed, a careful study of my own face reveals that when I smile the right side of my face almost always moves quicker than the left.
shrinking down to tightly pursed lips all the way up to a full open-mouthed smile, frown, or shout. The cheeks, which most students ignored, were also capable of staying low or bunching around the eyes. Students often overlooked cheek motion and the resulting characters usually looked flat between the mouth and eye areas. By building in a range of motion I hoped to give my characters a greater sense of life. Similarly they had full eyelid, eyebrow, and brow motions. Characters could wink, blink, squint, raise brows in frustration, or happiness. They could furrow their brows and even display stress induced facial tics. In other words by trying to mimic human facial expressions my characters' performances were far more organic and lifelike than could otherwise have been expected. Character lip-synch came from pulling facial expressions out of the muscle range and not just from hitting the poses Mr. Blair had intended for two-dimensional cell based animation.

The Bob character's facial controls were perhaps too subtle, as one could not always see the difference when his cheeks or brows flexed. But for the OS' head, where a facial performance was vital to a believable sympathetic character, the morphing was robust and interesting and I think that her performance was quite strong.

**Animating to Sound**

With rigging done, a control structure in place, built-in attributes for set-driven keys and blend shape targets created, I was finally ready to begin animating "Upgrade." Creating good character performances was very important insofar as it would be the means by which I told my story. In essence, all I wanted was to create performances that would read and hit the necessary beats in order to move the story along. I wanted my animation to be clear and efficient enough to allow the audience to understand the story I was telling. In short I wanted competent animation.

Several problems beset me at this point. Namely, I was not a competent animator. My first two films suffered a great deal due to my characters' being too slow or too fast. For "Upgrade" I wanted to solve the issue of motion timing in order to concentrate on performance. To do this I needed to make sure the animation was appropriately timed to the sound and I needed a methodology for creating better acting with my animation.
For "Upgrade" I reversed my workflow and animated to a soundtrack that I had created during the pre-production phase. Until my thesis film, I had always done sound after the fact and the animation's timing had never really worked well. Moreover, the sound had never synched properly. Using sound as a guide helped me work out motion and timing issues, but failed to resolve the central problem: I was not a competent animator inasmuch as I had yet to produce a good performance with an animated character. I had taken a class in character animation and had read books on the subject but just wasn't getting it. In the hopes of learning a better method, I turned to the website of Keith Lango and his Pose to Pose animation techniques.

**Pose to Pose Animation**

By his own admission, Lango was not the originator of the notion of Pose to Pose animation (or organized keyframing as he called it). But his web-based tutorial was well known, highly considered and it served as my introduction to the concept. Lango claimed the following:

Pose to pose animation [was] also much as it [sounded]. The animator [picked] some seminal poses that, when timed correctly, [captured] the energy and direction of the shot. The animator [would then] go and create these poses and hit the timings, working to deliver the shot with structure. This often times [ended] up with some of the most powerful animation with very strong poses and tight timing, distilling the animation down to the very core of its being. It also often [ended] up looking stiff and mechanical and very stilted when the animator [wasn't] careful to think about keeping things alive (Lango, 2001).

This definition was very important as it included the inherent dangers of using this method. Within Pose to Pose animation, there existed the possibility that the resulting animation would look overly mechanical and would thus detract from the story telling. Given my initial problems with animating in a straight-ahead manner however, I
felt that I had to accept the challenges Pose to Pose presented and change my methods in an attempt to improve. Moreover straight-ahead animation sometimes “[resulted] in some genuinely inspired animation that [flowed] extremely well, (Lango, 2001).” But it could also “[end] up in a lot of dead ends and wasted effort when the animator [realized he'd] painted himself into a corner, (Lango, 2001).”

Essentially, the Pose to Pose method insisted on multiple passes of keyframing in order to block out and then refine poses. If created correctly, these disparate static poses would seamlessly transition from one to another when animated thus depicting a performance. The salient feature was that initially there was no animation whatsoever. The animator created poses where all keyframes were placed on one frame in the timeline for a given pose. The frame in question was chosen because the animator determined that this particular frame was the best frame suited for that pose. The pose was then held until the next moment in time that required a new arrangement for the continuance of the performance. Again the animator would choose one frame at some future point and create the new pose with all keyframes. No interpolation or tweening was to be allowed during the first pass.

Creating these static poses provided three advantages. They could be set up relatively quickly and played back to provide a quick “pop through” preview to show the animator how the entire shot was shaping up. If timing changes were required, the animator could simply go to the frame where all the keys for a particular pose were located, select them, and move them en masse to a more appropriate frame. Or, if a pose needed changing, the animator only needed to go to the appropriate frame and change key values. In this way all the keyframes were organized and easily handled.

Because I was animating to a prerecorded soundtrack I felt that the audio would help provide my timing cues for the initial poses in my first pass. I would take a given piece of sound, and use the audio cues to create pertinent poses. I’d then play the poses with the sound to see if they both matched the timing and provided well composed images that evoked a sense of the performance needed. When corrections needed to be
made I quickly went to the appropriate frame and made whatever changes were necessary. By the end of the first pass I tried to have good poses and good timing. Even though the poses popped from one to the next, I could already see that this method was resulting in a better and more motivated performance.

Given that pose and timing issues were worked out in the first pass, I used the second pass, as per Lango, to set poses for breakdowns in transition and inbetween arcs. Both breakdowns and inbetween arcs were a means of adding the organic transition of motion to animation. If, for example, a character was raising a hand in the first pose and was then resting that hand in the second pose, the computer would have to determine how the hand got from the first to the second pose. If there were no inbetween arcs the hand would, when animation was allowed to occur, move in a linear fashion from the first frame and gradually adopt the new pose’s position by the second frame. On the whole this would look very mechanical and not lifelike at all. Inbetween poses would force the hand to hit an intermediate position. For example, human motion was rarely linear. Most people would rotate their limbs such that their movements would describe a series of overlapping arcs. This was true because when in complete motion the human body would be constantly rebalancing itself. As a result the body and limbs would swing around the moving center of gravity as weight was shifted.

To create this motion the animator would insert inbetween frames that would help reinforce these arcs to help add realistic movement. Moreover, human motion would rarely occur at a constant rate. Simple actions like standing up usually happened at variable speeds and nuanced performances absolutely required that a character’s motions be varied and complicated. The placement of these inbetween frames could help a character move from one pose to another more or less quickly and thus helped add a level of subtle believability to the movement.

Once the second pass was complete static poses would no longer be informative. It was then time to introduce motion and animation into the review process. For the third pass, I selected all the keys and allowed the computer to apply a linear interpolation between them. This resulted in the
first actual animation motion for the shot. Although it was very linear, this pass' motion
gave a sense of what still needed to be corrected between the posing and the timing. Any
identified problems were fixed. These could have included changing the timing or poses
on existing pose-frames. It could also show that still more inbetween frames were
required to create more intermediate poses in order to refine the motion. Once these
corrections were made, I previewed the scene again with an eye toward finding more
mistakes. The third pass did not end until I could not find any obvious problems with the
animation.

After all the errors seemed to be fixed I moved on to the fourth pass. The first
thing I did during this pass was save my old work and then save the fourth pass file under
a new name. Until the fourth pass was finalized all the keyframes for a given pose were
still located on one frame in the timeline. As of pass four that would no longer be true.
Keyframes from one pose would start moving through the timeline and could even come
to rest on or near frames that corresponded to other poses. Once keyframes started to
move around the animation data would become increasingly messy and thus hard to deal
with. It was a given that by the end of the fourth pass the animation data would be a very
complicated jumble that, if done right, would provide a great performance. Thus, having
an organized backup copy just in case everything went wrong could be very
advantageous. I always made sure to save the third pass data in an older file before
moving on to the fourth pass.

Once the old third pass data had been saved, I began to alter the keyframe data in
several ways. For the fourth pass, I started by offsetting keys. It was rarely the case
during regular motion to have a human character's various joints all hit certain poses at
one exact moment. Instead people moved various body parts at different times and at
different speeds depending on what they were doing and how they were doing it. I
therefore offset certain keys to make it look like certain body parts were following other
parts. For example: when walking, a character's shoulders typically swung counter to the
rotation of the hips. The shoulder's swinging then propelled the upper arm, which pulled
the elbow and forearm in turn. Typically the rotations of the upper arms would lag
slightly behind those of the shoulder just as the elbow would start to bend slightly after
the upper arm had hit its peak in rotation. Thus offsetting the appropriate joints helped to create the feel of secondary and tertiary motion when the character walked.

This offsetting of keys was vital to creating good animation. The mechanical and robotic feel that could ensue in the Pose to Pose method most often came from too many keyframes on the same moment in the time line. It was this offsetting and the ensuing overlapping of complex motions that created a fluid and organic movement. I constantly tried to perfect the animations I was creating by modifying the rates and placement of these offset keys. Additionally I tried to offset keys for pairs of limbs in an asymmetrical fashion, thus imbuing a further degree of organic non-uniformity to the animation. For example, when Bob flipped over the laptop and landed on the bed, the initial pose has his impact on the bed coincide with that of his feet on the wall. Newton’s first law of motion dictated that Bob’s legs would still be moving after the initial impact, as did the prerecorded sound track.\(^6\) During the fourth pass his feet were moved back in time so that they hit the wall slightly after his body came down on the bed.

In addition to offsetting keys it became necessary, during the fourth pass, to change the method of interpolation between those keys. Linear interpolation moved an attribute from one value to another in a linear fashion corresponding to the mathematical equation \(y=mx+b\) where \(m\) was the slope (a function of calculating the difference of the \(y\) coordinates divided by the \(x\) coordinates between any two points on the motion curve). The resulting animation was often very mechanical as its rate of motion was constant. By changing the keys to spline curves one obtained a series of motions that had a built in ease-in and ease-out. This was so because spline curves interpolated such that they “\([caused]\) the animation curve to be smooth between the key before and the key after the selected key. The tangents of the curve \([were]\) co-linear (both at the same angle). This \([ensured]\) that the animation curve smoothly \([entered]\) and \([exited]\) the key (Alias/Wavefront, 1999).” Often this was accomplished by slowing down the motion right

\(^{6}\) The sound, made by recording myself doing somersaults on my own bed and getting my dirty shoes on my bedroom wall, clearly has an initial impact followed by a first foot strike and then a second.
before and right after the key as the tangents forced the curve on either side of the key to approximate the key’s uniform value. The endemic slowing and speeding of motion in flat tangent spline curves helped create a more believable motion insofar as it added further variance to the animation making it more unpredictable and organic to the viewer. But just changing the curves from linear to spline did not guarantee good motion. I would then check each curve individually, changing tangents to help make realistic motion. Where necessary I would change a curve’s slope by adjusting the tangent or I would break tangency when abrupt changes were necessary.

By the end of the fourth pass of animation I was beginning to see real performances come out of my characters. Their motions were clearly timed to the sound and the manner of movement was markedly better than in my previous animation attempts. As I was still unsure of the quality of my work I would often turn to fellow students in the lab and solicit critiques and suggestions. When possible I would implement their suggestions in an attempt to further improve the quality of my work. The final results were certainly stronger than any animation I’d created in the past. I still felt that in many scenes it could be made stronger. I clearly needed much more practice before I would feel totally comfortable as a character animator.

The animation was the central means by which I tried to tell my story. All the designing of the shots, the modeling of the props and the rigging of the characters was just a means to get to an animated story. All the supporting structures were created to help the audience place the performance in a context that helped them understand the story I was trying to tell. In essence, the props and models were created to immerse the audience into the world of the story. Nothing helped bring an audience into a story more than sets and characters that are appropriately and vividly textured.
Texturing

Good texturing served to inform the audience about the world the animator was presenting, while enhancing the storytelling through the creation of additional details and aspects that infused the presented world with more layers of ambience and perhaps meaning. It was the deliberate combination of thoughtful artistic design and technical proficiency. After animation it was the most visible aspect of the animator's work. If texturing was done incorrectly it could keep the audience from accepting the visual material. When done well, however, texturing did not call attention to itself, but rather seemed to be an endemic facet of the film and added to the visual landscape thus enhancing the story.

Good texturing first had to defeat the essentially artificial look of computer-generated topology. When unshaded, computer generated geometry was a theoretical wire-frame of intersecting lines. To create a sense of surface the software had to apply a shader network to the wire-frame model. A shader was a, “node [that consisted] of an output and an input, and they [were] linked together based on the definition of light and surface representation to create an image (Choi, 505).” What this meant was that the software created certain nodes whose attributes could be applied to the wire-frame. This node, called a “shader,” would cause the computer to interpret the wire-frame as a surface and give it topological features that were based on what the various outputs were fed from the shader’s available channels. The channels in question could include color, diffuse color, transparency, incandescence, bump mapping, and in some cases specularity. These channels could also map files or procedurally created patterns that also effected how the topology would appear. A shader node with constituent files feeding into it was known as a shader network. An initial shader applied to a model provided the material aspect of a surface. “A material [was] the base substance of a

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7 Indeed, a few years ago an undergraduate presented a fairly well animated short in which the ground plane's textures flickered incessantly. I can barely recall what his film was about but I can still remember how visually jarring the bad texturing was. Had he worked this issue out, I am almost positive that his film would have made a longer and more positive impression. I was determined not to make this mistake with my thesis film.

8 There are several types of shaders available in the MAYA shader library, but a cogent discussion of each one and its properties is beyond the scope of this paper. Interested readers are referred to the MAYA online documentation and Demers' "Digital Texturing and Painting" (see bibliography).
surface (Demers, 20).” Thus a shader network added aspects of texture to the material. “Texture [was] the adjective of the Material... Texture [had] more to do with the look and feel of the material, the wear and tear of the material, and its design or pattern type (Demers, 20).”

Initially a shader network, consisting of a lone Lambert shader was automatically applied to wire-frames in any given MAYA scene. Lambert shaders displayed the color channel data on the surface with little or no variance. They had no specular channels and as such could have no specular highlights; but they would display light-created shadows. While one could do fairly detailed work with just the channels provided in a Lambert shader, most digital professionals would, when resources allowed and project goals necessitated, use more robust shaders to create richer surfaces. In the early years of computer generated imagery even nodes with specularity could only create topologies that seemed plastic and synthetic. It was because of this reality, that PIXAR’s first film, “Toy Story” featured plastic toys. In the ensuing years, however, shader networks grew and could ultimately mimic most surface types more convincingly. Since more varied surfaces were possible, the look and feel of the output imagery became the choice of the texture artist. An artist used textures to create imagery that looked better than purely computer generated surfaces because it appeared more real to the human eye. Beyond that, the texture artist sought to use imagery that brought something visually interesting to the content of the work being presented.

Indeed, texturing did not have to be photo-realistic to be good. A fair amount of stylization had always been acceptable if it looked similar to the other stylizations being employed in a given piece of animation. Whether photo-real or not, a well textured image could help enhance the story telling by adding informative details. “Upgrade” never attempted to create a photo-realistic environment. The characters were too cartoon-like and exaggerated for photo-realism to be acceptable. Thus all the surfaces for characters and props were stylized to an extent. For example, all plastic materials for computer parts were shiny and just a little bumpier than real plastics would appear. The wooden floor in Bob’s room had a grain, clearly delineated floorboards, and had lost shininess in areas upon which it has been heavily trod. But the wood texture on the floor surface is merely suggestive of wood in basic coloring; the bump map allowed the boards
to be uniformly smooth and only created depths in the cracks between the floorboards. The resulting structures looked identifiable, but were too simple to be real.

Textures For the Set’s Floor Including Color, Specular and Bump Maps

Nevertheless the textures on many of the models in the room helped tell the story by providing details about Bob that revealed his personality and thus sold the story in which he relentlessly and lustily pursued attractive computers. For example there were eighty-four individual books on the shelves in Bob’s room. They all had one basic shader node applied to them. This shader used a switch node to assign one of thirty-two possible book covers to each individual book model. Thirty of these titles concerned themselves in some way with computers. This helped show the audience that Bob was a bit fanatical when it came to technology. Moreover two of the three posters in Bob’s room also carry pro computer themes. One was a poster that showed a girl hugging a personal computer and bore the caption: “Manga Girls Love Computer Geeks.” Upon seeing this along with

Moreover all the computer titles were actually spoofs of books that actually exist. This was done because it made the books look correct but upon closer inspection was actually funny. Two of the titles are just books that I love and were inserted out of a sense of whimsy and homage.
the framed picture of a computer on Bob’s desk, the audience would hopefully perceive that he had a deep love of computers and that this in turn helped them believe in the computer romance that ensued during the movie. Thus the details provided by the textures helped to create an environment that furthered the story and conveyed key aspects of one of the characters. This was an example of good texturing insofar as it served the story.

If taken too far, however, the texturing could detract from the story. Initially Bob’s room was far more slovenly in look an appearance. This was entirely due to the textures assigned to the room itself. In the first version the room’s walls were crumbling. The plaster was non-uniform and very bumpy, many visible cracks were displayed and in some areas the wall itself seemed to have crumbled away revealing the bricks beneath the plaster. Additionally, the ceiling tiles were far more stained and decrepit in the first version. The room’s textures were immersive but created a creepy ambiance that seemed to take away from the intended story. Instead of seeming like an unfaithful technophile caught in a love triangle, Bob’s room suggested that he was a denizen of some underworld tenement. That perception really didn’t fit with the story. Consequently the room was redesigned to have whole walls with a few scuffs and stains on them. This merely suggested that Bob’s room was “lived-in,” that is it was often occupied. This look helped the story in turn because Bob rarely left the room.

In fact, its lightly worn down quality helped show the audience that the room with the computer was in fact Bob’s whole world. Not long after the re-design the room was shown to a fellow student whose critique essentially called for more grunge. Her position was that the redesign was too flat to be visually interesting. After much deliberation and thought I decided to reject her suggestions. Bob’s room was meant to be an environment that helped immerse the audience in the story about him and his computers. It was not meant to be so overwhelmingly obvious that it detracted from the characters’ performances and in so doing obscured the story. I created a room that provided a level of ambience and a degree of information. It brought the audience into the world but allowed them space to watch the performance.

Thus the texturing served the purpose of enhancing the story while not diverting attention away from it. This was accomplished through the understanding of how the
designed elements would be implemented through the software. There were many texturing features available to the animator. For example MAYA provided fur and hair and other so-called dynamic paint effects. Many of these tools created interesting images that often have pre-animated features built into them. I studiously avoided them all.

Because I was merely trying to tell a story I decided to deliberately limit myself to those necessary components that would create good imagery and help me enhance the narrative. Anything else was deemed to be a needless exercise in technique that ultimately added nothing to the film. As a result I designed most of the shader networks to have the main attributes needed to create interesting textures but nothing more. These consisted of color, bump, specular, and occasionally incandescent maps. This was not to say that these attributes were not complicated, only that they were the only ones used.

Color mapping provided the basic look and feel for the objects in question. For plastic items such as computers it was typically a tileable ramp that consisted of one color slightly varying into a different shade and then back again. For the OS' face the color map consisted of one square shaped ramp over which each polygonal face's UVs were unitized. This created the computer generated grid appearance on the OS. The ramp allowed me to key changes in color value. This allowed the OS' face to change from green to red, as she got angrier. Bob's color mapping used a combination of painted colors for skin, and scans of cloth and denim for his shirt and pants. The bed's covers were likewise scanned swatches of cloth from my own
bedspread. These colors were then modified in Adobe Photoshop to make them simpler so that they would fit into the style of the film. The color for the silver laptop was created by scanning an Apple laptop and then doctoring it to take the Banana Book logo seen in the film.

Bump maps were similarly created to enhance the look and feel created by the color maps. For plastics that were rough, a grayscale image of tiny varying dots was applied. This made the plastics to look overly course. This was done because when textures look too smooth they seem unreal to the human eye. For this very reason no bump maps were used for the OS' head.

Conversely, Bob's bumps added a level of creases to his clothes and gave a grain to his hair and beard.

The bed's bumps were designed to create a level of bumpiness to the surface in order to simulate fabric. Depth maps were created to mimic the stitching found on the comforter and to add variance to those stitches thus giving it a crumpled, slept in look.

This bump map was very carefully constructed to follow a strict grid pattern because the bed's surface was NURBS based. Since NURBS UVs were built in and because the NURBS surface was a series of planes that had already been warped, a tight grid would conform to the flow that the modeling had already caused in the surface.

The laptop's bumping was far more straightforward in construction and function. Its bump map was a very high contrast series of lines that gave the laptop a scratched and worn look. This obviously went against the story line that called for the laptop to be brand new. I felt it was worth infusing it with some wear and tear to defeat the computer generated look that would result in the absence of a bump map.

Just as Bump maps helped remove a level of computer generated uniformity in the models, specular maps took it a step further. Specular maps governed how a highlight would fall on an object. If, for example, an object would normally take a highlight across its rim when the light allowed, a specular map could help break it up and make it look less uniform across the surface thereby giving it an individuality that flatly
shaded models lacked. Moreover the specular highlights changed profoundly as the lighting scenario changed. The plastic props took a subtle specular map which was a direct inverse of the file that created their bump map. This helped emphasize the granularity of their composition and again helped defeat their artificial nature.

Since the OS, on the other hand, existed in a virtual realm she took no specular map at all. I wanted her too look flat and computer generated since she only ever appeared as an image on a computer screen.

Similarly, Bob's body also took no specular map since his clothes were cloth and shine was to be kept to a minimum for them. His face and glasses, however took specular highlights that helped emphasize his facial expressions. Light glinted more readily off of his nose, eyes, glasses and teeth thus drawing audience attention to his face.

The bed, again a cloth item, took no specular map. Cloth was generally not considered to be shiny and while the shaders for all cloth items did have a general
specularity it was only a diffuse one.

The laptop on the other hand, had a very robust and complicated specular map. The laptop’s specularity highlighted the scratches but also showed fingerprints and smudges, just as real metal would do if it were highly shined and often touched by oily human hands.

Incandescence maps were used very rarely and only when necessary. The incandescence channel governed how much like a light source a surface behaved. Generally most surfaces did not shed luminance except when reflecting it from a cast light source. But the computer monitors, which were backlit, did cast light and so incandescence maps for the monitor textures were also employed. When used, they made the computer monitor and the laptop monitor glow. This glow conformed to whatever was actually on the screen. In this way the incandescence mapping helped the computer monitors simulate the observable functioning of their real world counterparts.

While these maps looked good during design they did not always apply well to the surfaces created. This occurrence was not atypical in 3D animation as textures would
arrange according to the established UV space and UVs were not always conveniently laid out. For example the monitors looked oblong but were in fact modified circular NURBS planes whose isoparms did not form a grid but rather projected spoke like out from the geometric center of the surface. When a shader was applied, unaided, to the surface the textures mapped not across the model but rather around its center pole. The resulting distortion made the image wholly indecipherable. When problems like these occurred, textures were applied not by regular means that spread them across the established UV coordinates of a model’s wireframe but rather as a projection. “Projections [were] like a slide show on a screen, (Dewers, 300).” In other words, they ignored the built in UVs of a surface topology and placed the intended texture across the surface. How this displayed could be specified by the user. Elements like the computer monitors required projection mapping techniques to produce satisfactory final products.

![Monitor Textured Without a Projection](image1)
![Monitor Textured With a Projection](image2)

The last texturing method used was the layered shader. A layered shader allowed more than one shader network to be applied to any model. Moreover it allowed several different shaders to simultaneously affect the surface topology independent of each other. An example of this would be to have the top shader govern the object’s specularity while a lower shader’s color and bump mapping showed through underneath. The layered shader was employed to morph the computer monitor. When the computer was a normal inanimate object, the top shader projected the monitor screen image onto the appropriate area. When the computer morphed into the monster, however, the top shader became fully transparent revealing the lower shader which turned the monitor area into a gaping red mouth.
Thus through the use of effective texturing the look and feel of the movie was enhanced. This was done without directing audience attention away from the story. Textures were often subtly employed. They were detailed enough to both break the dull computer generated look of the topology and also content-rich enough to provide embellishment and context for the world I created. Only the sufficient and necessary attributes needed to create the world were used. Any flashy effects that might have obscured the story telling were avoided. This was accomplished due to an understanding of how textures and topologies interact. When surfaces and shaders did not interact conveniently, my technical proficiency allowed me to easily create projections or layered shaders that defeated the problems. The resulting texturing filled the world of “Upgrade” with an interesting visual landscape and effectively served the story.

**Lighting**

Good texturing, however, would have been obscured and invisible without proper lighting. Achieving good lighting was a challenge insofar as lighting served both technical and artistic purposes.
“The Basic premise of good lighting [was] that, when done right, light [gave] objects or characters ‘meaning’ in their surroundings. It also [provided] an appropriate and intentional atmosphere that [would] be logically interpreted by the viewer (Berndt, 84).”

With lighting, methodologies were employed to help tell the story while not calling attention to the techniques being used for their own sake. Light was carefully used to help showcase the world that had been created. It established mood and aided in the story telling. As with all other aspects of “Upgrade,” the goal was to create lighting that contributed to the shot in question, adding only what was necessary. In other words the lighting scheme was meant to be simple and effective. In some ways it was, but not necessarily in the ways I had anticipated or planned.

Earlier versions of MAYA required volitionally placed lights. If one did not place any lights in the scene, rendering would result in a black image in which nothing could reliably be seen. This was so because “in Maya, surfaces [were] illuminated by light rays emitted from lights, (Alias|Wavefront, 1999).” When no light was present no illumination occurred. In the more recent versions of the software, however, an initial default light set was created. This initial light set bathed the MAYA scene in light that emanated from just off the rendering\textsuperscript{10} camera’s point of view. The resulting lighting scenario did provide illumination for the scene but it was generally flat and provided no atmosphere. “Upgrade” demanded a somewhat more robust set up than that provided by the default.

The goal was to create lighting that was interesting and that created the various moods for the different scenes. There were only two environments for the movie: Bob’s room and inside the computer. While this made lighting easier in some ways (as it meant that only two sets had to be considered for any possible lighting situations), it also meant that the film ran the risk of looking too similar from shot to shot. This would have caused the visual material to quickly grow stale and thus bore the audience.

Because Bob’s room was essentially a real-world analog, it made the most sense to create a lighting scheme that suggested the real world. In this case, three main lighting

\textsuperscript{10} Thus the MAYA render engine repositioned the default light set as different cameras were selected for rendering.
scenarios were envisioned; each one corresponded to a specific time of day. Thus lighting was set up to create scenes depicting sunny daylight, sunset, and nighttime. Not only did different lighting make for a more interesting visual experience but changing the time of day also allowed for a motivated and naturalistic lighting scheme that corresponded to needed moods and atmospheres, thus helping to tell the story. When to use which lighting set and what atmosphere to create, became the central questions while setting up the movie. Bizarrely, the answer came from listening to music. An old favorite musical of mine was *The Fantasticks* by Harvey Schmidt and Tom Jones. In one of that musical’s songs, “This Plum is too ripe,” the characters complain that “what at night was oh so scenic/may be cynic in the light, (Jones, 1960).”

The idea that certain times of day carried thematic or emotional elements and aspects sparked an idea. I had read that Vittorio Storaro had been the cinematographer for the Sci-Fi channel’s Dune miniseries. He used “light and color as story elements, (Van Hise, 138).” For example on Dune, “Each major group [was] identified and defined by color, (Van Hise, 144).” It followed that I too could light thematically. That is, I could use light and color to create specific times of day. These times of day would in turn, evoke the moods and atmospheres of the scenes. Vittorio’s lighting sense seemed to be the best way to do the lighting and *The Fantasticks*’ lyrics pointed to the perfect arrangement for the scenes. Of course, this being my film I also added a twist.

All of Bob’s romancing of the OS took place at night, when everything was scenic. It was at night that Bob built her; at night he delighted her with more software. In the night while Bob slept the OS confessed her love for him. Night was the time for bedroom promises after all and this seemed the best time to portray the character’s mutual infatuation. The night scene cast the room in a pale blue light, which emanated from spotlights at the window and an area light casting luminance
from the computer monitor. This light in turn bounced off of the walls casting structures in blue tones. For this bounce light, low intensity blue spotlights were employed. A key point light of warm, but limited orange, emanated out from the practical lamp behind the computer. This gave the characters warm and intimate surroundings. The illuminated spaces were small and cozy but the shadows were neither overpowering nor spooky.

While the night’s shots were scenic, the daylight sequences were certainly cynic. During the day, Bob discovered the OS was full and too fat. In daylight he went looking for a sleeker and younger laptop, and during the day the OS witnessed Bob rejecting her by taking his new laptop-lover to his bed. The daytime scene was lit with bright yellow primary spotlights. These simulated the sunlight that came streaming in through the windows. Gentler bounce light was cast from the walls and ceiling by spotlights with lower intensities and whiter colors. The cast shadows were dark and strong but they did not overpower the ambient light filling the room.

As a twist a third period of time was introduced. Night was scenic, daytime was cynic, and the colorful sunset, during which the OS’ confrontation with Bob took place, was psychotic. As the daylight gave way to a bold, brightly red and orange sunset the jilted lover’s ire rose to homicidal levels. During this sunset, the OS attacked Bob. She then threw the laptop out the window and consumed her former beau.

The sunset period was created by lowering the position of the sunlight spotlights from the windows from a high to a more horizontal angle. The sunlight lights cast deeper shadows but they had soft, feathered edges, thus blurring the distinctions between light and dark and by implication, insanity and reason. Similarly, the bounce light became more diffuse and less intense. Point lights were again used but their light was very soft and far-reaching. Shadows were deepened using special lights that cast negative intensities. These dark lights were used to deepen the darkness in the corners and crevices of the room where less light fell. Such areas were engulfed in an eerie darkness.

These three times of day were very different and also very distinct. As such it was imperative that the lighting within every scene for a given daylight-period be consistent with every other scene in its time period. For example, the sunset scenes were all very red with orange highlights. Had one shot in that sequence been lit in the blue nighttime scheme, the sequence would have looked inconsistent. Moreover the light’s
quality also depended on its positioning. In daylight, sunlight streamed into the room from a high angle outside the window. It needed to stay at that high angle in all cases. Because these very specific lighting characteristics needed to be maintained, it became clear that lighting would have to be an automatic process for every scene since it was nearly impossible to relight every scene individually and expect believable consistency.

A lighting rig was created to not only automate light settings but also to help adjust it, as events required. The room set was lit with MAYA generated lights for each daylight-period. When each of these periods’ light settings was perfected and finalized, the lights for that daytime-period were put onto a layer whose visibility was turned off. The constituents of a layer that was not visible did not affect the MAYA scene. Once that daylight-period’s lights were set and then invisible, the next daylight-period was perfected. In this way all three lighting scenarios were created in the same scene. Each layer was thus effective but did not influence or interfere with any other during creation.

Once all of the daylight-periods were created, all the lights were brought onto the same layer. This would have caused a poorly lit jumble of lights and would have totally washed out the scene with inordinate degrees of intense luminance. A control structure was next created to manage the functionality and interaction of all the lights in the scene.

The control structure was a NURBS curve that resembled a lamp. It sat well above the set and could easily be selected from orthographic views or the MAYA outliner window. The controller’s normal positional channels were removed, thus locking its position. New attributes were created for the daylight periods. These in turn were linked to the appropriate lights by means of set-driven keys. For example all the daylight lights were driven by the daylight attribute. Similarly the sunset attribute governed the sunset-specific lights just as the night attribute governed the nighttime lighting setup. When one of these attributes was set to 10 its constituent lights were all on at their pre-assigned highest intensities. When the attribute was set to 0 all the lights had an intensity of 0 and
thus were not illuminating anything. It is important to note that the preset highest intensities were not always very high. A light whose maximum value was determined to be 0.3, for example, never went above 0.3. Rather, 0.3 was its maximum setting when its governing attribute was set to 10. When its controlling channel was set to 5 it would have a value of 0.15. Thus all the lights turned up to varying values automatically, but because the same channel governed them, their relative intensities were always proportionally equivalent. That is, when the governing attribute was set to 5 all the subsumed lights were at half of their total allowable intensity. Correspondingly, an attribute of 3 set all the lights to 1/3 of their total value.

This was done because sometimes a chosen camera angle did not work well with the lighting rig at full intensity; often a surface looked acceptable at full intensity from a given angle but then got washed out by the light at a different camera angle. Dropping the lighting levels by lowering the governing channel’s value allowed the light to become less intense but the overall feel of the daylight period was maintained. Because all the other lights were proportionally intense at consistent and predetermined angles, it was hoped that this would maintain a consistent feel for any of the preset lighting scenarios. By and large it worked well. When changes in the lighting levels caused obvious discontinuity between shots, the controller was set to a level that was considered acceptable as a base and additional lights were brought in to bolster the lighting. These additions, however, were far less frequent than would have been required had each scene been lit individually.

At first, this automatic light rig yielded good results but took well over thirty minutes to render a single frame. Given the amount of scenes that were planned, this time lag would have made it almost impossible to render the entire movie by the deadline. Careful analysis and some research revealed that the light rig contained no less than fifteen individual lights that were casting depth mapped shadows. “A ‘depth’ rendering [was] done from the point of view of the light source, and later used during the rendering phase to determine if that light [illuminated] a given point (Brendt, 126).” Every light that cast a depth mapped shadow made such a computation. Thus every pixel that was rendered had to be considered at render time from every shadow casting light’s point of view. Indeed, the point lights were actually making six depth maps because they
generated depth maps in all directions. With no fewer than fifteen lights in the scene creating such computations it was no wonder that the render time was so exaggerated. To combat this problem, a MEL script was written that surveyed the light rig controller and turned off the depth maps for any light that had an intensity of 0 (See Appendix E). If a light’s intensity rose above 0 the script automatically turned its depth maps on. Once this script was in place and running, rendering time was reduced to six minutes per frame.

The light rig’s lights, however, were used mostly for the set. They did illuminate the Bob character when he was brought into the scene, but Bob often required additional lights that solely affected him. Occasionally additional light needed to be added to Bob to more dramatically light him. When this was the case additional lights were created and they were specifically light-linked to the Bob character’s geometry. These lights did not affect the room set and did not interfere with the light rig’s influence but they did have additional depth maps and thus increased render time again.

While the light rig and the additional lights for Bob were meant to give the room a real-world lighting quality, the in-computer lighting took a fairly artificial tack. The computer monitor itself cast a soft blue glow into Bob’s room but the scenes that happened within the monitor had no motivated light sources. As a result the OS’ face was always given a general three point light arrangement with a key light, rim light and fill light. This arrangement was a base and was changed to match the needs of any given shot. For example when the OS became furious the rim light cast dark shadows over her face and when she was longing for Bob’s return the key brightened up her wide-eyed expectant expression.

In the final analysis the lighting scheme was meant to look simple and intuitive. The audience was meant to accept it as real light and not wonder where any particular light source was coming from. It was meant to be invisible though very present. In order to create this simple effect, complicated lighting scenarios were created and controlled through complex governing structures like set driven keys, programming and brute force in the form of additional lights linked to very specific geometries. A lot of effort went

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11 Point lights created depth maps for the up, down, right, left, front and back directions. For tighter control one could, in theory, determine from which of these views the shadows emanate and cut out the others, but the point lights used in “Upgrade” were all omni-directional.

12 MEL is the MAYA Encoding Language. It is a computer language related to JAVA and C that allows the MAYA user to create custom functions, and programs that will run within the MAYA software.
into these lighting arrangements and they worked very well.

Rendering

Rendering was the final production phase. It could only be enacted after modeling, animation, texturing and lighting were completed. This was so because “[rendering] was the generic term for ‘creating a picture’ from a scene’s models, surfaces, lighting, and camera angle, (Masson, 160).” The process of taking all of a scene’s data and converting it into a raster image was complex and computationally intensive. Endemic to MAYA were two render applications, the MAYA renderer and the mental ray render engine. Additionally, RIT’s School of Film and Animation had PIXAR’s renderman software on its MAYA workstations. These three different renderers offered a variety of disparate options for turning the visual data in a MAYA scene into a raster image. The least robust of the three was the MAYA renderer and it was the one that was used to render “Upgrade.”

Mental ray offered a larger range of options than the MAYA renderer. It had custom shader nodes and its use of photons made for better light scatter and raytracing. Unfortunately mental ray was somewhat unpredictable. It often broke down and would render erratically. While it would have generated robust imagery, I did not feel it was worth the time and hassle to trouble shoot every scene that might have crashed; moreover my guiding principle of telling the story as simply as possible lent itself to the MAYA specific look. Thus a more powerful render engine like mental ray did not seem warranted.

Similarly, renderman was the professional rendering software of choice amongst 3D production facilities. It was a complicated and powerful program. I did not feel I had enough experience or knowledge to use it effectively. I preferred to use the render engine with which I was comfortable. Thus the built-in MAYA renderer was used to create the imagery for “Upgrade.”

Because the final film was going to be edited in Apple’s Final Cut Pro software all imagery was initially rendered at highest quality with a 720 X 480 aspect ratio. The MAYA renderer did render with raytracing for reflections but the value was limited to 2
rays. This made sense, as there were very few elements in the scenes that were actually reflective. Depth-of-field-effects were avoided throughout the film and camera focal lengths were always left in a default state. These enhancements could have added a greater sense of depth to the visual space that would have been created, albeit at the cost of added time to the rendering of each individual frame. I ultimately decided not to use them because depth cues above and beyond the built-in look and feel of computer generated 3D did not add anything significant to the story. Just as I could have had a slicker look had I rendered with Mental Ray photons, I didn’t because it would have amounted to one more neat trick in the film that I was using just to show that I could use it.

Instead I decided to render the film in the same way that I made every other part of it. I needed it to look sufficient in order to competently get my story across visually. Anything beyond that was considered to be wasteful given that I was working essentially alone and that time was a factor. Especially by the time I was up to rendering. By that point my deadline was very close and I had to have reliable results.

Image sequences were rendered as tiff files with embedded alpha channels. Occasionally, multiple render passes were made to isolate and later enhance specular highlights and shadow areas. For example the scene in which the laptop and the desktop fight was rendered in multiple passes so that the laptop’s specular shine could be emphasized.

In cases of multiple layers, or when background plates for outside environments were needed (such as skies or the hallway outside Bob’s room), animation shots were composited in Adobe After Effects. Once a clip was fully composited it was output as an uncompressed QuickTime movie file. This ultimately proved to be a mistake. Final cut pro required an NTSC DV compression when it rendered its files. It was thought that one could do that from within Final Cut Pro itself and that this would limit iterations of compression and its inherent degree of data loss to the last phase of production. This was
thought to be desirable on the grounds that compressing early and then again later would result in an increasingly degraded image quality. Ultimately Final Cut Pro would not write the uncompressed movie to DVCAM tape and it had to be first exported to a compressed format. Only then could it be re-imported and used for final output.

Rendering was completed in a fairly piecemeal fashion. As a scene was completed it was rendered while work began on the next scene. A rough cut was edited together and shown to Howard Lester at a weekly meeting. Howard and I had been meeting on a weekly basis to discuss story and structure. Once animation began, we met so that I could show him what I was working on. These meetings were mostly informative and Howard took a deliberately hands off approach. As I began to edit the film together, however, my meetings with Howard became more and more vital.

**Editing**

Howard has had long experience with film editing and it was for this very reason that I asked him to be my Thesis Committee Chair. The editing in my first two films was abysmal and I really wanted to do it better on “Upgrade.” Editing was the stage in which all the work I’d been doing was to coalesce into a coherent story. The editing approach that was developed in the meetings with Howard was one of constant experimentation and iteration in service to the storytelling goals. Initially we worked on the script, then the story boards and animatic. Finally we discussed the actual animation as shots and sequences. Along the way constant tweaks were made as they seemed necessary. In this way every aspect of production served as a phase of editing. This allowed the filmmaking to flexibly accommodate additions, deletions, and/or changes to sequences, in order to tell the story.

Many, many ideas were considered during the script-writing phase. Initially, they concerned very broad elements of an over-arching story. (In the earliest versions of the draft they were heavily tied to computer imagery designed to function as puns or make statements about current copyright law.) As the story evolved these ideas turned into specific visual images designed to convey an idea or beat for one shot. Each beat was scrutinized to help tell the story as directly as possible. Additionally, pacing and shot
duration was often discussed. Howard tried to get me to understand the changing rhythms that different parts of the film required. As a result the film slowly changed from a story about robot hackers and software cops into a love triangle between Bob and his computers. Each story point was examined to see if it helped convey the needs of the given moment in the narrative. When these elements were accepted and used in the production, they were still manipulated in any way that helped them more easily convey the beats necessary to convincingly tell the story of “Upgrade.”

Further changes were made once I saw how the storyboards flowed together. This was necessary because some things that worked on paper did not easily flow together visually. For example the script called for Bob to crack his knuckles, sit down, and prepare to work at the computer when he first set her up. While he did this, a nearby clock clearly showed that it was three o’clock in the morning. In the script this was written to show the audience that Bob was a die-hard computer user. But during the storyboard phase it became clear that Bob’s obsession for computers was not obviously shown by him working late into the night. Instead the storyboards were re-drawn to show Bob having a nearly orgasmic reaction to his newly built computer. This more clearly showed his decidedly abnormal love for data processing machines.

Every scene was thusly examined for simplicity and clarity. I tried to have every shot show one beat and one beat only. Similarly I wanted every cut to help give the audience a sense of the progression of the story itself. For example the scene in which the OS turned around and discovered the web page on which Bob had been shopping for her replacement was shot in three simple cuts that, I think, very easily conveyed her sense of shock and betrayal. First she turned to the page. She reacted with horror and finally the audience was allowed to see a static shot of the page showing all the different replacement computers. I trusted the audience to see this progression and determine the nature of her distress from these three simple beats.

Thus the scenes were built out of individual shots containing beats. These in turn were assembled to create a rhythm and pace that accentuated the story telling in the visuals. For example the initial assembly of the computer consisted of a few longer shots

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13 He was far better at building rhythm and cadence into a sequence. Through “Upgrade” Howard taught me a lot, though by the film’s end I still felt that I had a long way to go.
and very little cutting. This was done to indicate the laboriousness of the construction process. By contrast, the scene in which the OS experienced an orgasm due to Bob’s input started out slow as Bob stroked a few keys and she slowly realized that his actions were pleasurable to her. As they both got interested in their romantic computing activity the cuts between Bob’s increasingly fast paced typing and her ecstatic moaning were of shorter and shorter duration until the moment of climax. After which the cuts once again slowed down. This contrast of pacing built up and drew attention to the intensity of the orgasm scene.

Not only did this flexible editing method help in the building of the movie’s narrative momentum, but it also aided in scene placement as well. Initially the script and storyboards called for the OS to say, “Fine,” and turn red before the sunset shot. During the editing phase it became clear that greater dramatic tension was built if Bob’s activity with the new laptop computer dragged on as the daylight faded while the OS was forced to watch in frustrated anger. The scenes’ positions were reversed and the whole sequence seemed to flow better.

While it was a powerful approach to editing, the Mamet inspired method of story telling was hard to use. It required one to focus on the necessary visual imagery and discard anything else. This sounded like a good idea in principle. In reality it was very difficult. Getting a shot whittled down to only necessary components was daunting. Take away too much and the shot would not read. Leave too much and it would not be clear. Moreover, the temptation to include too much was great as it served the dual purposes of giving the audience eye-catching imagery that may have distracted it from the lack of story telling and it also provided the chance that some meaning (intended or otherwise) would accidentally arise out of the clutter.

When edited correctly the story would arise flawlessly. An example of this method working well would be the scenes during which the OS printed a love note, Bob crumpled it without looking up from his new computer, Bob continued to type as the day progressed into night, and then the OS’ face turned bright red as she began to attack him. The cause of her embittered rage was clear and the consequent action read very well. This was Mamet’s whole point about story telling. The audience saw each image and perceived the progression between them. The editing of these sequences was made easy
because each necessary component was required and nothing extraneous got in the way.

Of course good editing helped create this readability. Occasionally, however, mistakes were made and some sequences did not read as well as they could have. When the shots were staged clearly, and cut on the action in question the motion clearly informed the next shot. If one were to let the action pass and then cut to the next image or if the composition of the first scene did not easily flow into that of the second, the tie between the two became obscured. Unfortunately I ran afoul of this in several key areas. For example I found that the computer’s initial transition into obesity was disjoint and unclear. Initially the OS was an incomplete head comprised of an aggregate of polygonal faces. As Bob added more software, more polygons made her face increasingly complete. A scene showed him feeding her more and more software as her face grew ever larger. Eventually the computer monitor itself buckled for a split second and her head returned to normal size but the monitor remained slightly larger. Directly following these scenes came the romance sequence. Only after all that had occurred did an awkward fade to black happen. The next scene that slowly came up was a shot meant to happen some time later when the computer was already very fat.

The idea that Bob’s input has made her obese and slow did not come across very strongly. This was one of the weakest parts of “Upgrade.” It would probably have been better to have had the orgasm scenes all together and then have had a sequence in which Bob continued to feed the OS CDs after she was sated. She would become increasingly plump as this happened.¹⁴

Despite this muddled sequence of shots, most of the film’s sequences were very strongly cut and helped tell the story while creating rhythm and contrast between beats. The cuts were meant to facilitate the linking between the shots. Their placement and timing was the result of the editing that began with the script and storyboards and continued through the animation phase. The editing was completed about two weeks before winter screenings and at that time I showed “Upgrade” to two different groups for feedback. The first was a group of RIT and Eastman School of Music undergraduates.

¹⁴ In fact Howard wanted me to do something along these lines from pretty early on. But I rejected it because I wanted to stay tied to the sexual metaphor and thought that adding the food aspect would not work well. In retrospect I can see that he was right and greatly regret not having shot additional footage to show the feedings.
Their main critique was that I needed a better sound track. Fortunately the group that saw it included Nicholas Salve who had no musical training to speak of and yet was something of a genius when it came to creating digital sounds. Since the film took place around (and in some scenes in) a computer, I wanted music that sounded good but clearly synthesized. I asked Nick if he could spend the week making loops of music for each scene and he agreed.

The second group that saw the initial cut of "Upgrade" was my entire Thesis committee, Howard Lester, Tereza Flaxman, and Howard LeVant. They made many helpful suggestions for better cuts and/or better scenes. Tereza insisted that the opening didn’t read well and she suggested I replace it with a scene of Bob dragging the monitor across the floor; as opposed to the initial scene which depicted a worm’s eye view of the monitor being lifted out of its box. Howard Lester still wanted me to make the OS try to eat the input software with a big frog-like tongue. And Howard LeVant required me to make some scene adjustments in the shots leading into the fight scene.

Everyone agreed that the ending was weak. Initially "Upgrade" ended with the OS swallowing Bob, compressing him, fragmenting him, and then just throwing him in the trash. These were good sight gags but they lacked a finality that brought resolution to the whole movie. It was suggested that Bob survive the encounter and be chased off screen by the OS’ giant head. This scene was animated and became the final shot in "Upgrade." Every member of my thesis committee made very good suggestions and I intended to make as many of them as I could in the time that remained.

Nick and I agreed on all the scenes that were not going to change and he went to work on their music. The remaining scenes needed to be tweaked or reanimated before they could be timed out for scoring purposes. So I went to work on them. The opening was re-worked according to Tereza’s suggestion. Bob was animated pushing the heavy monitor box with his back while his legs propelled him across his bedroom floor. Similarly a shot in which the computer generated and printed a love letter was animated and inserted as per Howard Levant’s Suggestions. The ending was also changed according to the committee’s suggestions.

The sequences were completed, rendered and inserted, into the body of the whole film about a week before screenings. The newly created shots were passed to Nick.
While he worked on the sound I planned to create the OS’ frog tongue and create the feeding animation. This scene was saved for last because I had been resistant to the idea. Nonetheless, I fully planned to create the sequence because the committee had told me to.\textsuperscript{15} The animation was begun, but I came down with the flu for three days and was unable to get out of bed. When the illness passed I didn’t have enough time to properly animate and finish the scenes. Had I tried the results would have appeared slap-dash and hurt the whole movie. Consultations with Howard Lester confirmed this assessment and the final sequence was thus abandoned. Nick was told that the movie he had was the one that was going to be shown and he finished the music.

The day before screenings I assembled all the elements, shots, sound and music in Apple’s Final Cut Pro and did my last editing on the sound levels. I encountered some difficulty getting my levels just right and a fellow MFA candidate, Ginny Orzel, was gracious enough to take some time and work with me. After the final mix was done, I worked out my compression issues and finally wrote the movie out to the mpeg-2 format. I then burned it to DVD and submitted it to Stephanie Maxwell. After a year and half of scripting, storyboarding, modeling, lighting, texturing, animating, compositing and editing it was finally done. “Upgrade’s” ultimate running time came in at eight minutes and thirty seconds, and it was finally ready for screening.

Screenings

Graduate screenings had always seemed to be a somewhat farcical affair. When graduate work was screened, people would typically speak up only to offer a measure of praise to the presenter and then he or she would sit down. There was very little criticism offered by either faculty or students. Rarely was one given the opportunity to grow through constructive critique. Similarly, screenings made gauging the relative success of one’s film difficult insofar as the comments offered to the filmmaker were obsequious at best, nebulous at worst.

Still, if one was perceptive one could get a sense of the audience’s reaction. No one at a movie screening ever thought that he or she was being observed in the darkened

\textsuperscript{15} Again, if I had listened I really think the film would have been stronger during the obesity scene.
theater and so they typically acted very naturally. The attentive spectator could notice all sorts of things on the audience’s part as he or she observed them in the dark. For example no one seemed to talk during the showing of “Upgrade” despite its relatively long running time.\textsuperscript{16} I knew where the jokes and gags were in my movie and was rather gratified to hear people laughing when I intended them to do so. The applause afterward seemed genuine and robust so it certainly seemed that people understood and liked “Upgrade.”

The comments made were endearing, Howard LeVant remarked that in the two weeks since he’d last seen the film it had been strengthened a great deal. He said he was astounded at how much work I’d put in and told me that since I was now done I had to go out and get a life. I found that rather sweet in an odd sort of way. The overall approval on the part of the audience was gratifying and I left screenings with a sense of accomplishment. It had taken nearly a year and half of my life, had absorbed my best efforts and I hoped it had been successful.

Conclusion

It has been some time since “Upgrade” was shown publicly and I have had many opportunities to review the film and consider my work. The ultimate question was: did I accomplish what I set out to do? If so, did I do it well? The answer to both these questions is yes and no.

My stated goal from the outset was to make a good story. In judging my work against my earlier films I certainly did better. “Upgrade” was better than “Ooga Chakka,” my second film; just as “Ooga” was better than “In The Boiler Room,” my first. “Upgrade” had a clear story about a computer’s love life. It followed her as she fell in love with and was then jilted by her owner. He in turn had a bizarre love for a younger, newer laptop.\textsuperscript{17} The linear aspects of the shots formed a progression of events that were fairly clear and concise. Everyone who saw the movie seemed to understand what was happening. This was a marked improvement over “Ooga Chakka,” in which the title

\textsuperscript{16} 08:30:00 while the typical Graduate thesis film is usually shorter than 6:00.

\textsuperscript{17} I’m not entirely convinced that this love is so bizarre as I write this paper on a sluggish five-year-old PC whose monitor is clearly beginning to fail.
character’s mental movement through time seemed to be unexplained and ill defined. Similarly the film’s rhythms and beats flowed out of the story needs. The energetic fight shots were made from quick cuts on strong actions while the romantic moments were cut to feel unrushed and showcased sensual behavior.

“Upgrade” represented great growth on my part. But it had weaknesses as a narrative and I only partially rectified them. Mamet required the whole movie to be clear with each constituent part fulfilling its necessary function. He demanded that every beat in every shot in every scene look just the way it needed to look. As he put it, “The Boat [needed] to look like a boat the keel [didn’t] (Mamet, 24).” Unfortunately, as of this writing, not every part of “Upgrade” felt as clear to me as it could have been. The opening was clearer thanks to the added scene of Bob dragging the monitor’s box. Both the romance and computer’s subsequent descent into enraged madness read very clearly. But the progression into obesity was still unclear. I really needed to add the feeding scenes to show the audience how the computer grew as a result of being stuffed with software. Similarly many of the joke laden software titles were animated according to a pre-established sound track. The resulting visuals read as far as the story went. But had these plates enjoyed more screen time, audiences would have been better able to read their titles and thus the shots would have been funnier. Also the ending was very weak. I thought getting all the characters off the screen would provide a visual resolution and thus signify the end to the audience. Instead it felt like there was more to the film but I had not animated it.

Endings were difficult. I was told that movies ended when all the questions had been answered or when every loose end had been tied up. I was not sure that was the case for all stories. Nonetheless I did think that leaving nothing left was a tidy way of ending a film. That I still had not created a good ending to “Upgrade” clearly indicated that I still had a lot to learn as a storyteller.

In addition to the story’s weaknesses I had since had the chance to go back and examine the quality of the work that went into all the phases of production. I found that every area could have been handled better. My modeled geometry could have been cleaner and better laid out. My character rigging and facial expressions were better than I’d ever done and yet still felt mostly flat. My texturing was fairly pedestrian, the
lighting (easily the strongest aspect of the whole film) while adequate could have been made more efficient and pushed farther, the animation was barely competent at times, and the cutting needed some further tweaking as there were a few jump cuts and other ambiguities that arose from shot placement. All in all, “Upgrade,” despite having been screened probably could have used a lot more work.

And yet identifying all these problems was the result of the very progress I’d made in all of these areas. In my earlier films I couldn’t worry or fret over any of the aforementioned issues because I was too inexperienced with any of them. Indeed when I was making my first films I was struggling too hard with the basic elements of motion and couldn’t concentrate on story telling. For example my first film barely had modeling of any sort and the motion was too slow. My second film made use of much better modeling and texturing but my animation was still very rudimentary and I had very poor editing and pacing. If “Upgrade” was flawed it was still better than any previous efforts. Thus it was precisely because of my growth in making “Upgrade” that I was able to see where I made mistakes. I trust that my next film will be even better on both story and technical levels.

In conclusion, it became obvious that making 3D animated movies was an amalgam of artistic and technical concepts. I approached “Upgrade” assuming that the artistic side of story telling would be the main focus and that all the technical work would be subsumed under the dictates of the narrative. I modeled, textured, lit and animated only what I thought was necessary for story telling. When I animated, I tried to animate characters that gave performances. I was not interested in simply moving objects through space over time. I tried to make each shot convey a beat necessary to furthering the story and assembled them into a conglomeration of scenes that sought to simply show the events as they unfolded. Along the way I honed many technical skills and even developed new ones despite my attempts at not being innovative. The resultant story was strong, though flawed. The visual imagery was striking but could have used further improvement as well. In essence, the results were merely the end of a given learning process. In this case it was learning how to make “Upgrade” with the skills I had. What I didn’t realize was that in telling this story I would gain perspective on better ways to tell the next story. Every attempt at making a finished product teaches the craftsman about
the craft. I now have new skills and abilities and I can’t wait to begin using them to learn something new.
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Appendix A: Original Thesis Proposal
“Natalie, Merchant Protection Software and the Corporate Raider”
**Working Title:** “Natalie, Merchant Protection Software and the Corporate Raider”

**Producer:** Aharon Charnov  
**Client:** N/A  
**Budget (actual):** = $4,422.00  
**Committee** Howard Lester  
Howard LeVant  
Duane Palyka

**Start Date:** 5th July, 2003  
**End Date:** June 16, 2004  
**Running Time:** 6:30  
**Release Format:** DV Cam

**Story**

A piece of hacker software, called The Corporate Raider, hacks into a computer to steal a copy of a new piece of software called Natalie; Merchant protection software police programs try to stop him. He succeeds but maybe gets more than he bargained for.

**Synopsis**

On a typical looking computer desktop, the corporate raider emerges from the modem icon. He enters, looks about, and dives into the CPU icon disappearing as he goes. The computer’s security system goes off and two merchant protection software cops are released. They track him through the computer’s various directories. The CR eludes and fights them, occasionally scooping up icons and throwing them at the cops, or by launching viruses to fight them. At one point he opens up a slide show type program and the ensuing presentation, done in true hokey corporate style, makes his argument for why he loves Natalie and must obtain a copy of her. The cops watch, enthralled, only to see him getting away again. In hot pursuit they follow him into a QuickTime window. The movie player’s environment is entirely 3D CG and through it we watch the CR make his way into the vault-like protected security area where Natalie is being stored. He (literally) cracks the security firewall.

In the vault, the CR finds Natalie, floating, dormant in a shaft of white-lit ones and zeroes. He adores her obsessively and must possess her. He makes a copy of her but finds his exit barred by the two constables. The CR admits they have caught him, but releases a series of infinite pop-up windows between the cops and himself. While the cops are busy closing down these windows, he makes good his escape.

Elsewhere and later the CR lovingly activates his copy of Natalie. It is right out of a Frankenstein movie. The beautiful Natalie awakens and the CR is blissful. Suddenly she tells him that she needs to increase her functionality but the CR doesn’t understand. She begins to pull him apart piece by piece and adds his components to her own. As she does so she gets bigger and bigger. Finally nothing but a disembodied head sitting at the foot of the all powerful Natalie system the CR has cause to think he probably shouldn’t have made this illegal copy.

**Approach**

I will be using 3D Animation with heavy use of compositing CG with CG. I intend to use a limited lip-sync for the corporate Raider who doesn’t actually have a mouth and a more robust lip-sync for Natalie who is more human. I also intend to use the crowd generation I am currently working as a means of populating my world with relatively little investment as to modeling and animation.
Working Title: “Natalie, Merchant Protection Software and the Corporate Raider”

Producer: Aharon Charnov  
Client: N/A  
Budget (actual):  
Committee: Howard Lester  
Howard LeVant  
Duane Palyka

Start Date: 5th July, 2003  
End Date: June 16, 2004  
Running Time: 6:30  
Release Format: DV Cam

Budget Breakdowns

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<td>@ $15.00 per design X 18 designs =</td>
<td>$270.00</td>
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<td>@ $15.00 per hour 40 hours =</td>
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<tr>
<td>Graphics</td>
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<td>@ $10.00 per medium sized image X 100 images =</td>
<td>$1000.00</td>
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<tr>
<td>Sound</td>
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</tr>
<tr>
<td>Music: Composition - Original Music =</td>
<td>$400.00</td>
</tr>
<tr>
<td>Music: performed: 3 Musicians</td>
<td></td>
</tr>
<tr>
<td>@ $20.00 per hour for 2 hours =</td>
<td>$120.00</td>
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<tr>
<td>Lip-sync</td>
<td></td>
</tr>
<tr>
<td>@ $15.00 per second for full Lip-sync X 97 seconds =</td>
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</tr>
<tr>
<td>@ $10.00 per second for partial Lip-sync X 97 seconds =</td>
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<td>Below The Line Subtotal =</td>
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<td>Wages &amp; Salaries Subtotal =</td>
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<td>Service</td>
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<td>---------------</td>
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<tr>
<td>Telephone</td>
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<tr>
<td>Legal</td>
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<td>Accounting</td>
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<tr>
<td>Amortization</td>
<td>$25.00 per day</td>
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<tr>
<td>Archiving</td>
<td>$10.00 per day</td>
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<tr>
<td>Rent</td>
<td>$640.00 per month</td>
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<tr>
<td>Utilities</td>
<td>$50.00 per month</td>
</tr>
<tr>
<td><strong>Administration Subtotal</strong></td>
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**Preproduction/Research/Development**

### Titles
- **Title Design**
  - $200.00
- **Title Animation @ $20.00 X 4 hours**
  - $80.00

### Storyboards
- **Black and White @ $40.00 per frame X 36**
  - $1,440.00
- **Character Sheets @ $200.00 X 2 characters**
  - $400.00
- **Previsualization/animatics @ $20.00 per day X 5 days**
  - $100.00

### Modeling
- **@ $20.00 per lead character X 2 lead characters**
  - $40.00
- **@ $15.00 per set creation X 8 sets**
  - $120.00
- **@ $10.00 per inarticulate prop X 12**
  - $120.00
- **@ $10.00 per background character X 1**
  - $10.00

### Testing
- **@ $20.00 per day X 5 days**
  - $100.00
- **Particles testing @ $25.00 per day X 5 days**
  - $125.00
- **Software installation/upgrades**
  - $2,500.00

**Preproduction/Research/Development Subtotal**
- $5,235.00
- $500.00
Production

Materials = $200.00 $100.00
Travel and expenses $15 a week X 40 weeks = $600.00 $600.00
Equipment rentals = $250.00 $0.00
Digital to analogue conversion $75.00 per day X 10 days = $750.00 $0.00

Production Subtotal = $1800.00 $700.00
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<tr>
<td>Equipment Rental</td>
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<tr>
<td>Music: mixing @ $20.00 Per day X 1 day</td>
<td>$20.00</td>
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<td>Music rights</td>
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<td>Editing supplies</td>
<td>$150.00</td>
<td>$0.00</td>
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<td>Stock footage</td>
<td>not applicable</td>
<td>$0.00</td>
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<tr>
<td>Answer &amp; Release prints</td>
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<tr>
<td>Foley recording @ $10.00 per second X 97 seconds</td>
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<td>$0.00</td>
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Post Production Subtotal = $1,490.00 $0.00
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<td>Subtitles</td>
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<td>Release prints</td>
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<td>Tapes 50 Tapes @ $0.68 per tape =</td>
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<td>$34.00</td>
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<td>DVDs 15 disks @ 2.00 per disk =</td>
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<td>$30.00</td>
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<tr>
<td>Beta Cam 20 Tapes @ $10.00 per tapes =</td>
<td>$200.00</td>
<td>$200.00</td>
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<tr>
<td>Advertising</td>
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<td></td>
</tr>
<tr>
<td>Festival entry fees =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel @ $60 per car trip X 8 car trips =</td>
<td>$480.00</td>
<td>$480.00</td>
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<tr>
<td>Per diem $75.00 (best) [$50.00 actual]</td>
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<tr>
<td>per day X 10 days =</td>
<td>$750.00</td>
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<tr>
<td>Distribution Subtotal =</td>
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<td>$1,894.00</td>
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### Working Title: “Natalie, Merchant Protection Software and the Corporate Raider”

**Producer:** Aharon Charnov  
**Client:** N/A  
**Budget (actual):** $4,422.00

<table>
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<th>End Date</th>
<th>Running Time</th>
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<td>5th July, 2003</td>
<td>June 16, 2004</td>
<td>6:30</td>
<td>DV Cam</td>
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#### Milestones:

- **July 5 – July 18, 2003**: Start Date
- **July 18, 2003**: Script drafts
- **July 25**: Final Script
- **August 1**: Storyboard
- **August 29**: Animatic
- **September 19**: Character modeling
- **September 26**: Character rigging
- **September 30**: Character texturing
- **October 1**: Character Rig testing
- **November 12**: Milestone 1 review with committee
- **November 26**: Props Modeling
- **January 7**: Props Texturing
- **January 21**: Sets Modeling
- **January 28**: Sets Texturing
- **February 4**: Background Painting
- **February 16**: Dynamics testing
- **February 20**: Crowd Scene Testing
- **February 20**: Casting Voice Actors
- **February 23**: commissioning composer
- **February 27**: Voice master
- **March 26**: Exposure master
- **March 29**: First Pass Animation
- **April 12**: Milestone 2 review with committee
- **April 23**: Second Pass Animation
- **April 30**: Final Animation
- **May 7**: Crowd Scene Integration
- **May 19**: Light rigging
- **May 21**: Rendering
- **May 26**: Compositing
- **May 27**: Editing
- **May 31**: Milestone 3 review with committee
- **June 1**: Music
- **June 4**: Foley/SFX
- **June 7**: Final Mix
- **June 8**: Titles and credits
- **June 9**: Print to Master
- **June 16**: Milestone 3 review with committee
- **June 20**: Department Screenings
Appendix B: Revised Script
INT. A TYPICAL COMPUTER WORKSPACE OR OFFICE - NIGHT

A SERIES OF QUICK SHOTS

The camera pans across the floor over an open box. There are packing peanuts strewn about the floor. Bob puts the monitor down. Bob plugs the CPU into the wall socket.

The monitor comes to life. The OS is a mesh of polygons that resemble a broken face.

Bob ogles the computer, stroking the top of the monitor as it turns on. The OS looks at him, lips wrinkled into something between a snarl and a frown.

He sits down at the monitor. Bob cracks his knuckles and begins to type furiously.

Bob is wearing headphones that are plugged into the CPU. He is dancing around. The OS' face smiles and starts to bop to the music.

He pulls out one CD, puts in another and clicks a button.

New Software icons slide by, one by one, becoming more of the OS' now complete polygonal face. At first she seems scared as each new facet creates more of her face. But when the first one attaches she notices it, glows a bit brighter and smiles. The CPU becomes physically bigger. Her eyebrows arch and her lips part. As she notices each new face add on to her she becomes more and more orgasmic. She moans, closing her eyes. Text rolls across the screen saying, "oh, don't stop." Her face becomes more robust, more human. It glows brighter and brighter green. The CPU grows to gigantic proportions.

Bob brings in computer peripheral after computer peripheral. Each one is plugged in and a line of green light connects itself to her. She enjoys each new sensation and the computer gets bigger as they are added.

Looking straight on the monitor the CD tray to the now enormous CPU is open and on the monitor, the OS is looking at it. She looks straight at the camera and back to the tray. She pouts. Bob's hand reaches in and places a new CD in. She notices it; her eyes roll back into her head and she sighs.
The monitor looks up at Bob and Bob looks down at the monitor. The OS’ face beams a happy smile. Bob Smiles back. The camera holds on their adoring gaze for a beat.

The OS’ face winks then looks down. Bob is sleeping at the base of the Monitor. The mouse strokes his head. On the monitor we see the OS’ face gazing down at him adoringly.

OS (whisper)  
I love you.

INT. A TYPICAL COMPUTER WORKSPACE OR OFFICE. - DAY

Bob is typing and using the mouse. His work gets faster and faster until eventually his hands become a blur.

The OS is bringing up window upon window. All sorts of web pages and movies and graphs pop up faster and faster. The OS’ smiling face superimposes over this and her eyes glow bright.

Fade out.

INT. A TYPICAL COMPUTER WORKSPACE OR OFFICE - EARLY EVENING

Bob is sitting at the computer. The computer looks plump and saggy. The monitor’s plastic case is rolling over the screen. The CPU tower is bulging at the bottom. The OS’ face (if it is seen) is pudgy. When she moves, she is very slow and seems always to be bogged down by her own weight.

Bob opens the CD drive, which opens very slowly.

BOB (VO)  
One more program and I’ll have everything I need!

Bob places the CD onto the tray and tries to load it in the machine. As before the software icon slides across the monitor screen but it cannot integrate into the OS’ polygon face. She’s full. It tries from several different angles to no avail. An error message pops up which is full of computer nonsense.

Bird’s Eye view of Bob, who gasps, hits the computer and looks up. In this scene we can see the myriad of
peripherals in his room and all the long cables in the room.

BOB
You’re full? You can’t be full.
Noooooooooooooooooooooooooo!

She spits the CD out and it embeds in the wall behind Bob.

INT. A TYPICAL COMPUTER WORKSPACE OR OFFICE - MORNING

Bob is drinking coffee while looking at an Internet page with new computers for sale on it.

The OS’ face is behind this window and she’s trying to peek over it but is too fat to get around it.

Bob finishes his drink and gets up from the computer.

The OS nudges her way around the Internet page and turns around to read it.

INT. INSIDE THE COMPUTER - TEAL

A SERIES OF QUICK SHOTS

The camera faces the OS as she faces the page. The Page is reflected on her.

Close up on the Web page as it scrolls down. It shows advertisements which read: “New Model,” “Sleek Curves,” “Large Drive,” “Really Large Drive and tons of RAM,” “Upgrade NOW!”

In profile the OS' face is sitting there unblinking, mouth wide open.

INT. A TYPICAL COMPUTER WORKSPACE OR OFFICE - MORNING

CU on the Monitor the OS’ head is still facing the Internet page. She turns around wide-eyed. Looks around.

Bob’s chair is empty.

She turns the other way.

Another corner of the room is empty
CU on the Monitor. The OS' face composes itself. Her eyes are tiny slits. She grins a tight-lipped grin. The Web page behind her shatters and disappears. She turns dark and red. The whole screen fades into a swirling red and black eddy. Fade to black.

INT. A TYPICAL COMPUTER WORKSPACE OR OFFICE - EVEING

CU on the OS' face. She's dozing off.

SFX
Sound of a door closing in the distance.

CU on the OS' face. She rouses at the sound and looks at the door. Lips slightly opened, eyes wide. The Door opens.

The OS is almost looking towards the door.

Bob enters the room, carrying a "Banana Book-Brand" Lap Top. He walks in past his desk. The Monitor tracks his motion as he walks past.

Bob sits down on the bed. He opens the laptop and starts to fiddle with it.

The OS stares at the two of them, mouth open. She blinks twice. She looks off somewhere, and then she looks back towards Bob and the laptop. She closes her mouth and nods.

Bob is working with the new computer, whose face is very pretty and sleek. The printer near them spits out a paper with a large heart on it. Bob stops typing. Leans over to the page and takes it up.

The OS' eyes widen. Her mouth is open in slight smile.

Bob crumples the paper and tosses it aside and goes back to working with the new laptop.

The OS' mouth closes into a tight frown.

INT. A TYPICAL COMPUTER WORKSPACE OR OFFICE - DAY HEADING TOWARD DUSK

A SERIES OF QUICK SHOTS
Bob and the new laptop are smiling and working in the foreground while the OS is in the background, the Mouse lifts and taps him on the shoulder. He knocks it aside without even looking up.

The old headset lifts up and is offered to Bob. He notices it, yanks it out of the old computer. Bob then plugs the earphones into the Banana Book.

From over his shoulder, the Banana Book sticks her tongue out at the OS.

The OS’ face turns red, then black. Her eyes change to yellow and red rings. Her face pulls back into a snarl.

From over Bob’s shoulder the laptop can be seen. Window after window is popping up and Bob is working with the headphones on. He stops, looks around, reaches off screen, to get some book. Bob flips through it. He looks at the computer. He looks at the Book. He presses a button on the lap top. A window opens or closes.

    BOB
    No, that’s not it.

Bob gets up and walks off screen.

The mouse slides in from the other direction, pulls out the headphones. It comes back and wraps around the Banana Book and slowly starts to drag it off.

Bob lunges in and grabs the book. He pulls the mouse’s cord off and goes, mouse in hand, to stare at the OS’ monitor. It looks back up at him. Its angles are very sharp.

As Bob stares down at the monitor the WACOM tablet rises behind him.

    BOB
    I just don’t know what’s gotten into you.

It acts like a spatula and scoops up the laptop. It carries it off to the window.
The WACOM tablet carries the laptop past the camera, a close up of its monitor reveals it is sending little "help" messages. The tablet dangles the laptop out the window.

Bob turns to see this. His mouth opens in a grimace. He rushes to save the laptop, arms outstretched. The scanner wraps around one of his feet and trips him. He flips over to his stomach and crawls for the door. The mouse slams it shut.

The Computer picks itself up on its various peripherals and starts heading over to the laptop.

The Laptop's face is trembling. The OS is about to loom over the laptop, when Bob grabs her power cord.

The OS stops short. Her eyes go wide. She turns to see Bob, holding her power cord, ready to yank it from the wall. She looks at him.

He looks at her and gives a slight tug on the cord. A spark emits from the wall.

The OS, lips pursed, moves back from the window, bringing the laptop within reach of Bob.

OS

Ok.

Bob lets go of the power cord, takes the laptop, and puts her down on the bed.

Once, she's down, Bob steps up to confront the Monitor.

The monitor morphs into a giant mouth and swallows Bob whole.

It settles back to a monitor and we can see bob banging on the monitor and he fades away. The CPU bulges. The OS, very fat now smirks.

BOB (muffled)

Help let me out! Hey!

INT. A TYPICAL COMPUTER WORKSPACE OR OFFICE - DUSK TO NIGHT TO MORNING
The OS sits there occasionally Bob bangs on it from within. Her smile eventually turns to a straight face.

She looks around.

From the bed, the Laptop is looking at her. It looks at her, blinks. Looks left, looks right and then back at the OS. The laptop's mouth opens.

The OS looks around her.

\[\text{SFX} \]
Crickets chirping.

The OS lifts her mouse and tries to punch a few of her own keys. Instead of functionality we here irritating computer beeps.

\[\text{SFX} \]
Computer beeps.

The laptop's head leans to the side and smirks.

The OS looks at her, closes her eyes, lifts and turns her head and the monitor away. She quickly opens one eye then another and then, tongue sticking out furiously types at the keyboard with the mouse.

\[\text{SFX} \]
Computer beeps

\[\text{BOB (very far away)} \]
Help me please.

The OS frowns.

\[\text{OS} \]
Sigh.

Slowly, she turns over to the laptop, which is trying to bend her top, screen-half, towards her keyboard but she can't reach it.

The laptop stops and looks at the OS.

The OS purses her lips.
Fine.

The OS spits out Bob, who tumbles to the floor.

Bob looks over.

The OS is looking at him, scowling.

Bob frowns. The he looks over in the direction of the bed.

The WACOM tablet is ready to scoop up the laptop. The laptop, with eyes wide open looks at it. The camera pans over to the power plug.

Bob open his mouth in a half smile.

The Monitor morphs into a snarl.

OS

Gr.

The Camera pans to the door. The mouse tightens its grip on the handle.

Bob tightens his mouth

The OS tightens her mouth.

Bob stands up and walks to the bed. He picks up the banana book and brings it over to the CPU and plugs it in. The OS diminishes somewhat and the laptop gets a bit bigger. The two OS faces look at each other as their screens begin to become identical. They smile.

Bob sits back down at his chair and starts to type using both machines. The camera pulls back and fades to black. The end.
Appendix C: Original Story Boards
Appendix D: Color Prints
SYSTEM 2F.A.T.
WARNING
memory quotient
Intended software
SYSTEM 2F.A.T.
Great-looking
This computer is hot, it is so hot it sizzles. Ouch! I get burned just thinking about it.
Appendix E: Expressions
Light Controls:

```java
if (set_03_monitor_fat_05_MOUTH:LightCONTROL.NIGHT<1){
    set_03_monitor_fat_05_MOUTH:MoonLight_OShape1.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:MoonLight_OShape1.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.NIGHT<1){
    set_03_monitor_fat_05_MOUTH:MoonLight_OShape2.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:MoonLight_OShape2.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.NIGHT<1){
    set_03_monitor_fat_05_MOUTH:stand_lamp_cast_lightShape.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:stand_lamp_cast_lightShape.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.NIGHT<1){
    set_03_monitor_fat_05_MOUTH:Dresser_Lamp_cast_lightShape.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:Dresser_Lamp_cast_lightShape.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.DAY<1){
    set_03_monitor_fat_05_MOUTH:DayLight_spot_0Shape1.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:DayLight_spot_0Shape1.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.DAY<1){
    set_03_monitor_fat_05_MOUTH:DayLight_spot_0Shape2.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:DayLight_spot_0Shape2.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.EVENING<1){
    set_03_monitor_fat_05_MOUTH:dusk_point_OShape1.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:dusk_point_OShape1.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.EVENING<1){
    set_03_monitor_fat_05_MOUTH:dusk_point_OShape2.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:dusk_point_OShape2.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.EVENING<1){
    set_03_monitor_fat_05_MOUTH:dusk_point_OShape3.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:dusk_point_OShape3.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.EVENING<1){
    set_03_monitor_fat_05_MOUTH:dusk_point_OShape4.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:dusk_point_OShape4.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.SUNSET<1){
    set_03_monitor_fat_05_MOUTH:dusk_point_OShape5.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:dusk_point_OShape5.useDepthMapShadows=1;
}
```

106
set_03_monitor_fat_05_MOUTH:sunset_spot_0Shape1.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:sunset_spot_0Shape1.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.SUNSET<1) {
    set_03_monitor_fat_05_MOUTH:sunset_spot_0Shape2.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:sunset_spot_0Shape2.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.SUNSET<1) {
    set_03_monitor_fat_05_MOUTH:sunset_lamp_specialShape.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:sunset_lamp_specialShape.useDepthMapShadows=1;
}

if (set_03_monitor_fat_05_MOUTH:LightCONTROL.SUNSET<1) {
    set_03_monitor_fat_05_MOUTH:sunset_bounceShape.useDepthMapShadows=0;
} else {
    set_03_monitor_fat_05_MOUTH:sunset_bounceShape.useDepthMapShadows=1;
}

**Monitor Swap:**

if (Monitor_mouth_controller.Monitor_mouth <=10) {
    MOUTH_Monitor_01.visibility=1;
    MOUTH_Monitor_02.visibility=0;
}
else {
    MOUTH_Monitor_01.visibility=0;
    MOUTH_Monitor_02.visibility=1;
}

**Cable Correction:**

if (.I[0]<1){
    .O[0]=0;
} else {
    .O[0]=1;
}