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THE WORLD IS THINKING

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Good evening. I'm Stuart Brand from the Long Now Foundation. Brian Eno has been with Long Now from the start. He named it the Long Now Foundation, he gave the first talk in the series of seminars about long-term thinking, and he's a member of the board and is known as well as being one of the big contemporary musicians and composers and artists, a very very comfortable and creative collaborator with other people.
And so on sort of a trial basis tonight, we'll see what it's like to put a creator of music with a creator of games.
Games for computers are really news that stays news. The first serious computer game was Space War, 44 years ago in 1962.
Written by a group of hackers at MIT...who was it, Steve Russell, mainly, along with Alan Cotec, Peter Sampson, and Dan Edwards.
Ten years later, 1972, this was written in Rolling Stone: "Space War was the illegitimate child of the mating of computers and graphic display. Remember back in 62 complication was something you sent off to the manufacturer, you sent the data away, like colorform, and then it came back days or weeks later, hopefully usable, but not always. Space War was real time. It was the illegitimate child of mating of computers and graphic displays. It was part of no one's grand scheme, it served no grand theory, it was the enthusiasm of irresponsible youngsters, it was disreputably competitive, it was an administrative headache, it was merely delightful.
"Yet Space War, if anyone cared to notice, was a flawless crystal ball of things to come in computer science and computer use. It was intensely interactive in real time with the computer, and encouraged new programming by the user. It bonded human and machine through a responsive, broadband interface of live graphics display. It served primarily as a communication device between humans. It was a game. It functioned best on stand alone equipment, which was a big deal in those days. It served human interest, not machine. A lot of the work being done then was trying to keep the machines interested and games didn't care if the machine was interested or not, and mainly it was delightful."
I wrote that. In 1972. 44 years later, computer games still lead the way, and Will Wright leads computer games. Please welcome Will Wright and Brian Eno.
Thank you very much.
Hi everybody, can you hear me?
Can you hear me? Thank you. Thank you all very much for coming. And the format tonight is slightly undecided, but...essentially we're going to talk about games, generative music, and what those things do for us, and what's different about them from things we've known in the past. And I'm actually the assistant here, this is actually Will's talk.

No, not really. I'm encouraging him to basically interrupt me at every stage.
Overcome his English reserve.
Shut up. You're interrupting me.
Well, that's the spirit.
We're going to talk and interrupt each other for about an hour and then there'll be questions, which I think you know to write down on pieces of paper which will be thrown away at the back of the room. And then Stuart will ask the questions he wants to ask us anyway.
Now you know. And I have to say what an honor it is to share the stage with Brian, whose work has been very inspirational to me for as long as I can remember.
Well, thank you. Can I reciprocate that, thank you very much.
So, I'm going to do some boring Power Point at the beginning of the talk, and I think Brian's going to score my boring Power Point with very interesting experimental music.
So, you know, I actually just got back in town recently a few days ago and I was trying to remember what time the talk was, and so I went to the website, The Long Now Foundation, and saw that the talk was Friday, June 26th, which, consulting my calendar, I found that those two things were incompatible. Which I found ironic for an organization whose sole charter is to chart the passage of time, you know.
But when you're dealing with ten thousand years, a few days doesn't really make that much of a difference.
Yeah, I mean it's...So I think we're probably missing half the audience that came here Friday, but...So I wanted to start just a little bit by delving into compression a bit, because I think a lot of what we're going to talk about, this is underlying it. And I know that all of you find the idea of compression just fascinating. But really, it's the basis of a lot of really interesting systems.
In fact, what we know of science is really observing the natural world around us.
You know, all the data that we can see and collect and observe. And trying to compress it into the simplest, most elegant rule set as possible.
You know, in some sense we even use that as a guide post.
You know, when Watson and Quick discovered the structure of DNA, they did it by building these models of them, and they tripped across the idea of the double helix, and it was so aesthetically pleasing to them, they just kind of knew it was right.
And games really are just kind of the opposite process. We're trying to come up with very very simple rules that we can decompress into these elaborate worlds.
And I think the kind of work that Brian's doing as well kind of speaks to that, looking for very simple systems that can generate really interesting complexity.
It's called laziness, really. But um, yes, I suppose the thing that most impressed me, one of the musical things that most impressed me in my life was a piece by a composer called Steve Wright, which is an extremely simple piece, in terms of the inputs in the system.
It's two loops of tape that run out of phase with each other and get progressively more out of phase, and thus generate a very complex piece of music.
Well, I was so impressed that something so simple could create something so powerful.
When did he do that?
It was 1964, I think, that piece, it was called, "It's Going to Rain."
And the amount of actual sonic material in the piece is 1.8 seconds long.

But the piece is thirty minutes long, or something like that.
Oh really. So what are the duration of the two pieces.
Well, it's the same loop on two machines, 1.8 seconds long, and one machine runs slightly slower than the other, so gradually they-- the relationship between the two loops shifts and in fact that's been the basis of a lot of the music I've done since then. Music for Airports, for example, was based on that idea. And a lot of the ambient music is based on this notion of, instead of trying to design a piece from the top down, which is what you normally think of as composition, you know, you have the whole piece in your mind and then you sort of build it all like an architect makes a building, this is more like a gardener. You have a seed and you plant it and you see what happens, you know.
So when that seed comes out and it's not what you like, or what you expect, do you go back and make a new seed?
You go back and make a new seed, yes.
So it's much more the process of discovery rather than composition or engineering.
Yes, and you're sort of in the same position as an audience, actually, because you're listening to the music for the first time as well, so the music is generating itself anew for you, the listener, as well as for the audience, so it puts the composer in an interesting new relationship to the music, I think.
Yeah. I think as a creator it also puts a big challenge on you, because now you're in the process of exploring rather than engineering or sculpting.
Yeah. So now you have to care about your inputs and your systems a lot more, since you aren't designing the whole thing, you're not specifying in detail the whole thing, you're making something that by definition is going to generate itself in a different way at different times, so.
Yeah, we see that a lot with simulations, because we're always looking for very simple rule structures that we build into prototypes, and we just turn them on and see what happens, and then from there we will start modifying them, and it's very much the process of surprise and discovery, and it's so non-linear, it's so counter-intuitive, that it's very difficult to kind of have an end result in mind as a target and then shoot for that. It's actually far more productive to just kind of experiment and let the results of those experiments kind of present opportunities to you, that, you know, "Oh that's really cool. I never would have in a million years thought to go there. But these simple rules brought me there."
Yeah, well, this is sort of a new way of being an artist, really, I mean it's not so new now, people have been doing it for thirty or forty years, but to make it explicit and to say, "This is what I do," and to own up to the fact that what you're doing is making seeds rather than forests, you know, letting the forests grow themselves.
So I thought we would delve into generative systems across a broad range of topics here, you know kind of one of the pre-eminent ones is biology. And this is one that we're very familiar with. Richard Dawkins, the biologist, estimated that the typical willow seed actually all it contains is about 800k of data, which is enough to fit on one of the old floppy disks. Which is really amazing, when you imagine all of the trillions of atoms and all the complexity in a willow tree, that the genome of it compresses down to that small is very powerful ratio there. It also, we see examples of this in things like the

behavioral sciences. You know, ants have very simple rules, but when you
combine the simple rules, they display amazingly elaborate, intelligent behavior.
Spirograph is a great example, one of the most understandable examples,
you know, using simple geometry to create these shapes.
Another example of a very simple generative system is wind chimes, of course.
That's a generative system that people don't take very seriously.
In fact, that's like the first generative music...you think?
I think it probably is, yeah.
I guess it's not really algorithmic.
Aolian harp is probably the first one.
Actually, it's an interesting question, you you draw a distinction between let's say randomly
generated music, like wind chimes, and algorithmically
generated, where there's some deterministic rule underneath the system.
Well, it's-- one part of course, of the wind chime thing, the most
important part isn't random which is the pitch of the--
The notes.
The notes. So the only random part is when they occur and how they
cluster together. And that sounds generative to me.
Have you done systems that involve more randomness?
Yes. What, in the sound itself?
Or in the selection of the notes, for instance.
Yes. So I've experimented with all sorts of forms of randomness, and
I've found that I nearly always end up constraining it quite a lot.
It seems like on some level of complexity you wouldn't even be able to determine
whether it was random, or there was a complex algorithm underneath.
That's true, yes.
And is that something aesthetic?
They become functionally identical.
Because it seems like a lot of this studying for music involves patterns, repeating
patterns that a listener can kind of start to identify and anticipate as they're coming up.
Well, that's from what I call narrative music that's true. But in the seventies, I came
up with this word for a kind of music that more and more people were starting to do,
which I called ambient music. And that was quite a different idea. That was the idea of
music as a sort of steady state condition that you entered, stayed in for awhile, and then
left. So it was music as painting more than as narrative. So it doesn't have
beginning, it doesn't have development, it doesn't have climaxes, particularly, it's closer
to sitting by a river than watching an orchestra, for example.
Yeah, I actually spent a lot of time listening to your ambient albums, and I found
them interesting because I was aware of them on a very subconscious level, it
wasn't like most music, where you're hearing it and thinking about it, and kind of starting
to kind of get into the rhythm and stuff, but it would just totally change your perception of the
world around you without you even realizing that it was your
audio system doing that. It seemed almost subconscious.
And you stayed awake.
Yeah, well. Actually, I used to do a lot of work to it, you know. The other

music we'll discuss will wear on me after awhile, but the ambient stuff will give me this trance like state. In fact, it was interesting, because it brought me into this relaxed, trance like state, but kept me awake, somehow kept my brain active in an area that I wasn't even aware of.
Yeah. Well, I think some of that music came out of trying to find something I could listen to while I was trying to work.
Oh really. Okay. So you didn't like your other music while you were working.
No, it's too attention-grabbing, you know. It's designed to grab your attention.
Exactly. And that part of the brain is what you want to apply to your creative work.
Yeah.
You know, and somehow it keeps that part of the brain fed.
You better go on with that, we've got loads of slides to go. We're never going to get to spore, otherwise.
Okay, all right, yeah we do. Yeah, fractals, fractals. You've seen these. L systems.
Yeah, yeah.
This is the boring Power Point part of the lecture. Also some direction in interesting form like fractals allow us to generate very organic looking shapes. And they come in a variety of kind of styles, but it's actually quite amazing that there are patterns embedded in this that you can clearly see, but at the same time there's a very organic nature to them. These are more L system things. A lot of art, I tend to think of, as generative. You know, artists will use very primitive elements, but in combination, they evoke totally different feelings. Much more complex forms.
My favorite painter. Kandinsky.
Even in design, we're starting to see more people use generative systems. Christopher Alexander's work is very much about this, how he looks for patterns, rules of grammar, sort of applied to design. There are other things known as shape grammars, which are being used in things like architecture and industrial design. These are ways of applying transformations to certain design rules to generate new designs, that you can then go through and prune, and kind of score for efficiency. When you do music, and you're coming up with these rules, there must be some process of you playing with the rule set, listening to it, saying I don't like that, playing with the rule set again, so basically pruning out the rules you don't like to zero in on the rules you do like.
Yes, exactly, and finding out that one always is inclined as a composer to put more in than you need as a listener. So one of the very good things about working on this is that it has a speed control.
Oh. So you listen to these things in fast-forward?
I work on them much faster than I end up releasing them, generally.
Oh really? Wow.
And in the days of analogue tape, a lot of the music I released was released at half the speed I recorded it at.
That's like people doing film editing, where they're always zipping through the thing.
And it's the opposite of what people do on television, where they always accelerate, you know. I find with music, if you're making it, you always tend to fill the gaps.
You want to paint the whole picture. But if you're listening, you actually want a lot

less than that. So I do that. The simplest way is simply by slowing it all down.
You should release an album with all the speeded up versions, that would be interesting. This is as Brian heard it while composing it.
The amphetamine version.
Right, yeah really.
Amphetamine ambient.
Really. That's great, like acid jazz. We see generative systems in psychology.
It's amazing how humans can see patterns in almost anything, and we're always searching for these patterns, even if they don't actually exist. And we've even engineered things that kind of bring us more into meditative, spiritual realms that in some sense are generative systems for the mind. And games, of course, are a great example. This is my favorite game of all time, Go. Which has two simple rules, but the strategy is just amazing the way it unfolds in kind of unpredictable ways. And you know, this is one of the clearest examples of generative systems in emergence that I've ever seen.
This game, by the way. There's a book by Francis Fitzgerald called Fire of the Lake, about the war in Vietnam, and she once interviewed a Viet Kong general after the war, and she said, why do you think you were so successful, he said well, the Americans were playing chess, but we were playing Go. And that really captures the difference between the two games.
Go is about a hundred times more complex than chess, really, in terms of the range of strategy. And in fact, the compression ratio between the simplicity of the rule set and the depth of the strategy is just an amazing ratio. I think the ratio is interesting in the entire world around us, like looking at the DNA vs the willow seed and the willow tree. You know, that compression ratio indicates a certain ratio of generative system, you know, and emergence. A lot of that is based upon symmetry, that we see in a lot of different ways, in symmetrical operators rules. When we're building models on the computer, you know, a lot of these become games, and in some sense, models are abstractions of reality. What they kind of remove is interesting, they're only presenting you with relevant information. When I do a game I actually build physical models of the stuff.
When I did a game called the Sims, it involved the screen of the neighborhood, and one of the first things I did was actually go build a physical model of it , out of like model train materials, and that abstraction is kind of interesting to me. We abstract things not just spatially in games, but also in time.
You know, time is something that you can play with on computers and interactive systems, in a totally different way than you ever get the opportunity in reality.
One of the most important things about games is the fact that they have re-start.
You can replay the same situation over and over from the exact same starting position, which you never get the opportunity to do that in reality.
In some sense, I guess, generative music is the same way.
Well, this is one of the very interesting things about generative music, that you can start it again, and it unfolds differently, and this is very fascinating, because it implies a sort of space of possibilities that you gradually become familiar with, so instead of becoming familiar as you normally do with a piece

of recorded music, with this particular story, you become familiar
with a sort of envelope of possible stories that the music might unfold along.
Yeah, in fact, that's exactly the same thing that happens in games.
You know, the players are kind of exploring...
Good gracious, that exactly illustrates what I just siad.
Yeah, how about that. We must be on the same wavelength. In games,
you know, the computer, actually, when it's playing chess, is analyzing every possible move
that you might make and it might make, and it's in fact building a map of all the possible
moves, up to some level of depth, that might happen in the game, and that's how
computer AI's work, and even board games, in some sense, become a map of the
possibility space. You know, all the different spaces on that board indicate states that
you can be in, in this game. Most people just don't think of it as a map really, in that sense.
You can think of our games as in fact these very elaborate landscapes, where
there's terrain, and the terrain might represent challenge, difficulty, some areas
are very smooth slopes that you can climb up very gradually, other ones are steep cliffs,
that are incredibly challenging to hit. So there is in some sense a friction in the
possibility space in an interactive experience, and I guess when you're working
on music, there's a certain amount of probability that you might enter certain
regions of that possibility space, certain regions may be more probable than others.
Yes, I remember one very funny thing that happened once. I used to use a particular
generative piece, for all of my sound and light installations for many many years.
And I must've listened to that piece for thousands of hours, unfolding in its various different
ways, and I was setting up a show in Venice once with my assistant, it was late at night,
and we were setting up and the show was due to open the next day. And
suddenly, the beginning of Tammy Wynette's Divorce came out: dum dum...
Was that pure chance?
Pure chance, yes. The thing had suddenly clustered together to produce the first
couple of bars of Divorce, and we were both very tired, and we looked up and
just fell on the floor laughing, it was so funny. It never happened again.
Well, you just didn't listen long enough. That's interesting because that kind
of implies the vast space that music you know occupies, that it took that
long just to hear one tune out of the thousands of tunes--
One tune that I recognized, out of several thousand hours, yeah.
It kind of implies that composers are finding this very small amount of listenable
space within this vast, you know, astronomically large sea of potential sounds.
Yeah. And whenever you think of a space like that, and you think of the
possibilities that have been explored so far, you immediately start to think of all the
ones that haven't been explored. Like if you think of the space of all possible sea shells.
And then you think of the number that have actually been
explored, it's a very small part of that. And you wonder--
There's a quality rating, so most of the random compositions you can make probably
sound awful, correct? And so you're looking for this region of quality sound.
Yes. Yes. You want to be on the cusp, where it doesn't sound random, but it
doesn't sound too obvious and too predictable. It doesn't unfold like you would
expect it to, but it doesn't unfold in an entirely unexpected and disconnected way, either.

So you're exploring this huge space. It makes me wonder if there's any, you know, algorithmic solution to at least find some rough measure of quality, so you're not having to sit there and listen for a thousand hours to
get a sense of the quality of the entire range of that system.
Well, that's a moving target, you see, because whenever you listen to a piece of music, you really are listrening to the latest word in a conversation that you've been having ever since you started listening to music. You know, you hear every other piece in the piece you are listening to at that moment. So as
your taste changes, and your experience changes, that target will change all the time.
Can you imagine any sort of even this past computational filter that would pre-listen to the music, analyze the structure, look for a pattern, whatever, that would at least prune out the 90% that you obviously don't want to listen to
and let you focus your efforts on the 10% that has some promise?
Would you like to work on that for me?
Sure, I would love to. You just have to give me the algorithms, I'll cut it right up for you.
No, it's, funnily enough there's been a lot of research into that, because you know there are always people trying to figure out how you write a hit.
Oh, I see. Formalizing the--
Something I wouldn't mind knowing about.
The hit generator.
So there's been all sorts of attempts to do that,
but they've been astoundingly unsuccessful so far.
Yeah, I can imagine how difficult that would--
Shatteringly unsuccessful. In fact, they're almost formulas for doing the opposite.
Oh really.
Yes.
So maybe that would work.
So they're quite interesting in that respect, in that they are counter productive.
It sounds kind of like a stock trading program. In the sense. You're hitting this moving target and so many dimensions at once.
Better get-- sorry. I know Stuart Brand is going to rap
us over the knuckles if we go over the--
So we have these possibility spaces that these players are navigating, and in some sense designers even think we're actually engineering these possibility spaces in a very kind of abstract sense. In the Sims we actually had two main dimensions that the player would kind of pursue as a goal state. One is material success,
getting larger house, a better career, etc, and one is social, getting a larger family, more friends. Really we wanted the players to kind of balance the two factors, and that would lead to the highest level of success in the game. They could go for one or the other and they would end up on a local maximum.
In some sense the game is very much like bowling. If you kind of went
off to the side, you'd end up in the gutter, and you had to get it right down the middle to get the highest level of success in the game. This is actually a map that we made of several thousand players playing the game across those dimensions. And so we were actually able to capture player's movement through these possibility spaces and

start to analyze kind of where players, you know, coordinating, coming together, where are they fanning out and diverging. And we're learning a lot of interesting things about that. I think a lot of times with linear storytelling, that's what's happening as well. This is one of my favorite scenes from Indiana Jones, from the beginning of the movie, where he's running out of the temple with his treasure, and all these traps are going off. He almost falls into this pit, this giant boulder rolls over him, and as a viewer, I'm imagining every one of these things as a possible failure state. What would happen if the boulder rolled over him, what would happen if he fell in this pit, what if this trap got him? And so even though I'm seeing one path through that possibility space, my imagination is filling out all the possibilities that could have happened, and that is a lot of the drama. Is me understanding that possibility space that surrounded him, and the one particular path he took through it. And I think that's the element of a lot of drama. Now we go to stuff.
Stuff.
Yeah, stuff. At this point, I think Brian is going to start playing us some music.
There you go.
All right. We thought we'd give a few examples of some generative systems here. And why don't you describe what you're playing.
Um. I will if I can get the volume right. I have to get this balance between where you can hear it and yet still hear us. Actually all the pieces I should be playing today, I made today.
That's the power of generative systems, right?
Right. Because I have a new computer which is supposed to have all the contents of my old computer, it was only when I arrived here that I discovered it had none of the contents of my old computer.
Don't we love computers?
It just had the names of all the contents of my old computer.
That's a very powerful feature, too.
So rather than just recite the names to you, I made several new pieces of music.
In programming terms that's called dangling pointers.
This piece was meant to go with-- oh yeah yeah we're going onto the exciting stuff.
So these are cellular automina, which a lot of you are probably familiar with, which the idea behind these is that they are very simple rule systems, and we will run the rule, and it actually analyses every cell within here. Each one of these cells looks at its neighbors, analyses what's around it to determine its new state. And so it's the same rule applied to every cell because the number of neighbors is different. You get different patterns emerging. So I'm stepping through this very slowly.
Can we just-- we should perhaps give the audience some idea of what these rules are like. They say things like, If um--
Yeah, let me--
If three of your neighbors are alive, you're going to die, or you're going to survive in the next generation. If you've got only one neighbor alive, you'll die. If you've got two neighbors alive, you'll persist, whatever.
And that's the exact rule set that Brain's described--
Those kinds of rules.

Is probably the most well-known example of a cellular automina, and this is Conway's life, and that's this rule set basically. You have three or four neighbors who survive, if you have exactly four neighbors, and this is going into every little cell and counting how many neighbors you have to determine if a new cell is created or destroyed. But now as we run these...I'm going to run it fast, now...you start seeing these amazing patterns develop. And this is entirely deterministic. So from those very simple rules--
So there's only those three rules, and what's very very interesting, is if you make a tiny difference at the beginning, it can translate into a huge different in the life cycle of the thing, so you know, if you start with a grid of nine squares with one added to it, it will last for 53 generations. If you add one more square, it will last for 15,800 generations.
And this pattern I'm showing here, every time I run and load it, it will generate the exact same result. And so all of the complexity you're seeing as it runs here is embedded in a couple of simple rules. And these are very interesting systems, because there are so many different things that you can kind of generate with them. Different patterns, symmetries, some of them are very beautiful. And this is actually-- we were playing with this earlier today and we were noticing that certain pieces that Brian was composing worked very well with certain rule sets. It was somewhat unpredictable as to which ones went well together. But it's actually two generative systems basically kind of playing off each other, having never even met.
I'm reluctant to play this too loud though, because I think it's a bit disturbing to have-- oh that's lovely, isn't it.
Now I'm actually pulling back on this pattern, this is ways in doubt, and as we zoom in closer and closer, you're seeing different patterns at different scales here.
So what you have to think about is, suppose you had to make this as a film, what we're seeing here. It would be very complicated, that's a lot of information.
You had to specify it as a visual phenomenon like that. But what's actually happened is there's a tiny little set of rules and this landscape for them to work in. And the set of rules, well it's typically like a 2k document or something like that. And you get all that richness, so. This is really the power of generative systems, that you make seeds rather than forests.
And this is very much the type of thing where you have no idea what it's going to look like when you build the rules. You turn it on, and it's always just a a total surprise. These were actually developed in I think the forties by Von Oyman.
Before he even really had fast digital computers to run them on, and another interesting thing about these, is how fragile they are.
So because this one for instance, if we go back to the starting position, you can see it's just two simple cells. As we start running the pattern, it starts expanding, but it's totally symmetrical, bi-laterally symmetrical here.
And as we run it, it maintains that symmetry through its entire life. But if I pause it just for an instant and add one cell somewhere where it shouldn't be, and then run it, it will end up breaking the symmetry. So now we've broken the symmetry just by putting one cell on the wrong spot. So these things are very complex but also very fragile in some sense.
They're very dependent on their initial conditions as well, so what they start out with totally determines their life, it's a very sort of sad view of human possibilities, really.

How fragile it all is.
And how nothing can change much. Terribly sad really.
Well you see that in biology a lot actually. The genetic structure is such that only the viable organisms will survive, and so every one of my ancestors had to survive to reproduce, and a lot of times there are whole regions of evolution that are cut off to us, because we have to jump across this chasm of unfitness.
Yes, I sometimes wonder about my ancestors on that score there.
This is another example of things that we can do with these systems, we can actually.
Just put a little-- see, this is a little machine, you see.
Yeah, a very elaborate little machine, I can like put one little cell in the wrong spot here, and very quickly the whole thing just kind of goes to crap. That was one cell, and... and now the whole cycle's broken, these guys are going off forever in that direction. We can actually use these things for doing simulation. In fact, a lot of our games are built upon cellular automina at a very simple level, to simulate what seemingly is a very complex thing.
Sim City, which is one of the games I worked on many years ago, in fact is underlayed by just a set of very simple cellular automina like this, you know they have very simple rules for things like crime and traffic and pollution, and on top of that we lay all these nice graphics of cars, and factories and all that. But really underneath, it's a very simple grid system like this, that allows us to simulate things, and it took awhile to discover the rules, but once we actually put together a few simple rules, we got to systems where we were seeing emergent phenomena, we were seeing things like gentrification, just through the simple actions of the crime, land value rules. And stuff like that. And it seemed like it was a much more complex simulation than in fact it really was.
Let's go to another little example here. This one is a little more visual in some sense. This is a simple program that actually has some very simple rules for figure drawing and opposability of the figures, and what it does is it generates paintings, basically, on the fly, it kind of knows how to draw a few things like plants and people.
Oh, I know what this-- This is by, um, is it Bernard Cohen who wrote this? What's his name? Or Harold Cohen?
Let's find out. And I will register this, I promise. Let's find out. No, it was Kurtzwald.
Yeah. But every time you run this, basically, it generates a new painting.
And it's interesting just because the computer's obviously doing fairly random re-distribution of the poses and the figures and the colors and whatever, but they're still evocative, I can look at each one of these things and there's a certain mood that's kind of evoked for me, looking at them, that I'm sure the computer wasn't thinking about that at all.
But this is one of the other interesting things about generative systems, they depend a lot on the observer as well. So one of the things, a lot of my work counts on is the idea that if you put something onto a cd, people will tend to think it's probably music.
Is that a function of the cost of the cd, or uh...
But it's funny, it's like if you put something in a frame and hang it in an art gallery, people will think it's a painting. And they'll reserve a special kind of attention for that, which they don't give to computer screens or to their shoes or whatever. So I think something I'm very aware of is that people tend to connect things together in their brains. A lot of my work involves using light and sound together, and I never

synchronize them, but people always think that they're synchronized.
In what ways do you use light? Like light shows, or?
Ooh, that's a big long story. I don't think we should go there, actually.
Well, now I have to.
Well, if we get time later, but that takes a long time. I don't
want to I want to get to spore, basically.
Well, we can do that right now, and we can hear a long story?
It looks like Julie Christie.
Maybe it is. Okay, let's switch screens over to this computer and audio if we can.
So I'm going to show you a game that I'm working on right now that relies very
heavily on generative systems, and it's called Spore. The rough idea was inspired by the Powers
of Ten, which was a book and movie done by Charles and Ray Eames, actually done earlier
by a Dutch screen teacher named Kees Boeke, called Cosmic View, but I'm sure
you've seen this idea in the film or the movie where you have a guy in a park and it
goes down to the cellular level, to the atomic level, all the way down to the quarks,
and then it pulls all the way back to the planet, and the sun, and the galaxy.
And I always thought it was a very unique perspective, and it was kind of
missing the dynamics, I always wanted to see the dynamics on different
scales, so that was part of the inspiration behind the Spore.
Another part of it was I wanted the players to create most of the game. So almost
every piece of content in the game is createable by the players. I'm just
going to show you a few bits and pieces of it here. The game actually occurs across multiple
scales, from cellular, to kind of evolution creature, up to tribe, city, civilization, and
then in space. In fact, you're actually kind of involved in developing
evolving civilization from a single microbe. Every level of the game also
has an associated editor where the player is in fact actively creating the content.
I want to show you kind of an example of what that looks like, because a lot of
the underlying elements of the game involve the players having very powerful editors.
So this is our creature editor in the game. And so it's a very simple kind of skeletal system
where where I can drag out things, I can inflate them with the mouse, we want it to be
extremely open ended with the player. We have a palette of parts over here that we can
kind of grab and use and stick onto the thing. Very claylike, you know, everything I
can basically kind of sculpt like clay. Different types of parts. These are feet. As I start
putting parts on, the creature starts coming to life. I can kind of morph and scale these
things. Now let's give the thing a mouth here. All these parts have handles, I'm going
to scale this up a little bit. There we go. And maybe give it some eyes. And maybe a
set of arms as well. To grasp things. Now the interesting thing about this is that no matter what
the player designs, the computer has to figure out how this thing would behave. So here
in a few clicks in about two minutes, I've created a fully 3D character. The next
step is actually coloring the thing. Now this is all generative as well. So basically
we have simple rules for how the computer should paint this thing. So we basically
select a color, and each one of these spheres here represents a different algorithm, which is
a different pattern on the creature. So we can go for stripes, spots, scales. We can overlay
and mix different patterns, so I can pick another color here, and then put different stripes.
The computer's actually analyzing things like where the torso is, where the legs are, very much the

way a texture artist would. And in fact, you know, typically a computer texture artist would spend a couple days texturing a creature like this. So here in about 3 minutes, you know, in about 30 mouse clicks, I've created a creature that's roughly equivalent to what a Pixar artist might create over several weeks. And...And now the computer actually analyses what we've made and brings it to life. So in fact, this is the way this thing would move. And so no two creatures will actually kind of move or behave the same way in this game.
So. Can I just interrupt a minute?
Certainly.
You see the way it's heaving up and down there.
Yeah. That's its breathing.
So is the computer told in every case to say, what would this thing do when it breathes? Does it always do that sort of thing, it always makes a decision about...
Yeah, everything it does, the computer's making some decision. And sometimes it's abstracting out elements of the creature...you know, maybe its mass, and weight, and size. The way it moves is very based upon how long the legs are, how many feet, you know, it can move in radically different ways if I put like seven legs or tentacles, or whatever. And so there's a range of possibilities that the computer has to kind of understand based upon the structure of the creature that you've designed. So everything the creature's doing in the game, all the behaviors, have to be animateable by the computer algorithmically. As well as emotions. So we have to be able to show when the creature's happy or sad, algorithmically. And depending on what you design, they can be you know quite tricky. So we take this creature and we actually bring it into the world, and you're actually playing in a full world of other creatures that were designed by other players. So as you design a creature in this game, you're actually interacting with other creatures that other players have designed automatically.
And how is the, how is the set of other creatures that you interact with chosen?
It's chosen by the computer based upon what you've done in the game. So it's based upon how well you are as a player, your skill levels, based upon a number of other things, so.
Do you as a player-- can you reject sets? So if the computer puts you in a landscape which you don't like very much, can you say, I'd rather have another set of creatures, please?
Well in some stages-- in later stages of the game, you can do that. You can give the computer kind of directives on the kind of content you want. So it's trying to select content that's not only appropriate for your kind of skill level but also your aesthetic style. So you make some purchasing decisions in the game. Make selection decisions. And the computer tries to extract that very much the way Amazon recommendations does. And so in the game, I basically need to find food to eat, so my guy isn't too powerful, so I don't want to go for that food. We're going to go over here. Easy pickings here. So we're going to...again, my creature is doing everything algorithmically, based upon how I've designed it. Now these guys aren't very strong but they're very social, so they're actually kind of sticking up for each other, so even though they're weak, I'm not going to get very far with them, so I'm going to go for something a little but easier. That's not it. Um, I can...oh, here we go, some people, herbivores, over here. If I'm quick, I can go get a bite of their egg here. They're not too happy about that. They're herbivores, but they will defend the nest. But I did get some DNA points. Now not only am I just trying to survive in this,

but there's a whole social game. If I can find members of my own species like this, I can basically socialize with them, and as my brain level advances, I get higher levels of communication with them. Now this one's ready to mate, so I can actually mate at this point in the game, and this is algorithmic mating.
That will be banned in several states, won't it?
Yeah. So I actually plan every generation of my creature through evolution, and that will give me access to the editor again.
Can I ask you something? If your creature doesn't survive the evolutionary struggle...
Yeah, basically like the restart thing that I showed you earlier...oh I have to defend my eggs here, hang on one second. Get out of here. I have to defend these long enough...Basically, if you died in this stage of the game, you would fall back one generation to your last egg and get an opportunity to redesign your creature for the next generation. So this is the creature I had. Now I might decide I want to make this creature faster, so what I'm actually doing is playing every version of my creature, every generation of it through evolution. So I'm going to take off these feet, put on something a little bit faster. And this is how I actually increase the performance of my creature over time.
And do you pay extra as it were for these, you know, for high performance features.
Yes, in fact there's a currency that you're earning, kind of DNA currency that you're earning in the game that you can spend in the editor. So every level of the game...
So if you design something like a sloth, that would actually be very cheap, would it?
Yes, in fact you can actually start as a slug. We had this little slug thing we called Oogi, that you know, had basically a mouth, and that was about it.
I knew someone like that.
Yeah it was re-- It was very tricky--
I married her.
--guy to survive with. Now I'm going to make my guy a little bit scarier. You can also make changes to your guy that are more aesthetic. So my happy go lucky guy is going to get a little bit more serious here.
Can you also modify the behavioral characteristics, or does the computer deduce those from what you've done physically?
In the editor, you're designing the physical characteristics of your creature. Once you get into the game, you're actually designing its behavioral characteristics by the way you play it. So if I'm going to play my creature as very social, then it will start to reflect that in the game by how often I socialize with my other creatures, I might become more of a herdsman mentality, and work together. Like with small creatures we were at before. So here I've redesigned my creature, but as you come back into the game, we actually don't start with the full size, we start with a baby. So this is the baby-fied version of the adult that I've just designed. We run actually a little simple neo-natal algorithm, so the head is exaggerated, and a few other things.
And so the social game, I can actually click on these guys and have them socialize, play together. And as I do that I kind of earn-- this is like playing the friendship game in the Sims. And these guys will then start to follow me and mimic what I do. So here we're playing together, and now at this point, the guy will become my friend. I get the little friend thing. And now he'll roughly follow me around. And I can get a little pack of my little baby friends here. And we can go over here and we can kind of like annoy our

neighbors, the herbivores again. Those guys are a lot bigger than we are, but we're pretty fast. Yeah, they're getting annoyed now. Yeah, they will definitely get us.
But I'm going to skip ahead here a little bit. Now actually, I'm going to skip a lot of the intermediate levels of the game, and eventually you develop intelligence and you start controlling an entire tribe of these guys, and you control their technical advancements, you can get them things like fire or spears, etc. You can design things like their hut. Like in every level of the game, you're dealing with things that the player is creating. And using generative techniques underlying that. That's what makes it possible for in 20 clicks the player to create something, is that we've made so much of it algorithmic on the computer side. So that gives the player a huge amount of creative leverage that the computer becomes a creative amplifier to the player. Eventually you start building entire cities and you can design buildings in the cities. Eventually vehicles, as the civilizations start interacting with each other. And I'm going to skip way ahead here. This is going to be the same planet that we were on, same creatures, but this is basically the end of the civilization phase. And so--
What?
The end of the civilization phase. And so these creatures have you know advanced all the way through tribal, city, and siv, and now they're at a high level of technological advancement. You can get a sense of some of their cities. All of these buildings were designed by the player in the editor. The cities that you're competing with were designed by other players in the editor and downloaded to your computer automatically to basically fill out your world. As well as the vehicles, etc, here. So here's our home city. Now at this point in the game we can click on it and we can go to the next stage of the game, where we're actually entering the space side of the gamer. Now the UFOs that we have here are like anything else, the player can create them. And this is our civilization that we were playing as evolution earlier, now basically entering the space age. And so they're having a little launch going on here. So they're having a little celebration.
Now at this point in the game, I'm actually kind of controlling this UFO and flying around the planet. This is the planet that we evolved on, and we've been playing the entire game on this planet at this point. We can get a sense of some of the other styles of buildings. This is some of the other cities that I basically built during the civilization phase of the game. Now, at this point in the game, one of the things that I might want to start doing is going out and colonizing other worlds. One of the things I might want to do is collect biological samples on my world. I can do this with this abduction beam that allows me to kind of go in using scientific principles here. So as we suck these things up into our UFO they're going into the cargo hold, and we can use them. One thing we found that was kind of interesting was that we can use the abduction beam to throw things. Really far. We may actually get some of these guys into orbit.
But now also for the first time we can pull all the way out, and see the entire planet that we've been playing on. And these planets are generated as well. So using very simple rules, we're able to generate entire planetary systems. So as we pull back here we can see kind of a very slight ring around the planet. As we keep pulling back, we go out to the interplanetary view. So here's our home solar system. That we evolved in. These are other planets. This one I can tell has some type of life on it. So we're going to fly over this planet. Pull down the surface. Again, these planets are all generated algorithmically, and we're hoping to have a vast variety of planets. This one's a bit more kind of

fantastical and imaginative than the first planet we started on.
So we might want to take our creature, pick up our home planet, and start introducing them to this-- now this planet already has a whole atmosphere and in fact somewhat of a simple ecosystem. Some of the other planets are more barren. In fact you have to kind of bootstrap from the very early stages up to this level. So let's find a spot up here. Drop my guy down. There we go. They get a little stunned when they get dropped. Okay, they didn't get along with the neighbors too well.
One of the things we can do is we can scan these guys with our scanning tool, and so any other creatures that we see on this planet we can scan them into a database that we call Sporepedia. And now the database we can access, and Sporepedia basically is a record of all the content that we've come across in the game. So in some sense this is kind of a collection game. There's a card that's built for every piece of content. So this is our home star, the planets around it, I click on that and I get planets. This is our home planet, this is the planet that we're currently visiting right here. This is the species that I've scanned on this planet. Each one has ratings, etc. And so we can use that to kind of keep track of the stuff that we come across in the game.
Is progress in the game always hierarchical, in the sense that you start at one level and you proceed up the echelons, or could somebody for instance come up with a virus that actually had a planetary impact. So somebody specializes on the lowest level and doesn't decide to evolve into a larger creature.
Oh, well you can stay at different levels, but the idea that we would be simulating viruses at the same time that we're simulating the entire planet, is basically kind of unmanageable, you know, from a complication point of view. So at every level of the game we're abstracting out the levels below and above. And we're actually running very low-res simulations when you're not there, on different scales. But when you're back there we have to regenerate the content. And so a lot of this is us kind of propping up the illusion of thousands and millions of things all going at the same time, but we're really going with abstraction and regeneration.
So to give you a little bit better example of that, as we pull back from this, now at some point I can upgrade my UFO, and eventually I earn the ability to pull all the way out from our home solar system to the interstellar view. So this is a region of interstellar space around our home system. Stars, we have a lot of other things that you might see with the Hubbel telescope. Things like black holes, nebula, etc. We can fly to each one of these. And these are, in many cases, worlds created by the computer. In other cases they're worlds created by other players.
So if we zoom into one of these worlds here, these new solar systems, we now see a different set of planets here, and so this one close to the sun is a very hot rocky planet, this one it would be a big terraforming challenge, we can pull down...like the last planet was a very imaginative, kind of almost Disneylike planet. This is a much more realistic planet. This is in fact much like the early earth was about 4 billion years ago. Kind of a hot, volcanic world, here. Pull down to the surface. Bring up the sound a little bit. Some of these worlds as you're exploring them you will come across things, and so there might be alien artifacts or things that you can kind of scan into a UFO.
So there's a whole kind of aspect of exploring this vast world, and the fact that we can generate an infinity of these worlds kind of means that you never run out of things to

explore. A lot of these planets are going to be entire civilizations that other players have created that are brought down to your computer as copies. And so as you play the game, it's keeping track of not just the creatures that you've designed, but entire planets. You can sculpt entire plants once you get to this level with UFOs.
So here's another world. This has actually got civilization on it. And this world is orbiting this gas giant, it's actually kind of a moon around this gas giant here. And this was created by another player. But it's asynchronous. In other words, the other player's not online right now. What happened is, the computer's observed the way the other player played this. They might have played this as a very peaceful race, or trading people, or explorers, and the computer tries to stay fairly consistent with the way that player has basically programmed their behavior. So we're going to go up--
Do your impacts on that planet register on it permanently, I mean will they be there for the player when that player returns?
Well, one of the points of this is that we want every player to be able to be a hero in their own universe. And so I want to be able to to whatever I want to do on this planet without ruining that player's experience. So this is where it's asynchronous, and this is why I'm playing with a copy. But at the same time, the other player's going to get a report of how many people came in and trashed his world, or made alliances with it, or whatever. So you get reports back from what we call the metaverse, which is all the parallel universes that people have played this game in.
So these guys are kind of wondering why we're here. At this point I might try maybe firing some fireworks. Okay, they liked that. I keep impressing them. Now the relationships I can develop with thiese other races go a number of different ways, we can be trading partners, we can end up forming an alliance or federation, in this case they've decided to worship us, so...as gods.
How tiring.
So we might pick one of them up and bring them with us.
Oh, okay, so they didn't like that. That was bad.
That's how we treat friends.
But I have weapons, somewhere here. Oh here we go. Yes, I'd like to shoot back at these. So I basically inadvertently sparked an interplanetary war here. Kind of a major oops.
There's Americans doing that all the time.
Yeah, that's about right.
Just keep your hands to yourself.
No comment there. Okay, I've basically taken out their defenses and now I can do whatever I want with them, but at this point I should probably run.
Just blow them up.
It was an accident, you know. Actually, one thing that we found is that the terraformig tools--
The intelligence was wrong.
Yeah. That's right. I can erase the evidence just by bringing a few comets down. This is actually terraforming tools that we use to bring oceans to a planet, if I drop enough comets on here, the ocean levels will start rising here. And I can eventually erase what I've done, hopefully. So this is the global warming fast forward version. You can pretty much recreate-- so here we are. Okay, that should do it. All right. Now, we don't know if this is the home world of this species or just a colony. Okay, so they're upset. Okay,

sorry. It was all an accident. As we pull away from this, we're getting another message on our com screen. Oh, okay so we just started a war, and in fact, that was just one of the colonies, so now we have to head home to defend our home world.

So this region of space we're looking at here represents several thousand stars, you know, that the player can explore, many of which are player generated, many of which are computer generated, but even this represents just a very small fraction of the entire world that the player can actually play in. We're actually dealing with several million worlds that are all unique. And the only way that can actually happen is the fact that the world the fact that his galaxy is continually being created by the collected efforts of a million players as they play. And underneath all of that is the power of these generative systems, and giving the players that kind of amplification through these editors, that those generative systems provide. So that's the Spore demo.

Fantastic.

Thanks. So I think we're right on time for the Q and A stuff.