Internet of Things

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FACULTY

Dr. R. A. ROSELINE M.Sc., M.Phil., Ph.D.,
Associate Professor and Head,
Post Graduate Department of Computer Applications,
Government Arts College (Autonomous),
Coimbatore – 641 018.

UNIT - IV

INTEGRATED APPLICATIONS

BUSINESS MODELS

NETWORK DYNAMICS

UNIT-IV

INTEGRATED APPLICATIONS

Integrated Billing solutions in the IoT:

Billing in the IoT era

Accounting and billing have traditionally been specialty areas with standalone management systems. However, modern billing systems need to be well integrated with all aspects of the businesses they serve in order to capitalize on the IoT. These systems also require the capability to accommodate increasingly complex business models and pricing structures.

For years, it was simple and linear: a buyer would purchase a product or service from a seller with a one-time transaction, and the process was complete until the next time that customer needed to make a purchase.

This way of conducting business will soon be a thing of the past. In fact, it already is for many businesses that understand the new requirements to compete in this subscription-based, customer-driven marketplace. While the IoT presents some complications for billing, the opportunities it creates are even greater.

Simplification of IoT billing is a strategic business necessity

The right technologies and partnerships will enable businesses to:

quickly and accurately gather and analyze their data alter and add to their billing processes as necessary act on all of the resulting intelligence to manage their customer journeys and capitalize on the IoT adapt, grow, and increase their competitive advantages, despite changes in the market The solution to IoT billing challenges comes down to implementing a modern billing system that facilitates the ease of data exchange between varied technology and business components, in alignment with holistic business requirements.

IoT Business Models:

Old business models

The basic business models that currently exist in the IoT and IIoT space are:

1. **Retail sales :** Equipment or device manufacturer expends its own money or raises financing to build products which are then sold to customers. The equipment or device manufacturer only captures value during that one transaction, the expectation is that there

is a positive margin between revenue and expenses and that customers will buy more of the same product or other products.

2. **Product lease/Subscription :** Instead of selling the machine/device, the vendor leases the product to the customer.

New models

It's imperative that new businesses and startups should explore new models for value creation and capture. The new business models will stem from the increased interactions afforded by IoT and IIoT (Industrial IoT) devices.

Capturing value from human factors, analysis and machine interaction

An example will best serve here. Some business models can lie at the intersection of the 03 elements above.

There is a business model where a customer pays for insights drawn from the interactions. In the case of Proxxi the device keeps the technician safe by alerting him/her and the control room when unsafe conditions are detected.

The main business Models

There are 5 main business models enabled by IoT between the IoT company and the customer

IoT Business Model #1: Subscription Model

Since IoT products have 24/7 connection to your customer, you can leverage that connectivity to develop a recurring-revenue business model. Now instead of having a one-time sale, you can offer a subscription model in which your customer pays a fee in return for continuous value.

A subscription model enables your IoT product to implement many of the benefits available to software-only products. Basically, you are introducing an "as a Service" business model for a system that includes both software and hardware.

By using SaaS models as a reference for your IoT business model, you can explore creative ways to monetize your product, not only with a monthly subscription, but also by providing paid upgrades or even implementing a "freemium" model, if your strategy supports it.

Another benefit of this IoT business model is that it empowers your company to foster an active relationship with your customer. In the past, hardware manufacturers used to "throw their products over a wall", meaning that once they completed the sale, they rarely interacted with their customer again.

IoT products break down that barrier. As your device gathers more data in your customer's surroundings, you will be able to learn more about your customer and provide more valuable features tailored to their specific needs.

Some common IoT applications using the subscription model include "monitoring as a service" and "predictive maintenance as a service".

IoT Business Model #2: Outcome-Based Model

The outcome-based IoT business model is an example of an innovative approach enabled by IoT products. The idea is for customers to pay for the outcome (or benefit) the product provides, as opposed to the product itself.

Remember the saying, "People don't buy drills, they buy holes?" Well, the outcome-based model works in the same way. Customers pay for the "holes," as opposed to paying for the drill.

For example, think of a water pump manufacturer. In the past, their business revolved around selling pumps, and they measured success by meeting quota on a certain number of pumps per quarter.

But let's be real. Customers are not looking to buy a pump. They are looking to move water from point A to point B for some purpose. They need water to cool another system, to water plants, or to power a generator. Moving water from point A to point B is the real need of this customer.

Imagine a sophisticated pump manufacturer who creates a next-generation pump that monitors the amount of water it pumps. The manufacturer can now talk to the customer in the language they care about: the amount of water pumped (similar to "holes drilled"). In this case, the customer is not buying a pump. Instead, they are paying a variable fee per month for the amount of water they source. They are paying for the outcome, which is water sourced.

Your company can be creative when implementing an outcome-based IoT business model. For example, you (the manufacturer) can decide whether you'll lease or sell the pumps. If the customer is interested in the outcome (water sourced), then they might not want to have a depreciating asset (the pump) on their balance sheet. Therefore, having them pay for the water sourced, as opposed to paying for the pump itself can reduce the customer's objection to buying expensive equipment.

IoT Business Model #3: Asset-Sharing Model

A big concern when buying expensive equipment is whether the customer will be able to utilize the equipment to its maximum capacity. This is where the idea of sharing assets comes into play.

We are starting to see this IoT business model already with car-sharing or bike-sharing companies. Think about it like this: why do I need to pay for the full price of a car if it's going to be parked outside my house 90% of the time. Could I just pay for the amount of car I use?

IoT has the potential to solve this problem, and we are already starting to see solutions with self-driving cars, virtual power plants, shared drones, etc.

This IoT business model revolves around selling your extra capacity back into the market. The goal is to maximize the utilization of your IoT product across multiple customers. That way, each customer pays a reduced price and you are able to get faster market penetration, compared to when a single customer has to pay for your complete product.

I had the opportunity to work within this model, deploying smart batteries for commercial buildings at Stem, Inc. The batteries provided energy to the building, and if there was extra capacity, we sold that energy back to the Grid.

In this IoT business model, the batteries are a shared asset between the building and the Electric Grid. This approach allowed our customers to get our systems at a reduced price since they didn't have to carry the burden of paying for the whole system, whether they use the extra capacity or not.

You might be thinking, "Why not just install a smaller battery?" That's a fair question. Sometimes, they don't make smaller batteries (or smaller pumps, or turbines, etc.). Most of these systems are very complex, so you can't get custom sizes. You can either throw away that extra capacity or figure out a way to monetize it. That's where the intelligence built into IoT products can help you.

IoT Business Model #4: The "Razor Blade" Model

Your IoT product can be designed for selling other products. In this model, you might sell the IoT product at cost or even at a loss since the goal is to get the product in the customer’s hands, so you can start selling your other products. This business model is sometimes called the “Razor Blade” model, where the goal is to sell more and more disposable razors, and therefore, the razor handle is usually sold at cost or even given away for free.

This business model can be very lucrative for products that have consumables needing constant replacement. For these types of products, it is very important that the customer never run out of the consumable. Otherwise, the product loses its value proposition.

You see, the challenge for manufacturers of these products is that there might be a gap between when the consumable runs out and when the customer reorders it. Sometimes that gap becomes permanent, and the customer never buys again. But what if the product itself could reorder its consumables whenever it needs them?

That would provide value for the customer AND for the vendor. Therefore, the goal of this IoT business model is to turn a “normal” product into an IoT product to automatically reorder its consumable before it runs out.

IoT Business Model #5: Monetize Your IoT Data

The value of the Internet of Things is in the insights you can derive from the data you collect. The question is, who benefits from those insights?

Think about companies like LinkedIn or Facebook. They collect a huge amount of data from all of us (often for free) and although they provide us (the user) with value for providing that data, the real value is provided to advertisers and other third party companies that use the data to promote their products and services.

In this case, LinkedIn or Facebook are tools for collecting data to offer it to advertisers. That’s how they make money.

The same business model works in IoT. You can build your product to provide value to the end user and also to collect valuable data you can then sell to a third party. In this approach, you can offer your IoT device at no cost to eliminate the buying friction for the end user. The goal is to deploy as many devices as possible to collect data. You are looking to build a network effect. The more devices you have out there, the more attractive your data proposition will become to third parties.

There are many examples of products leveraging this IoT business model. Think of energy efficiency devices installed in buildings to monitor their energy consumption. The building manager benefits from this data, but utilities or other aggregators can pay a hefty sum to receive aggregated data from thousands of buildings.

The same is true with devices that monitor your driving habits. They provide you with some interesting insights, but insurance companies get the most value, as they are able to understand driving patterns for thousands of people.

This model can be a line extension of your core business, meaning you can start by solving the needs of your end user, and later you can decide to branch out into monetizing their data. These two models don't conflict with each other as long as you make your customers aware of how their data will be used and make sure to safeguard their privacy.

Keep in mind that sharing aggregated data with other companies is not just an add-on to your existing IoT solution. It's a full product that requires understanding your third party users, assessing the impact on your infrastructure, etc. I recommend using the IoT Decision Framework to see how this new functionality will impact your existing product.

By the way, if you plan to open APIs for your customers to access data, then it's important that you think of that API as its own product and ensure you'll provide a good developer experience.

IoT Business Model #6: Pay-Per-Usage

Having sensors on your hardware device means you can monitor your customer's environment and how much they use your product. This opens the door to an innovative IoT business model where you charge your customer for the amount of time they are actively interacting with your product.

In this IoT business model, the goal is not to make money on the device itself. Instead, you are using the data produced by the IoT device to track usage.

Here's a good example of this IoT business model: Metromile—Pay-per-mile insurance

Metromile is a San Francisco-based insurance company. Their goal was to create an innovative pricing structure for their car insurance product while solving the challenge of San Francisco residents who don't use their car very often. The solution was to create an IoT product that tracks how much people use their car.

Using this data, they can calculate risk and therefore provide a per-mile price for the insurance. Notice that in this example, the customer is not paying for the usage of the IoT product itself (an ODBC adapter). Instead, customers pay for the usage of the device monitored by the IoT product (the car).

IoT Business Model #7: Offer a Service

You can use an IoT product to offer a new service (or enhance an existing service) to your customers. In this case, I'm not talking about an "as a service" type model. Here, I explicitly mean providing a service, with real people involved.

Population Models:

Information Cascade:

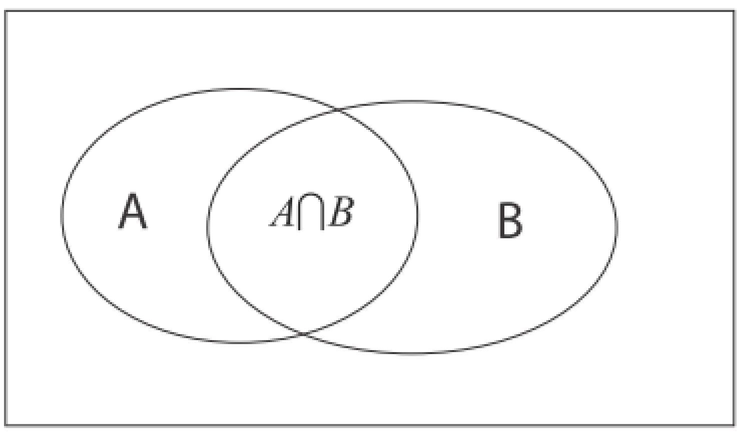
- It could be rational to do so:
    - You pick some restaurant A in an unfamiliar part of town
    - Nobody there, but many others sitting at a restaurant B
    - Maybe they have more information than you!
    - You join them regardless of your own private information
- This is called *herding*, or an *information cascade*

Herding:

- There is a decision to be made
- People make the decision sequentially
- Each person has some private information that helps guide the decision
- You can‘t directly observe the private information of others
    - Can make inferences about their private information

Modeling information cascades

- Pr[A] where A is some event
- „*What is the probability this is the better restaurant?*“
- Pr[A | B] where A and B are events
- „*What is the probability this is the better restaurant, given the reviews I read?*“
- Probability of A *given* B.



- *Def:* $$\Pr[A \mid B] = \frac{\Pr[A \cap B]}{\Pr[B]}$$

$$\Pr[B \mid A] = \frac{\Pr[B \cap A]}{\Pr[A]} = \frac{\Pr[A \cap B]}{\Pr[A]}$$

- So

$$\Pr[A \mid B] \cdot \Pr[B] = \Pr[A \cap B] = \Pr[B \mid A] \cdot \Pr[A]$$

$$\Pr[A \mid B] = \frac{\Pr[A] \cdot \Pr[B \mid A]}{\Pr[B]}$$

Notation:

- P[A] = *prior* probability of A
- P[A | B] = *posterior* probability of A given B
- Using Bayes‘ rule
  - Applies when assessing the probability that a particular choice is the best one, ***given*** the event that we received certain private information

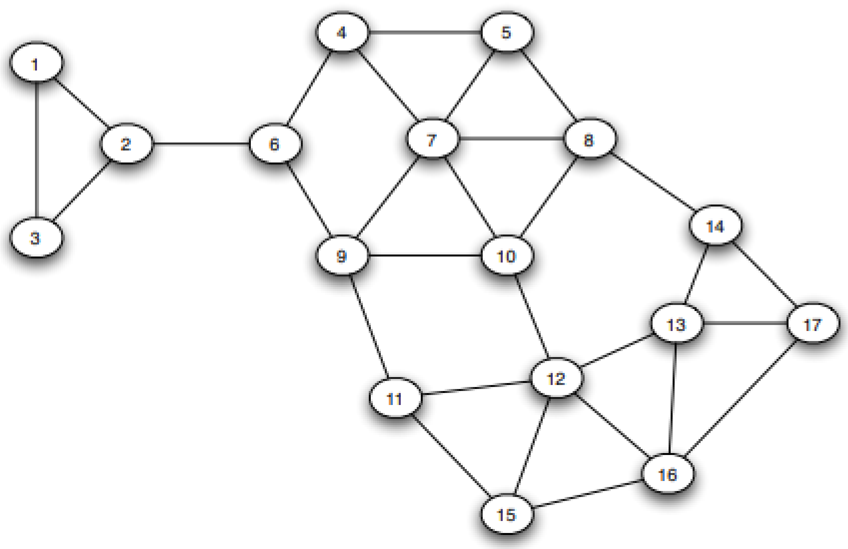
Structural Model:

Cascading Behaviour

Cascading Behavior. In any network, there are two obvious equilibria to this networkwide coordination game: one in which everyone adopts A, and another in which everyone adopts B. Guided by diffusion questions, we want to understand how easy it is, in a given situation, to “tip” the network from one of these equilibria to the other. We also want to understand what other “intermediate” equilibria look like — states of coexistence where A is adopted in some parts of the network and B is adopted in others. Specifically, we consider the following type of situation. Suppose that everyone in the network is initially using B as a default behavior. Then, a small set of “initial adopters” all decide to use A. We will assume that the initial adopters have switched to A for some reason outside the definition of the coordination game — they have somehow switched due to a belief in A’s superiority, rather than by following payoffs — but we’ll assume that all other nodes continue to evaluate their payoffs using the coordination game. Given the fact that the initial adopters are now using A, some of their neighbors may decide to switch to A as well, and then some of their neighbors might, and so forth, in a potentially cascading fashion. When does this result in every node in the entire network eventually switching over to A? And when this isn’t the result, what causes the spread of A to stop? Clearly the answer will depend on the network structure, the choice of initial adopters, and the value of the threshold q that nodes use for deciding whether to switch to A.

The above discussion describes the full model. An initial set of nodes adopts A while everyone else adopts B. Time then runs forward in unit steps; in each step, each node uses the threshold rule to decide whether to switch from B to A. 1 The process stops either when every node has switched to A, or when we reach a step where no node wants to switch, at which point things have stabilized on coexistence between A and B.

Let's consider an example of this process using the social network in below Figure



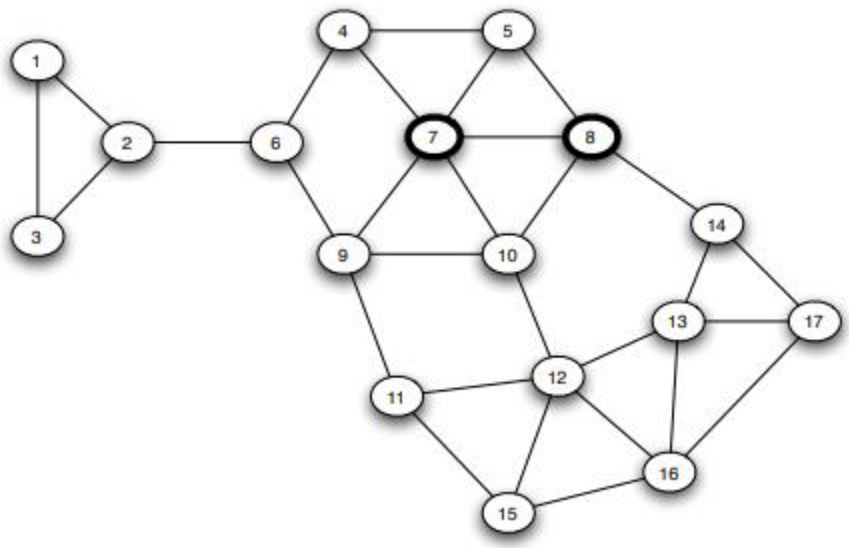
Suppose that the coordination game is set up so that a = 3 and b = 2; that is, the payoff to nodes interacting using behavior A is 3/2 times what it is with behavior B. Using the threshold formula, we see that nodes will switch from B to A if at least a q = 2/(3 + 2) = 2/5 fraction of their neighbors are using A.

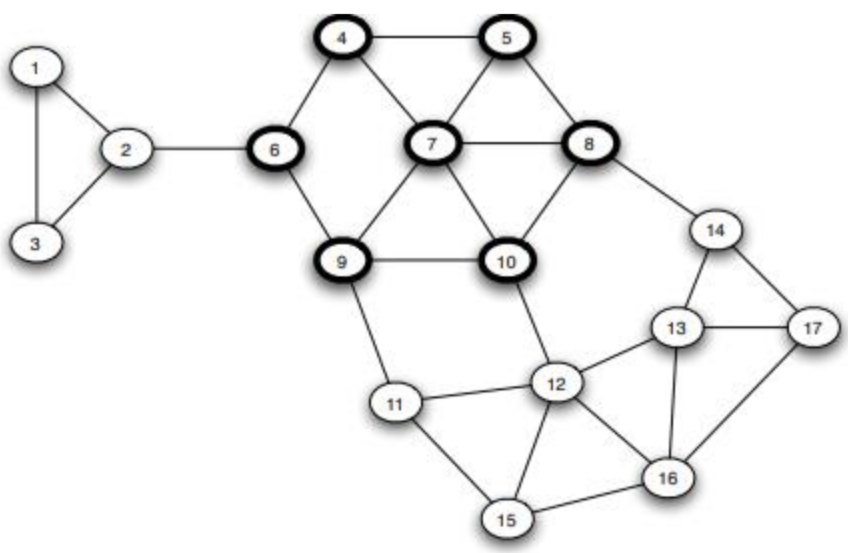
Now, suppose that nodes v and w form the set of initial adopters of behavior A, while everyone else uses B. Then after one step, in which each of the other nodes evaluates its behavior using the threshold rule, nodes r and t will switch to A: for each of them, 2/3 > 2/5 of their neighbors are now using A. Nodes s and u do not switch, on the other hand, because for each of them, only 1/3 < 2/5 of their neighbors are using A.

In the next step, however, nodes s and u each have 2/3 > 2/5 of their neighbors using A, and so they switch. The process now comes to an end, with everyone in the network using A.

Notice how the process really is a chain reaction: nodes v and w aren't able to get s and u to switch by themselves, but once they've converted r and t, this provides enough leverage. It's also instructive to consider an example in which the adoption of A continues for a while but then stops. Consider the social network in Figure 19.4, and again let's suppose that in the A-B coordination game, we have a = 3 and b = 2, leading to a threshold of q = 2/5. If we start from nodes 7 and 8 as initial adopters, then in the next three steps we will first see (respectively) nodes 5 and 10 switch to A, then nodes 4 and 9, and then node 6. At this point, no further nodes will be willing to switch, leading to the outcome in below Figure

We'll call this chain reaction of switches to A a cascade of adoptions of A, and we'd like to distinguish between two fundamental possibilities: (i) that the cascade runs for a while but stops while there are still nodes using B, or (ii) that there is a complete cascade, in which every node in the network switches to A. We introduce the following terminology for referring to the second possibility.

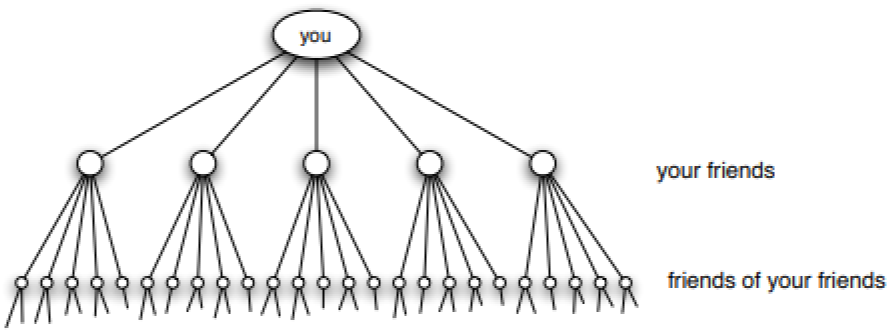




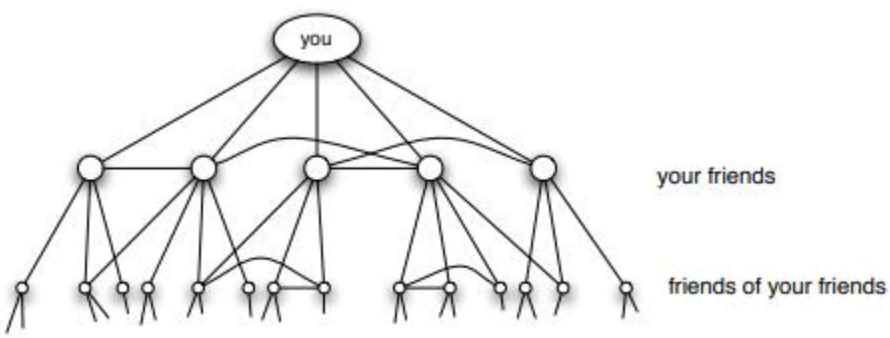
The Small world Phenomenon:

Structure and Randomness

Let's start with models for the existence of short paths: Should we be surprised by the fact that the paths between seemingly arbitrary pairs of people are so short? Figure 20.1(a) illustrates a basic argument suggesting that short paths are at least compatible with intuition. Suppose each of us knows more than 100 other people on a first-name basis (in fact, for most people, the number is significantly larger). Then, taking into account the fact that each of your friends has at least 100 friends other than you, you could in principle be two steps away from over 100 · 100 = 10, 000 people. Taking into account the 100 friends of these



(a) *Pure exponential growth produces a small world*



(b) *Triadic closure reduces the growth rate*

people brings us to more than 100 · 100 · 100 = 1, 000, 000 people who in principle could be three steps away. In other words, the numbers are growing by powers of 100 with each step, bringing us to 100 million after four steps, and 10 billion after five steps. There's nothing mathematically wrong with this reasoning, but it's not clear how much it tells us about real social networks. The difficulty already manifests itself with the second step, where we conclude that there may be more than 10, 000 people within two steps of you. As we've seen, social networks abound in triangles — sets of three people who mutually know each other — and in particular, many of your 100 friends will know each other. As a result, when we think about the nodes you can reach by following edges from your friends, many of these edges go from one friend to another, not to the rest of world, as illustrated schematically in Figure 20.1(b). The number 10, 000 came from assuming that each of your 100 friends was linked to 100 new people; and without this, the number of friends you could reach in two steps could be much smaller. So the effect of triadic closure in social networks works to limit the number of people you can reach by following short paths, as shown by the contrast between Figures (a) and (b). And, indeed, at an implicit level, this is a large part of what makes the small world phenomenon surprising to many people when they first hear it: the social network appears from the local perspective of any one individual to be highly clustered, not the kind of massively branching structure that would more obviously reach many nodes along very short paths.

THANK YOU

Study material for this course is taken from the Text Books and Reference Books, mentioned in the Syllabus.