Counter Intelligence
& Kitchen Sync

White Paper

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Table of Contents

Introduction........................................................................................................................................ 3
Primary Stage Devices: No Communication.........................................................................................
Secondary Stage Devices: Self Identity.................................................................................................
Third Stage Devices: Memory............................................................................................................... 5
Past Projects.......................................................................................................................................... 7
PC Inners MicroChef.............................................................................................................................
Mr. Java................................................................................................................................................ 7
Current Projects..................................................................................................................................... 9
Counter Intelligence............................................................................................................................... 9
Future Projects......................................................................................................................................... 11
CoolIO The ridge...................................................................................................................................... 11
Kitchen Sink.......................................................................................................................................... 1
Other Projects......................................................................................................................................... 1
Scenario Chocolate Cake......................................................................................................................... 1
Theory and Concepts............................................................................................................................... 1
Cloud Of Bits.......................................................................................................................................... 1
Context.................................................................................................................................................. 1
Recognise................................................................................................................................................ 1
Associate................................................................................................................................................ 1
Conclusions.............................................................................................................................................. 22
Credits & Acknowledgements................................................................................................................ 23
Introduction

This paper presents a vision of a future. In the last two decades a great deal of time and research has been spent on Living room of the Future projects. These usually meant big screen televisions, quadraphonic sound and strategically placed sofas. The problem with the living room is that it's a passive environment; the user sits and absorbs be it reading the newspaper or watching television. Compare this to the fundamentally interactive kitchen.

The kitchen is an intrinsically dynamic environment. Raw materials enter, are processed and leave. The user of the kitchen invariably contributes to that processing, whether it be putting a pre-frozen lasagna in the microwave or meticulously leafing through The Joy of Cooking for a four-course dinner. As the two-way conversation of the Internet is to the one-sided oratory of television, Kitchen Sync is to the Living room of the future.

Kitchen Sync is a digitally connected, self-aware kitchen which has knowledge and memory of its activities. It is a multifaceted system, consisting of both intelligent individual elements and fundamentally connectivity between those elements. In practice, we are building individual components while maintaining design philosophies that encourage inter-unit communication. Within the Personal Information Architecture group, we are also building an infrastructure specifically designed to enable communication between such elements.1

1 More information available from the leader of the project, Matthew Gray (mkgray@mit.edu)
We present here a basic overview of the three stages of devices which comprise Kitchen Sync. References to individual projects will be made clear as we go into more depth on the theories behind their operation.

**Primary Stage Devices: Self-Identity & No Communication**

At the lowest level of intelligent elements are devices which are only aware of themselves and do not communicate to the outside. One of the first realizations in working with Things That Think is that this is simply not interesting. With intelligence comes the need to communicate to move data in and out.

**Secondary Stage Devices: Self-Identity & Communication**

The first element of Kitchen Sync was a microwave, provisionally named PC Dinners and later renamed MicroChef. It embodied some of the basic ideas around which Kitchen Sync is based: identification and association of information with that identification. Later versions added more control over the actual use of the microwave including new functions correlating cooking time to weight, but the basic information/identification structure has remained unchanged.

Mr. Java is an exemplar of the second stage of Kitchen Sync. An intelligent coffee machine, it identifies the user through their cup and feeds the user the coffee they want and the information they want. For example, as an expatriate Englishman, I have a double tall latte and listen to the latest news from London.

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MicroChef as developed by Steve Gray (gray@mit.edu)
At the Media Lab, we refer to this in terms of bits and atoms. Mr. Java feeds the user the arrangement of bits and the arrangement of atoms they want. Atoms are things you can pick up, touch, manipulate. Its are information. A dog is an arrangement of atoms whereas the concept of a dog is an arrangement of bits. In this case, the arrangement of atoms is espresso or latte. Arrangements of bits can be the news from London or the local weather report or my personal stock portfolio.

Third Stage Devices: Memory

The third stage of Kitchen Sync has components that are not only self-aware but have some memory of their use. A Mr. Java coffee cup is tagged with a simple tag functioning similarly to a barcode. A given cup merely knows it is, say, object 1. A single step along is a coffee cup that knows when it was last used and will release this information when asked—perhaps by a coffee machine or a desk that wants to make sure your coffee doesn't get cold. Perhaps more useful is a fridge door that knows when it was last opened and if it's been closed since that point. The simple addition of memory adds a wealth of possibilities for an item.

One can also think of this third stage of having memory as being aware of temporal sequences. Mr. Java, a second stage device, functions in the instant when a cup is presented. He makes coffee and plays the news. Each cup is treated as a separate isolated incident unrelated to the one before it. Counter Intelligence, however, is aware of time and sequence. It's important to add the flour before putting on the icing for example.

We can continue along this trail. One project for the future is to produce a fridge which is aware of its contents and can take action based on that
areness. We envisage a fridge that is not only aware how much milk it contains but also orders more should that milk run out. Once a fridge or a cupboard, a pantry, a larder is completed Kitchen Sync will have reached a stage where there is a serious possibility of using the intelligent Kitchen on a day-to-day basis.

Eventually, we hope to assemble an entire intelligent kitchen environment and spend time working within the space and using the equipment on a day-to-day basis. In the long term, of course, we hope to see Kitchen Sync projects being used in commercial and residential kitchens.
Past Projects

PC Dinners / MicroChef

PC Dinners was the first Kitchen Sync project formed as a collaboration between myself and Steve Gray prior to conceiving an intelligent kitchen as a whole. In its simplest incarnation PC Dinners was a microwave with a barcode scanner controlled by a computer. It associated two sets of information with a barcode: cooking information and a sound file. They were tailored to the product so French toast asked you to "Please remove the toast from the packet and put it in the microwave, s'il vous plait." Frozen Danishes had the 'Danish Chef' saying something along the same lines with the addition of the occasional "bork bork bork."

Gray later added to the user interface providing the facility to change cooking times and store recommended times and also added a simple weight-scaling function. The project was renamed MicroChef.

Mr. Java

Mr. Java is an intelligent coffee machine. It's based on an Acorto automatic coffee machine which in its unaltered state makes a variety of hot coffee and milk-based drinks at the touch of a button. It interfaces with the diagnostic

More information is available in Gray's thesis
serial port, we were able to control Mr. Java by means of a tag reader placed under the spout.

The user places their cup under the spout as usual. The reader located under the spout reads the tag on the bottom of the cup and transmits the result to a computer. The computer could then issue commands to the Acorto to make the appropriate drink and play the associated RealAudio feed through the speakers.

Mr. Java does not gather information on individual users' coffee use although it provided that facility by letting users set their own URL for their audio feed which could let users keep track of their own consumption. However, we did keep track of overall consumption including dividing the data by day and by hour over time. For example, we saw a consistent daily pattern.

![Mr. Java - Purchase by hour of day](image)
Morning coffees peaked at 11am and another mid afternoon peak at 3pm. Barely visible at 9pm is our first espresso peak; apparently if you’re still drinking coffee at 9pm then it better be espresso.

This kind of information as of great interest to many sponsors: both Kraft Foods, owner of Maxwell House, and P&G, owner of Folgers, spend a great deal of time and effort tracking usage statistics such as these. Presently it’s entirely done by hand: someone sits next to the coffee machine with a clipboard. Mr. Java’s type of unobtrusive monitoring that can actually add value to the product being purchased has possibilities for a wide variety of applications.

Mr. Java has been a great success. EDS purchased an entire system for their Dallas MarketSpace of the Future and are presently considering assembling another ten systems for various offices and showrooms. Kyle Anderson, CEO of Acorto, sees Mr. Java as the missing element between a regular Acorto automatic espresso machine and the barista: it provides entertainment. A barista chats about the weather, tells jokes; Mr. Java adds back that functionality. There are currently plans to exhibit a Mr. Java in Acorto’s main lobby.

Current Projects

Counter Intelligence

The kitchen counter is one of the most used portions of the kitchen or space is invariably prime real estate in food preparation. A wide variety of tools are used in conjunction with the counterspace in any food preparation: weighing scales measuring cups, bowls, spoons and importantly ingredients. Counter Intelligence tries to integrate itself into your...
or habits by serving as an interface between you, the recipe, and the food being prepared.

Can a kitchen help you make brownies? You pull out the cookbook and start measuring ingredients into a bowl. Out of baking powder. Well you remember you can use baking soda, but do you double or half the quantity? Oops. Just put the eggs in before the milk. One doesn't matter whether they're listed in that order in the recipe if it doesn't. If you use semi-sweet chips instead of dark chocolate, how do you adjust the sugar? Can't see how much butter to add. That dark chocolate from last time got on the page.

Counter Intelligence takes away these problems. It's fully aware of a recipe: the sequence, the ingredients, possible substitutions. We're in the process of building it as a fully expandable system, enabling us to modify the user interface as we learn more. The current extremely prototype system uses a barcode scanner, a scale, and a keyboard for input, and a standard screen for output. It knows a handful of recipes and can suggest substitutions for one or two products and has a text-based interface.

Since writing this, Counter Intelligence has been changed to include a proprietary RFID sensing system in the place of barcodes and a touch screen for input and output. It is incorporated in a kitchen counter. We expect to add voice input and output in the near future.
We envisage a system almost entirely integrated into a standard space area. A scale built into the counter along with an RFID tag reader lets you identify and tare mixing bowls whereas other tag readers barcode readers or LazyFish could identify ingredients. A LazyFish could let you select ingredients and finished products by tapping their picture on the surface with the entire recipe becoming an interactive experience. Perhaps instead of a line of text saying “Mix in two cups of flour” Counter Intelligence will have a pair of elves projected on your counter apparently tugging at your real bag of flour.

The possibilities of Counter Intelligence are practically endless. We are consciously not predicting an exact path of evolution for this project or exact technologies to work with. By letting it evolve with the technology and change as possibilities arise we’re free to create and invent entirely new concepts of kitchen interaction without being locked into an obsolete model.

**Future Projects**

**CoolIO: The Fridge**

The concept of an intelligent fridge CoolIO is one that seems fundamental to the intelligent kitchen. We see a fridge as performing the following functions:

- Keeping track of its contents
  - Location in fridge
  - Date entered fridge
  - Expiration dates

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Magnetic field sensing devices.

• Keeping track of desired contents
  • Keeping at least one gallon of milk not more than two days old on hand at all times
  • Automatic shopping list generation or online ordering to replace staple items

An intelligent freezer could perform many of the same functions but could perhaps be easier to prototype as objects that go in or out of a freezer are generally either in Tupperware type packaging or in their original packaging.

We see the development of CoolIO or a similar intelligent fridge as a fundamental part of the Kitchen Sync vision.

Everything Bit: The Kitchen Sink

In an interconnected kitchen even disposal units are part of a communications network that keeps track of comings & goings. We see the sink in such a kitchen at a minimum having a tag reader to read tags from reusable containers beingashed Tupperware and the like.

Envision the following scenario. You've had lasagna for dinner and there's some left over. You put the leftovers in a Tupperware container and put it in the fridge. Is that lasagna as the fridge it remembers you made that for dinner. You confirm. Later on feeling peckish you pull out the leftovers and take half for a snack putting the Tupperware back in. CoolIO remembers that as in that tagged container and so assumes it still contains lasagna. Hungry again you pull out the remainder and eat it for lunch the next day.
You put the dirty container into Everything Bit, and wash off the food. As you do that, the tag reader reads the tag and washes off the data, labeling it as empty. Every time you use that container, the fridge will ask you what’s in it.

**Other Projects**

We see all kitchen appliances as having the facility to be integrated into the Kitchen Sync environment. Cameras above stoves can ensure that a tagged pot never boils over. Tagged Tupperware can work in conjunction with your sink so it knows when it’s dirty, when it’s clean, and what it’s got in it. Dishwashers know what they have inside and when what’s inside needs to be clean. Trash cans sort recyclables and when they’re full.

However, much of this level of automation is only possible when the entire kitchen as a whole is aware. The above projects, particularly Counter Intelligence and CoolIO, present fundamental portions of the Kitchen Sync vision. Much of the brainstorming to create these ideas has been through the establishment of scenarios: given a situation, what could Kitchen Sync do to help you?

We present an example and encourage readers of this paper to do so within their particular fields of interest.
Scenario Chocolate Cake

Kitchen, you announce, bringing Kitchen Sync out of its sleep. I'd like to make a chocolate cake for dessert tonight.

I'm afraid we're out of butter; the delivery was delayed. We can substitute olive oil though you liked that last time.

The sounds of John Coltrane fill the air as you assemble the ingredients list projected on the wall with the Kitchen only occasionally advising you on where you last put the baking powder. You put a mixing bowl down on the counter and look at the wall. The recipe is replaced with a grinning foot-high character in a tall cook's hat who points at the flour. You pick it up.

Four cups of flour. You start pouring.

One cup... two... three... three and half... and stop.

You put the flour back on the counter.

You can put that away now. You won't be needing it. And it'll make the place tidy.

Guess you accidentally engaged the “Mother” mode. Still, you continue with the rest of the recipe mixing and stirring. The Kitchen reminds you of the substitution and suggests you use low-fat chocolate—a suggestion you cheerfully ignore despite a twinge of guilt as it updates the calorie count at the bottom of the page. It's only a matter of sliding the cake into the preheated oven and waiting until the Kitchen reminds you to take it out. And if you're in the shower when that happens, you need not worry: your Kitchen will remember to turn the oven off even if you don't.
Theory and Concepts

Cloud Of Bits

We’ve discovered a lot of ways to look at human computer interaction and the very concept of data in the process of working with Mr. Java and Kitchen Sync. The first is a common enough realization at the Media Lab that we exist in a cloud of bits a set of information about your current condition. Today we mainly think of bits as perhaps graphics webpages QuickTime movies. In Personal Information Architecture we go beyond this definition and see bits as a spectrum ranging from the fixed and quantifiable to the fuzzy and intangible.

For example I am six foot two inches tall. That’s a constant and relatively unchanging bit. Continuing along our spectrum of bits I have a body temperature pulse and blood pressure that are measurable and recordable using a variety of sensors. Nearer the other end of the spectrum I may be hungry or want a particular kind of coffee today. These are far less fixed and easy to measure hunger is a function of blood sugar but goes unnoticed with sufficient levels of adrenaline in the bloodstream.

Context

In our initial design for Mr. Java we had thought about a number of ways to recognize users of the machine. One possibility for example as I transmitting badges previously used on the Penguin emo to great success. Stuffed penguins ore nametags that emitted a constant infra red signature saying in effect I’m Irv. I’m Irv. When Mort the other
penguin received this Mort and Irv would have a conversation as they were facing each other.

The problem with this is that there's no implicit context. We wanted to avoid the problem of a coffee machine that spewed out espresso whenever you walked through the 3rd floor kitchen. In the plans for Kitchen Sync there are many tag readers and ways to identify objects: it's important to know the context in which this is happening.

Another way to think about the importance of context is in thinking about sharing bits. Unless you know what you're looking for, it's hard to figure out whether the stream of information you're looking at is biometric data from a human being on a bicycle, weather data from a probe at Base Camp on Everest, or an I Love Lucy rerun. "Bits be bits." Once bits leave their creating environment it's important to ensure that they're implicitly and unambiguously labeled.

Recognise

Humans recognise objects through their senses: vision, touch, smell, and so on. Rather than have computers try to use the same senses to identify objects, an area in which there is already extensive research, we elected to use sensors developed specifically for computers. There are a number of systems in current use designed so computers can identify objects.

• Barcodes

Barcode technology has a number of advantages: it's cheap and it's widely available. Commercial products frequently come with barcodes.
enabling easy recognition.

However, there are problems with current barcodes as implemented in the UPC standard - that is to say, the labels on nearly every product you buy at the grocery store. They don't distinguish between different iterations of the same product – one can of tomatoes looks like another can of tomatoes. That's fine at the checkout, but difficult if you're trying to tell how many cans you have in your larder. If you're trying to keep track of how old milk is for example, it's important to be able to distinguish between two cartons of milk that have the same barcode but were purchased a few weeks apart.

One possibility would be for every PC code to have two separate parts: an identification portion and a serial number portion. For example, a particular bottle of apple juice currently has the barcode 2-26284-17513. 2-26284 refers to the company who makes the product, as assigned by the UPC council. 17513 is the company's code for “8 fl. oz. bottle Pressed Apple Juice.” Expanding this to include a serial number - thus, say, 226284-17513.0170222 - would enable tracking of that particular bottle's history, including storage, sale, and environmental conditions during shipping.

The most important change in barcodes will come when barcodes are no longer seen as identifying objects in themselves but as links to information. There is a practical limit on the quantity of information that can reliably be stored in a physical label space; there is no limit to the amount of information that can be linked to that label.

There's also a twelfth number in small print: that's the checksum for the reader to make sure it read correctly.
The next step will come when you purchase a product which has its own individual webpage. A can of beans will come with its own individual webpage detailing such information as production date, transport history and time spent on the shelf all entered automatically as it moves along the retail chain. Two apparently identical packets of rice you purchased on two trips to the supermarket can have entirely different histories of transport, storage and origin. This incredible quantity of information will begin to appear for high end items a web-accessible history of your car, say, but as time goes on will continue down the value chain.

- **RFID**

Radio Frequency Identification has the potential to be one of the most widely used and powerful identifying technologies we have. Tags can be battery powered or unpowered and can be purchased in a variety of sizes and configurations to allow for a wide range of uses. In particular they work through plastic, wood and other materials and can be set up to work in harsh environmental conditions where barcodes or less robust equipment would be unable to function. Our classic example of this is under the spout of Mr. Java where a polyurethane encased reader is regularly subjected to °C espresso. The kitchen is no place for fragile technology.

There are a wide variety of RFID tags. The simplest work in much the same way a barcode does giving out a single pre-programmed number then placed in the vicinity of a reader. It's also possible to store a limited amount of information on the tags themselves.
The main argument against tags right now is that of cost. Compared to a printed barcode, the cost is presently prohibitive except in harsher environments unsuited to barcodes. However, researchers at the Media Lab including Rich Fletcher and the recently formed Penny Tags special interest group are making great headway in this problem. Currently, a simple tag has a lower price limit of approximately ten cents too much to put on a packet of cornflakes, but an entirely reasonable way to track the history of a jacket. A tagged world will arrive, one bit at a time.

• Biometrics

Biometrics is the term used for identification of people by their physical attributes such as fingerprint recognition, face recognition, and the like. Much research is being done on their possibilities for security identification and the like. However, many people feel very uncomfortable about being identified in this way. We have made a conscious decision to avoid working with biometrics in Kitchen Sync as much as possible. Nothing says Big Brother quite like the phrase "fingerprint identification," except perhaps "retinal scan." There is a regretful tradition among scientists of ignoring such sociological issues with regards to new technology. We feel it is better to look for alternative forms of recognition technology rather than ignore this discomfort and the very serious issues behind it. For example, Mr. Java

http://www.media.mit.edu/physics/tags/tags.html
functions in a security and privacy conscious manner. No individual usage data is kept while providing the possibility for users to keep track of their own coffee consumption.

- IR tags

Infrared technology works in an intuitive way. If the transmitter say your remote control can't see the eye of the receiver say your TV it won't work. We call this line of sight. It has drawbacks: constant broadcasting is expensive in terms of power. However remote control type intermittent transmit devices are cheap and powerful. Only in line of sight can be frustrating as anyone who's tried to change channels from off to one side of the television knows. This can be a feature: a computer that doesn't see an object until you hold it up front of it makes sense to the user and is a simple way to download data.

The point of all of these different methods of identification is that there are a plethora of technologies with a variety of attributes that can be adapted to nearly any use. Encoding of information is not a single choice arena and includes ones that I didn't mention from magnetic strips on cards to touch recognition technologies. In considering any technology design it is important to take into account the wide variety of methods in which relevant data can be encoded.

Associate

The next step after identification is associating preferences with the object identified be it person cup clothing or penguin. These preferences fall into two categories bits and atoms. This is an important distinction in defining hat
e re loo ing to do in Kitchen Sync. Loo ing bac at hat as seen as a itchen of the future in the si ties through the eyes of the Jetsons e see a itchen concerned ith manipulating atoms mechanical hands come out holding frying pans into hich other mechanical hands crac eggs. We re not trying to deal ith manipulating atoms e re interested in bits.

Mr. Java for e ample associates t o sets of information ith each tag ith each individual s cup. One set is ho they li e their bits arranged and the other set is ho they li e their atoms arranged. Arrangements of bits refers to for e ample the latest ne s from P or the current earther report or the sports scores. Mr. Java goes out across the eb and pic s up the ealAudio feed of your choice and plays it hile your coffee is being made. Importantly e ve provided the facility for users to create their o n ealAudio or .au files by lin ing to a L hich could contain their o n personali ed stoc portfolio or their messages. This also provides them ith the means to trac their personal coffee consumption ithout Mr. Java storing such personal individual data.

This concept of preferences for bits and atoms is a po erful concept that can be e tended far outside the realm of the itchen. A car could recognise you through your ey or ey fob and ad ust the seats and mirrors atoms and the radio bits to your preferences. A ashing machine could recognise clothing going in through fle ibe I tags and no you might not li e your red T shirt in ith your other ise hite ash. All of these are e amples of simple but po erful operating concept

Within a conte t recognise and associate preferences.
Conclusions

The field of domestic media is one that will truly come to fruition in the next decade. We currently have use of barcode and RFID technology almost entirely in industrial and commercial settings. As with the computer, the pager and the microwave, we can expect this technology to start to be integrated into home life.

We’re frequently asked how long it will be until we see Kitchen Sync technology entering the marketplace. Different pieces of technology will no doubt take different periods of time to really become useful. Mr. Java is currently starting to move into the marketplace with the help of generous support and interest from S and Acorc. MicroChef / PC inner technology is already arriving in the home in a variety of forms notably in the Japanese market. Longer-term projects include Counter Intelligence and CoolIO which currently appear to be in the ten-year range as they require greater investment in an infrastructure and information base. Others will be affected by the degree of growth of shop-from-home services such as Peapod.

We are currently at the Model T stage of computers. The Model T is still not seventy years later for being available in any colour you wanted so long as it was black. Computers are currently available in any size you want so long as they’re a box. You can buy boxes that sit under your table on your table in your bag or in your pocket but they’re all boxes.

Kitchen Sync is one example of technology designed to not be a box but instead be a coffee cup, a counter, a toy. A vast quantity of research at the Media Lab is engaged in making non-box computers. Kitchen Sync and the Counter Intelligence SIG show an extremely exciting and viable area of research in this
arena with a great number of both commercial and research possibilities.
Credits & Acknowledgements

Photos

PC Dinners, pg. 7
Mr. Java, pg. 8
Mr. Java by Hour pg. 8
Counter Intelligence pg. 9
Mort & Irv pg. 1
Barcode pg. 17
Fingerprint pg. 19
IR Badge pg.
osie Jetson pg. 1

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