

The Wizard Speaks

[With occasional interjections from Red Ree of Anarchists 'r' Us]

How It All Started

I enjoyed the art and performance of the Nebulous Entity last year (Burningman 98). I was basking in the glow of last year's success and expecting to just go and enjoy other people's art, take it a little easy after the overcommitment of '98. Then Larry called me up and asked, "What are you going to do for the Wheel of Time?"

Being a somewhat literal-minded engineer, I thought: Wheel... Circle... 2000... OK, what about 2,000 lights in a circle... individually addressable... at a speed of 2,000 times a second... a Ring, artwork consisting of patterns and light!

The more I thought about it, the more it appeared I was not going to rest this year after all. Team building started in February. Because of the great work being provided by the members of this project crew, this huge project is getting done well. All these cool people have to have a place to hang, thus,

The High Energy Magick Camp

The name for the High Energy Magick Camp came from Terry Pratchett's Discworld series. Among the wizards at the Unseen University are a group of geeky younger wizards who spend all their time in the High Energy Magic lab looking for the basic particles of magic.

There are parallels between the L2K project and magical rites and rituals. Many magic rites take place inside a ritually defined boundary or circle. The Ring is a circle describing a great boundary around the fire ceremony that is Burningman. A small circle (the Pattern Buffer Lounge) is logically connected to the larger circle to concentrate the energy raised by the larger circle. There's so much personal energy involved that I had to call it High Energy Magick.

Interactions with the Ring through the Pattern Buffer Lounge are magical, in that you're performing actions that influence things you don't see, or that aren't obviously connected. It's a celebration of the small controlling the large, which is to me the essence of magic.

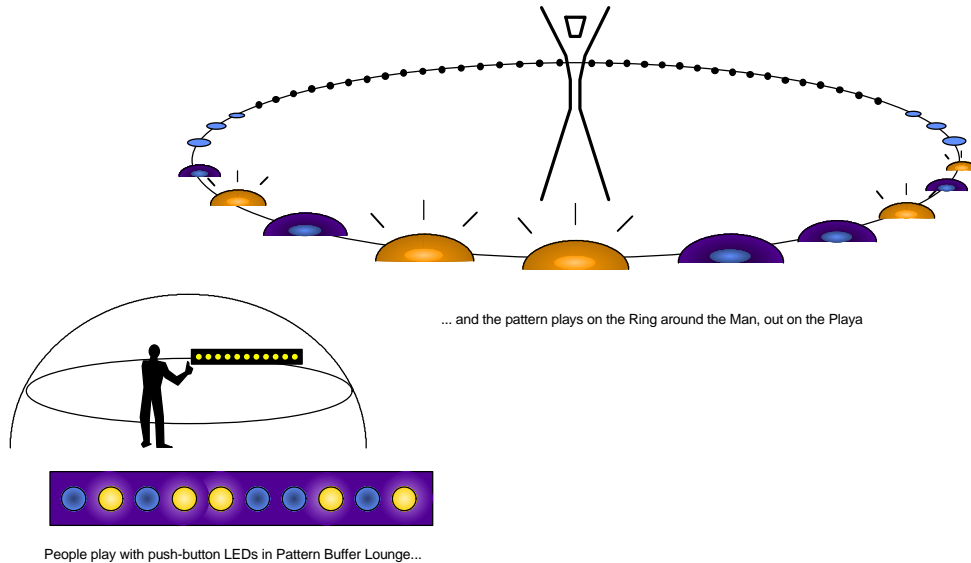
Interactive Areas in the Camp

The featured item of the camp is the "pattern buffer", a 30 foot dome with a ring of 2000 lights and pushbuttons that people can play with. Pressing the buttons sends light patterns moving around the ring, and then the patterns go out to a 2000 foot ring of lights around the Man.

These are four towers: a strobe tower, a laser tower, a blacklight tower, and a sound tower. Around camp, there will be several concealed proximity switches using photoelectric beams. As people pass through the beams, various features within the camp will respond. However, the actions of the towers are not necessarily controlled by the people closest to them. You might walk up to one thing, and something else will be triggered.

On the surface, the hardware appears very simple: a bunch of lights turning on and off. But, because of the high speed of these simple components, we can produce endless combinations and patterns. On the Playa, we will be discovering how to play this amazing instrument – which is really our own mind.

L2K Ring and Pattern Buffer Lounge



Individual's Sense of Scale

This project plays with levels of perception and sense of scale. On the one hand, the Pattern Buffer Lounge offers a small, intimate setting. You can play with the buttons, walk across it easily, and see the whole thing all at once. Just the opposite is true for the big ring out on the Playa. But at the same time, when you're in the PB lounge, feeling like you're in this private space, you're affecting the big circle. There's a gradual realization of this. The two contrasting spaces are connected.

There's some kind of metaphor in this. The macrocosm of the Playa being affected from the microcosm of the PB Lounge, the "as above, so below" concept, and the small influencing the large.

Pattern Matching

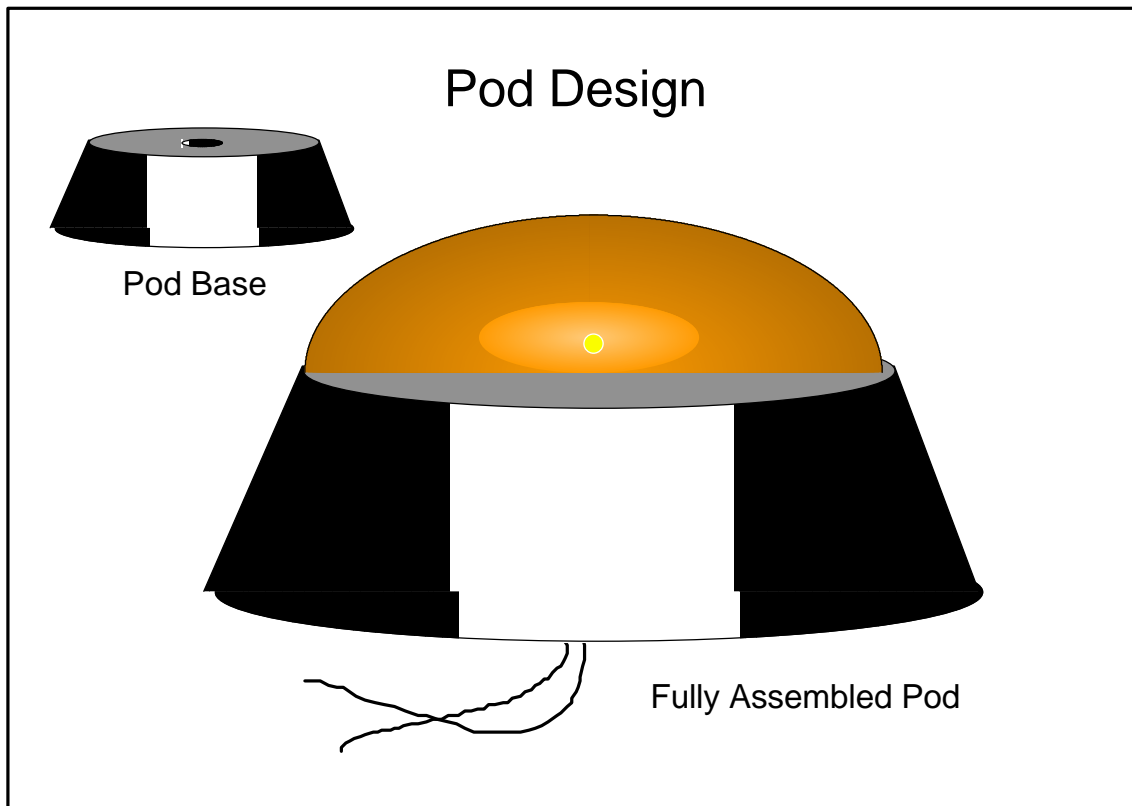
Human vision is an incredible pattern matching device. It has an almost unbelievable ability to look at almost anything and find what it's expecting to see; for example, seeing animals in clouds. We don't like randomness. We want patterns to emerge.

The fact that the pods are in the ground means that they define our sense of place and space. At one of the beach burns, a couple came up to the pods and started walking up and down on opposite sides, as if it were a boundary that they were exploring. Another person went and stood by one particular pod, and jumped up and down every time it flashed. This behavior is an expression of people wanting to be in harmony or in synch with their environment. I'm looking forward to watching the way people will interact with the lights on the Playa.

About the Pods

The pods, like everything else, are the result of experimentation. Originally, we tried encasing them in foam, or casting them in cups, before finally settling on the current rugged design. The pod base is a 1.5-

lb base of mortar mix or thin concrete, cast in a plastic breakfast bowl that has a straw stuck in the middle. Thus we have a tapered flattish cylindrical base with a hole running through the middle for the pod wires.



The LED lights, which we researched as explained elsewhere, are cast inside a plastic hemispherical lens shaped roughly like paperweight. Each LED has a pair of 1-foot wires with disconnects on the other end, so you can unplug the pods from the main harness for shipping and moving them around. The lenses, with the LEDs are then glued to the pod bases with silicon caulking, and the LED wires go down through the hole in the base.

This is a very sturdy and rugged design. We bury the pods so that only the lens is showing. Once they're buried, the pods can be stepped on, driven over, etc. without taking any serious damage. We have tested them at several beach burns and they seem to withstand the sand very well. Any abrasions can be polished off. Even with abrasions and cracks, as long as the LED point source is still visible, they remain effective.

LED Color

The particular orange we are using is a bright and flame-like color, very much in the spirit of Burningman. It catches the attention, induces excitement. The exact light frequency is 620 nanometers.

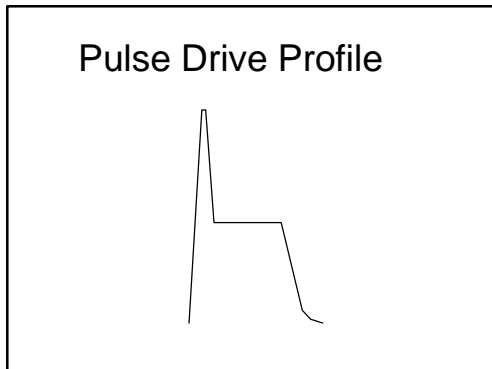
We experimented with different colors at the beach, and this particular orange was the most compelling. It's visible at 600-1,000 feet. Some of the other colors were either too expensive or didn't carry as well. For example the white was brilliant but cost \$5-6 per light, and the blue looked great but didn't carry.

Flash Pulse Control

There's a pulse drive that controls how the lights flash on and off. After experimentation, we found that varying the intensity of the light during the flash was far more effective than a simple on/off.

There's a peak of brightness, followed by a plateau, which then tapers off. The combination of brightness and duration is dazzling, and affects vision profoundly. It peaks at 20-25 Hz, which puts the effect in mid-

Beta, a highly active brain state. The lights appear to be much brighter, and the after-image is unusually intense. [Ree: *Those pods looked like eyeballs staring up out of the grass.*]



All this occurs in a fraction of a second, too quick for the eye to discern.

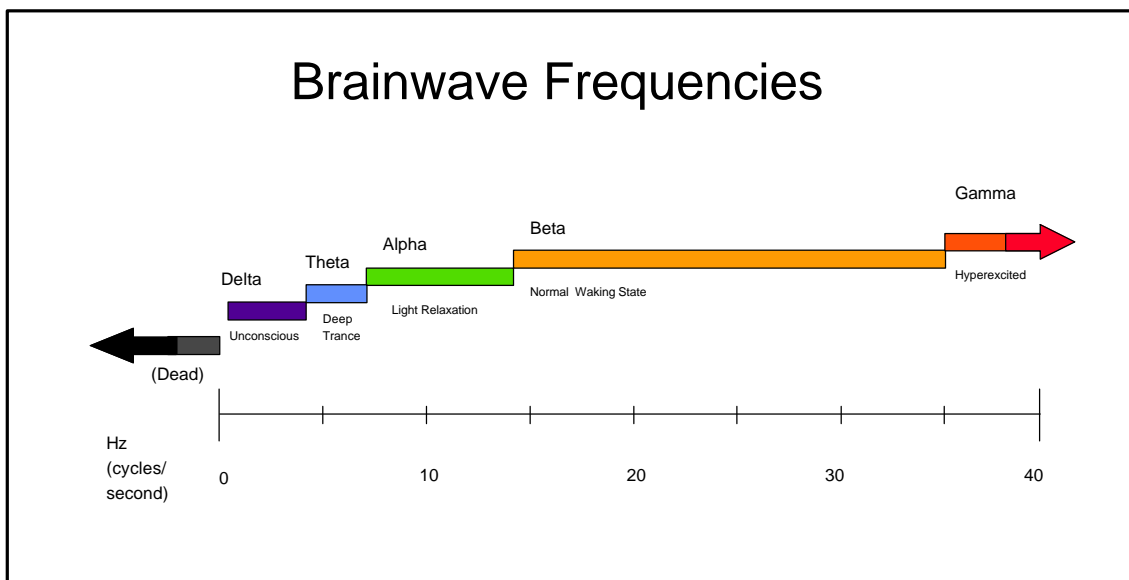
Our beach experiments showed that even in peripheral vision, this flash creates a strong impression of physical movement. It actually feels like something went by you.

Psychological Effects

Modern science currently classifies the following brain wave states, which are measured in cycles per second, or Hertz (Hz):

- Delta (0.5-4 Hz) - unconsciousness and sleep
- Theta (4-7.5 Hz) - deep relaxation; border between sleep and waking
- Alpha (7.5-14 Hz) - light relaxation
- Beta (14-35 Hz) - waking state or “normal” consciousness

There is also Gamma state which is a hyperexcited, manic state, characterized by very large bursts of energy. It’s not clear if this is ever desirable, or if it’s possible to use this state for anything.



Different light patterns produce different psychological effects. Certain frequencies of flashing lights draw the brain into different modes of operation. As we know from the Pokemon¹ episode, they can also induce epileptic seizures, but these are merely a side effect of the brainwave shifts. The Dream Machine at Burning Man 98 was an example.

Flashing lights can bring you to states such as lucid dreaming, meditation, or out-of-body sensations. The theory is that these brain states are associated with different resonant frequencies. By providing an external stimulus at those frequencies, you can induce these same states within the brain.

This doesn't work the same for everyone. For some, it only produces very mild effects. Also, you might not necessarily be able to bring someone from Theta to Beta, for example (deep relaxation to waking state), merely by flashing lights in a pattern.

The brainwave machines so popular among certain consciousness crusaders are a very personal sort of gadget. My challenge was, could I produce these frequency shifts in a large-scale presentation? The ring can go from 1 cycle/second up to 2,000 cycles /sec. It should therefore be able to reproduce any brainwave frequency of which the human brain is capable.

[Ree: If our brains only go up to around 35 cycles per second, why do we need to run the Ring at 2,000 cycles per second?] Because running the Ring at a high frequency allows analog looking brightness modulations (pulse width modulation). Plus, I needed 2000 cps to use all the lights in a sweep second hand.

[Ree: We can synchronize the lights with the music through our audio spectrum analyzer. Trance music is about 180 beats per minute, or 3 cycles per second; right at the Delta/Theta borderline]

Engineering Philosophy: Optimization

Since around 1976 I've been designing embedded systems with microcontrollers. Microcontrollers are tiny computers embedded in other systems. There are in things like cars, VCRs, microwaves, answering machines, phones with "features", telephone switches, Internet routers, and aircraft - especially the "fly by wire" aircraft, where the pilot doesn't directly control the plane. The thing about these embedded systems is they're invisible. You only notice them when they're not working.

In this type of application, it's considered elegant engineering to design devices in such a way that they simply vanish. In the L2K project, however, it's all visible. It's just for fun, and has no commercial value.

The fun and the challenge of this project for me has been optimization: to design the components as cheaply as possible, and the code to be as efficient as possible.

The first computer I owned was a 2Mhz Altair 8080 with 256 bytes of memory. I programmed it by flipping toggle switches on the front of the machine to load binary machine code instructions one at a time.

Even as desktop computers became more powerful, a lot of the work I was doing stayed minimal. In embedded systems there is always a requirement for compact and efficient code. Programming like this is fast becoming a lost art - *(did you know that Microsoft Office 2000 needs almost 700MB for a full installation?)*

"Put everything into everything" is the current trend. To me, however, design elegance is doing one thing really well, so that it is perfectly balanced to the task at hand.

¹ A particular episode of a Japanese cartoon program, Pokemon, had a character's eyes flashing red for about 5 seconds. It induced epileptic seizures in hundreds of young viewers. Children were apparently more susceptible than adults. Of course news shows replayed this clip numerous times, which only made the problem worse.

[Ree: One characteristic of this project is that every component was optimized separately, and then together, after extensive empirical experimentation. Everything – the LEDs, the lenses, the software, the spectrum analyzer, and the software – has been extensively researched, compared with other elements of similar make, then deployed in prototype form for demos and tests that mimic as closely as possible the environmental conditions under which the project will eventually run.]

About the Microcontrollers

They are called PICs. Each one has 1,024 words (each word is 14 bits in this case) of program memory, and 128 bytes of data memory. These chips are extremely cheap at \$1.70 each, which is important when you're buying 400 of them.

Programs Running in the Ring

Currently the program is right around 800 bytes. It consists of the following parts:

- Communications system
- Event list manager
- Code to read and de-bounce the push buttons [clean up signal when someone pushes them]
- Code to display the patterns

The Data communication around the ring is in 24-bit packets transmitted synchronously at 2,000 times a second. Each microcontroller simultaneously transmits and receives a packet of data using 50% of its available capacity. The other 50% of the CPU is used for decoding instructions, processing events, and displaying patterns.

Turning Live Data Sources into Patterns

Since packets are transmitted synchronously in real time, patterns from live sources can be transmitted and displayed immediately. We have a box with an audio spectrum analyzer that outputs 10 bands representing various audio frequency ranges. You can select different frequency bands to feed into the ring.

Pattern Overlay

There are three different ways to get a pattern onto the Ring, and each one can be functioning simultaneously with all the others for complex overlays.

- The first way is to program the Ring with an event list of up to 30 different patterns, on each of the 200 driver boards. By staggering event points around the boards, you can have the appearance of a single large pattern. This means that each of the 200 boards has its own set of 30 patterns, or $30 \times 200 = 6,000$ total available pattern events. For example, you can use this to program the sweep of a second hand clockwise around the Ring.
- The second way is direct display. every light can be changed individually up to 10 times a second by directly writing to that light. Or, any particular light can change 2,000 times a second.
- The third way is a shift command that takes a single bit, moves it 1 step clockwise, and adds a bit. Shift patterns can run at any rate, separate from other functions.

Playing Patterns Interactively

This is a very simple system, using only a few basic components. We start with a line, which is a set of points. This line is bent to form a circle. From there all other combinations are formed. We are playing within a boundary of great simplicity. This approach is the opposite of that taken by modern computer

graphics programs, with their perfect shading and super-realistic rendering. In the L2K project, there isn't a lot of preconceived structure. Any meaning is in the mind of the observer.

The Pattern Buffer can be played interactively in a number of ways. Each LED in the PB Lounge has its own button, which turns the LED on or off when pushed. A preset pattern can also set or reset the LED.

More complex patterns can be created by our PB "Lounge Lizard" patrons as follows:

- The Loop sits quiet. People push buttons. At some point the pattern is "stored" and then repeated, probably every 5-10 seconds. What people are currently playing is overlaid against what they were playing a few seconds ago. Meantime their new actions are stored again for playback in the next loop.
- Play pre-existing patterns (like the clock sweep) and let people try to catch it and "erase" it. They have to hit the LED push button at the exact moment that the pattern sweeps through, otherwise they'll add a new bit to the pattern instead of erasing the existing one. Whatever they did would go racing around the Ring.
- You could even have group games for "erase the pattern" with preprogrammed starting points. For example, a group in the North would try to make the Ring all light, whereas a group in the South would try to make it all dark (erase North).

The computer controlling the Pattern Buffer Lounge is a Z80 with 512K of battery-protected memory and 128K of flash memory. It also has a higher-level event list with programmable date, time, and event triggers. So you can program a particular pattern to start at midnight, for example.

Magic, Technology, and Engineering

Arthur C. Clarke once remarked that any form of technology is indistinguishable from magic (to a civilization that isn't advanced enough to comprehend it yet). I'd turn that on its head and say that any sufficiently advanced magic is indistinguishable from technology.

We're focusing our own will towards the effectiveness of small influences at critical points. That's what technology is, it's getting the most out of any action by applying that action in the right place, at the right time, for maximum results. It's a "Give me a lever long enough, I can move the world" kind of thing.

This ties back to my remarks about the importance of elegance in engineering, because every component in this project is designed for optimum fitness for the task. It's remarkable that I'm getting this level of functionality out of such tiny computers. But that's essence of it - engineering done right has a kind of magical feeling to it.

Tinkering with Reality

Physicists and magicians both do similar things, which is they tinker with the nature of reality. So too do the software engineers who were the creators of the Information Age redefine our notions of reality with respect to things like business and money.

[Ree: Physicists are closest to magicians because they're looking for the essence of the universe, and they start running up against surreal phenomena that can't be explained by normal paradigms.] If you go down far enough in hard science you come up in metaphysics. Particles pop in and out of existence, and people like Stephen Hawking, citing developments in modern physics, concluding that anything at all can happen.

Like these physicists, software engineers are doing magic all the time. They're redefining the world in tiny places, doing interesting things that end up having a massive influence on the world. They're totally focused on the task at hand, in their intimate space. It surprises them when their work is so far-reaching.

The Information Age and Reality

The nuclear scientists didn't all know right away that their work would lead to such mass destruction. After the bomb, Oppenheimer said that he had become the destroyer of worlds. I wonder why he never thought of that while he was doing it...

Information Technology is now as influential as the Industrial and Nuclear Ages. Information Technology changes the fabric of reality by redefining our notions of money and value. It removes boundaries between the group and the individual. We don't know yet what the end result will be. It could become a world of big brother watching everything you do. Maybe not, I'm hoping that tolerance, freedom, and self-expression become "normal" as people come to have ubiquitous access to other points of view.

Impact of Information Age on Society

The Information Age is leading towards a society with an increased emphasis on the individual, with power in the hands of connected communities that are no longer separated by geography. Maybe it will be possible to have technology with lower energy consumption by a return to community living. (Walk around your village, commute around the net)

I could enjoy that...