Auto-ID

RESEARCH GROUP FOR

Distributed Systems

Exchanging Information and Products by Merging Bits and Atoms

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Overview

- Background
- MIT Auto-ID Center
- Requirements
- Modules
- ePC
- Tags & Reader
- PML
- ONS
- Savant

- Auto-ID infrastructure by example
- Auto-ID benefits by example – "The Beer Game"

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Background

- **University of St. Gallen (Prof. Fleisch) and ETH Zurich (Prof. Mattern) founded M-Lab in 2001**

- **Applied Research in Ubicomp with seven Partner Companies**

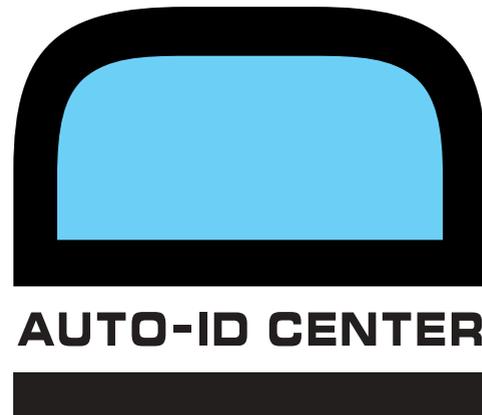- **From Business Idea to Prototype**

- **Also have Academic Partners**
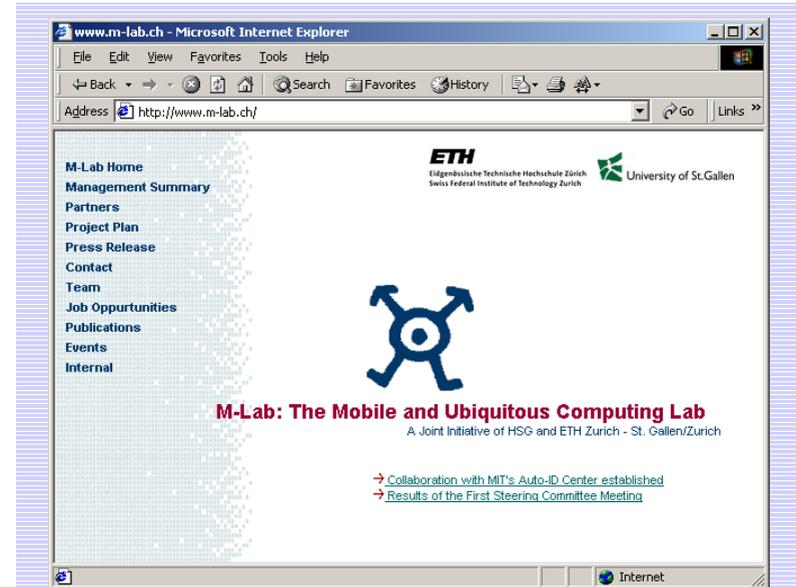
www.m-lab.ch

MIT Auto ID Center

- One important issue in Ubicomp and for companies: **Identification of products**

- 2. Part: Application Scenarios

- MIT and 46 partner companies founded the Auto-ID Center in 1999

- Idea: Connecting everything to the Internet

- Center provides necessary modules

AUTO-ID CENTER

Requirements & Goals

- **Identification and localization of products throughout supply chain**

- **No manual interaction**

- **Cheap, reliable, secure**

- **Wireless** transmission of identity

- **Association** with data on the web

- **Mapping** between identity and where to access data

- **Build on existing standards**
  - TCP/IP
  - XML
  - Hardware

Modules
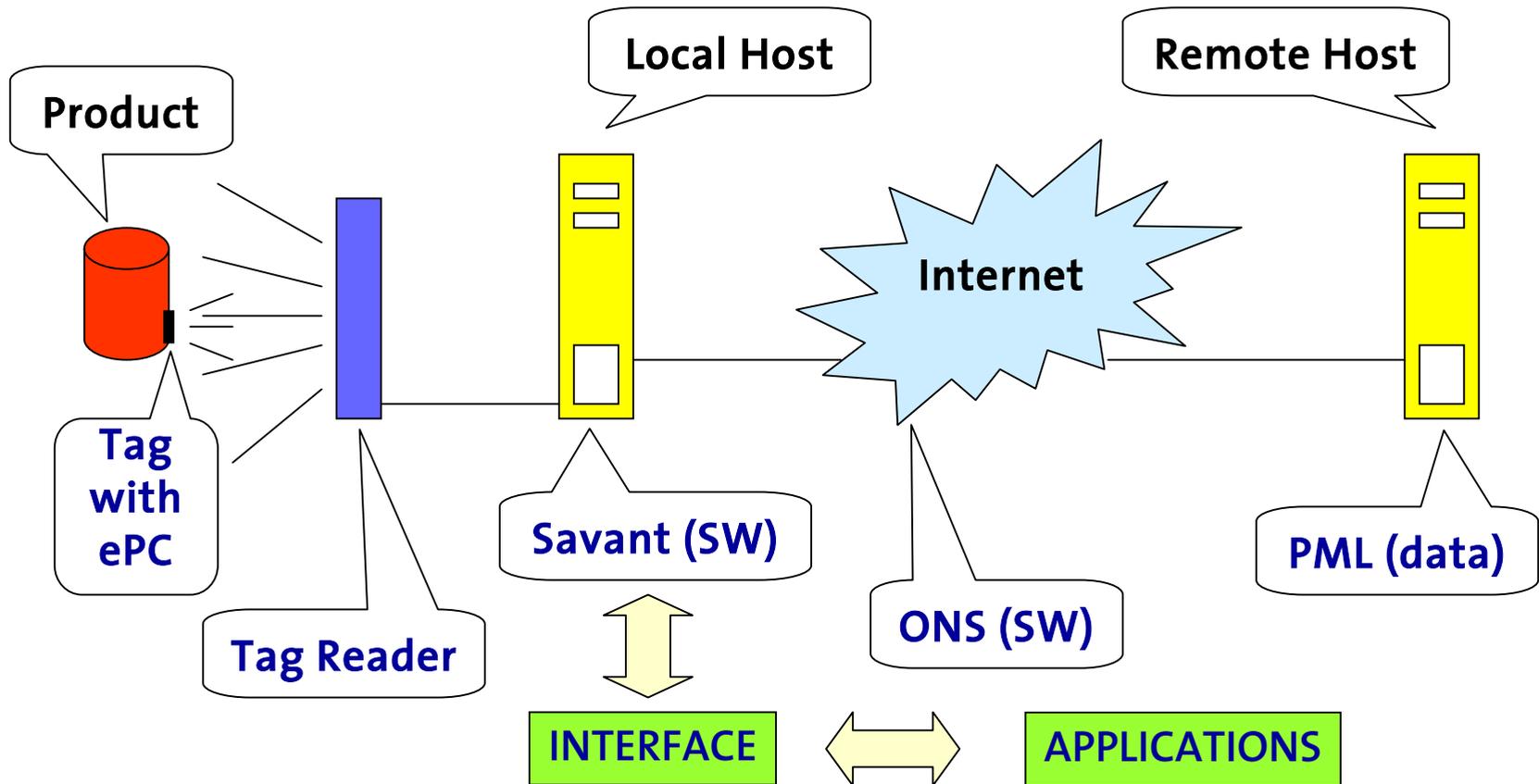
Electronic Product Code (ePC)

- Has to name each product instance uniquely
- Similiar to existing barcode systems
  - Can be integrated into ePC
  - Has an additional instance number
- Length of Code
  - Short to save chip costs and transmission speed
  - Long to cover all future applications

Header	Company	Product Group	Product Instance
8 bits	28 bits	24 bits	36 bits

Tags & Tag readers

- ## Tag properties
  - Processor
  - Read-only memory
  - Antenna

- ## No own energy
  - Inductive coupling

- ## Cost is most important issue
  - Currently: 1 USD
  - March 2002: 5 Cents

- ## Tag Readers installed at focal points
  - Shelves
  - Trucks

- ## Collision problems
  - Multiple tags
  - Multiple readers
  - Tag-reader

Physical Markup Language

- ## PML is an XML-based language

- ## Stores information about the product

  - ### Electronic Product Code

  - ### Location with a timestamp

  - ### Supports composition

  - ### Measurements, like temperature

    - Uses canonical units: Kelvin, Meter, ...

```
<node label=„name"
  ePC=„x...x">
...
</node>
```

- ## Will be extended evolutionary

- ## Problems: security, privacy, versioning

Object Name Service (ONS)

- **Problem: how to find the server on which the information for a product resides**

- Solution similiar to DNS
  - Mapping URL ▶ IP address

- ONS mapping: ePC ▶ URL

- Every company runs an ONS server for its products

Savant

- **Middleware**
- **Controls Reader**
  - Handles events
- **Aggregates and caches data**
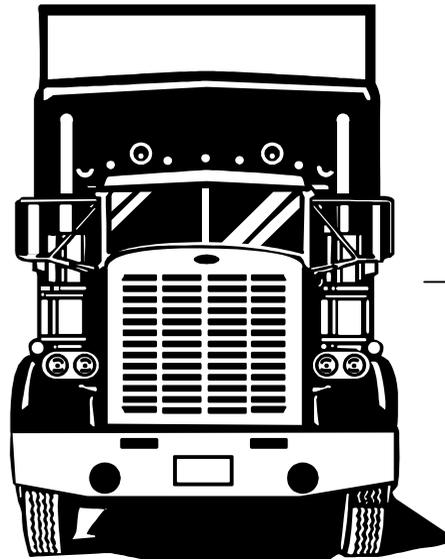- **API for 3rd party**
- **Contacts PLM Server**
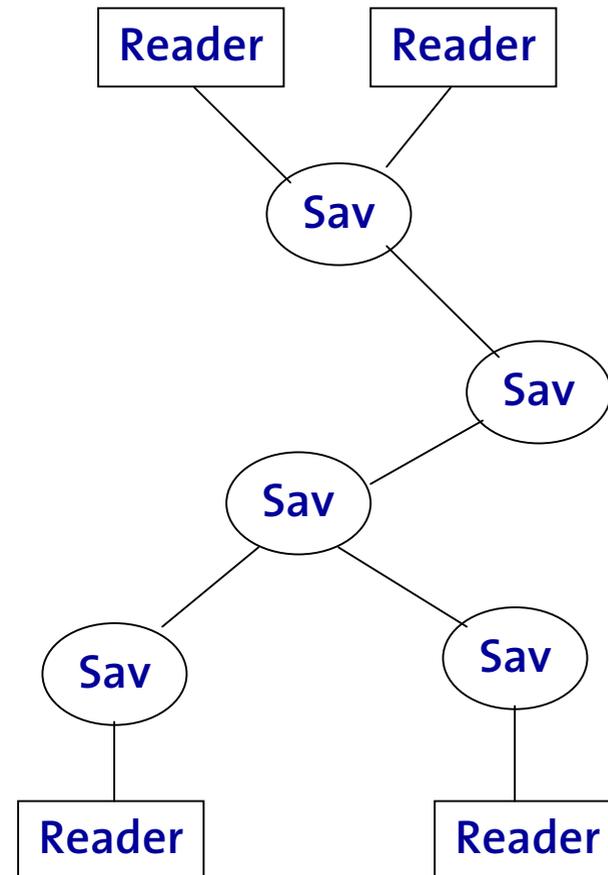
Overview over Part II

- Auto-ID infrastructure by example
- Auto-ID benefits by example – "The Beer Game"
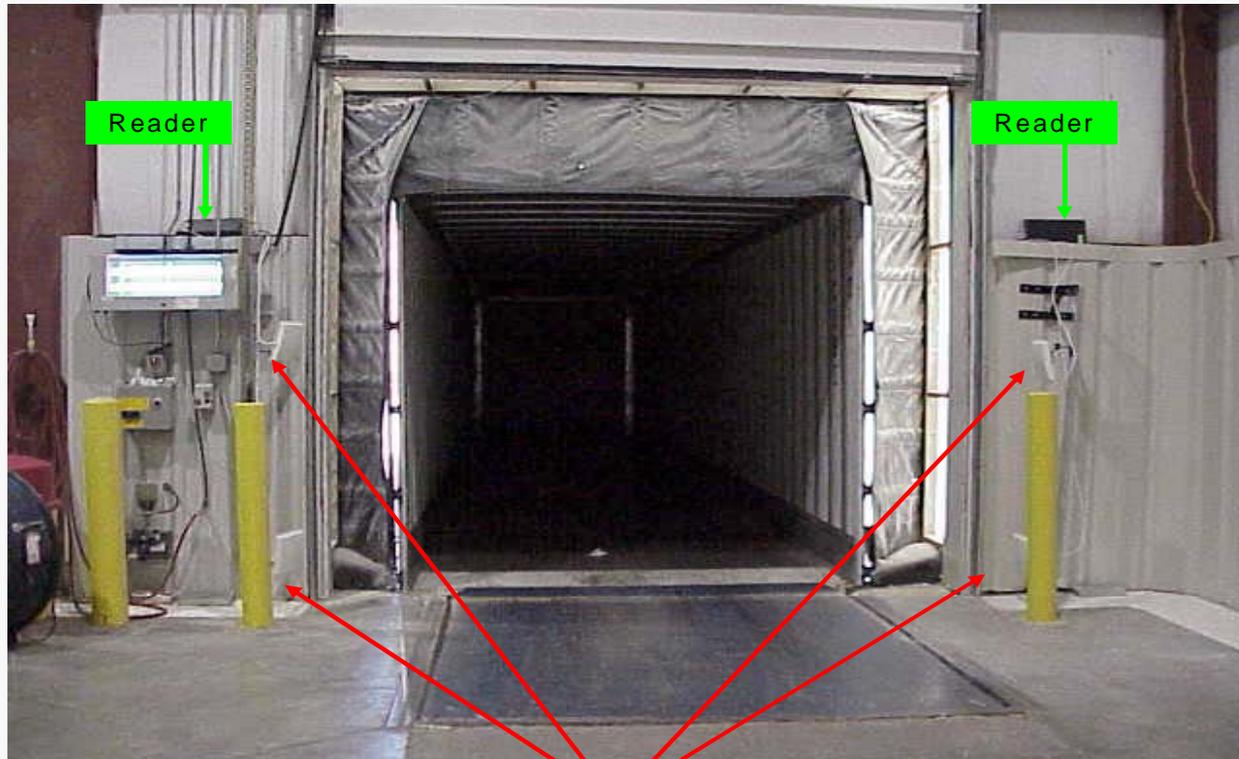
Auto-ID Sample Set-up

Factory

e.g. Coca-Cola

Transport

Wholesaler

e.g. Metro

Details

1 Outbound Dock Door – 2 Antennae per side

Reader   Reader

Antennae

Details cont…

Activity Diagram of tag read

Tag-Reader Infrastructure **Savant** **ONS** **PML-Server**

Benefits of Auto-ID tech

- Among others:

Real-time information from within the Supply chain.

Useful?

Overview over Part II

- Auto-ID infrastructure by example
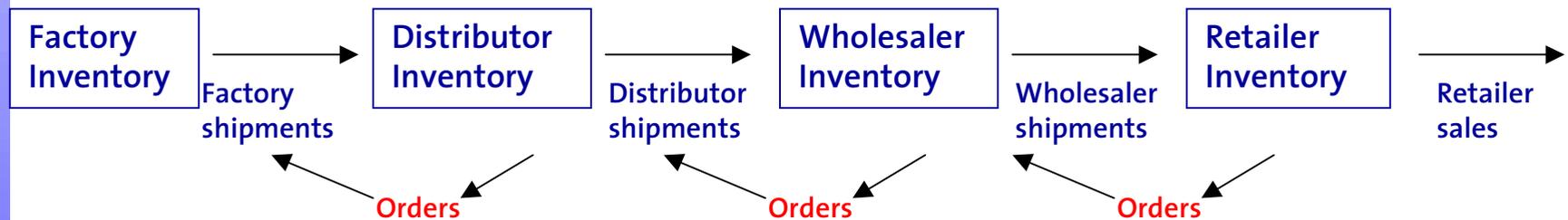- Auto-ID benefits by example – "The Beer Game"

Supply chain

Manufacturer   Distributor   Wholesaler   Retailer

| Factory Inventory | → | Distributor Inventory | → | Wholesaler Inventory | → | Retailer Inventory | → |

Factory shipments   Distributor shipments   Wholesaler shipments   Retailer sales

Orders   Orders   Orders

Beer Game

Player I   **Player II**   **Player III**   **Player IV**
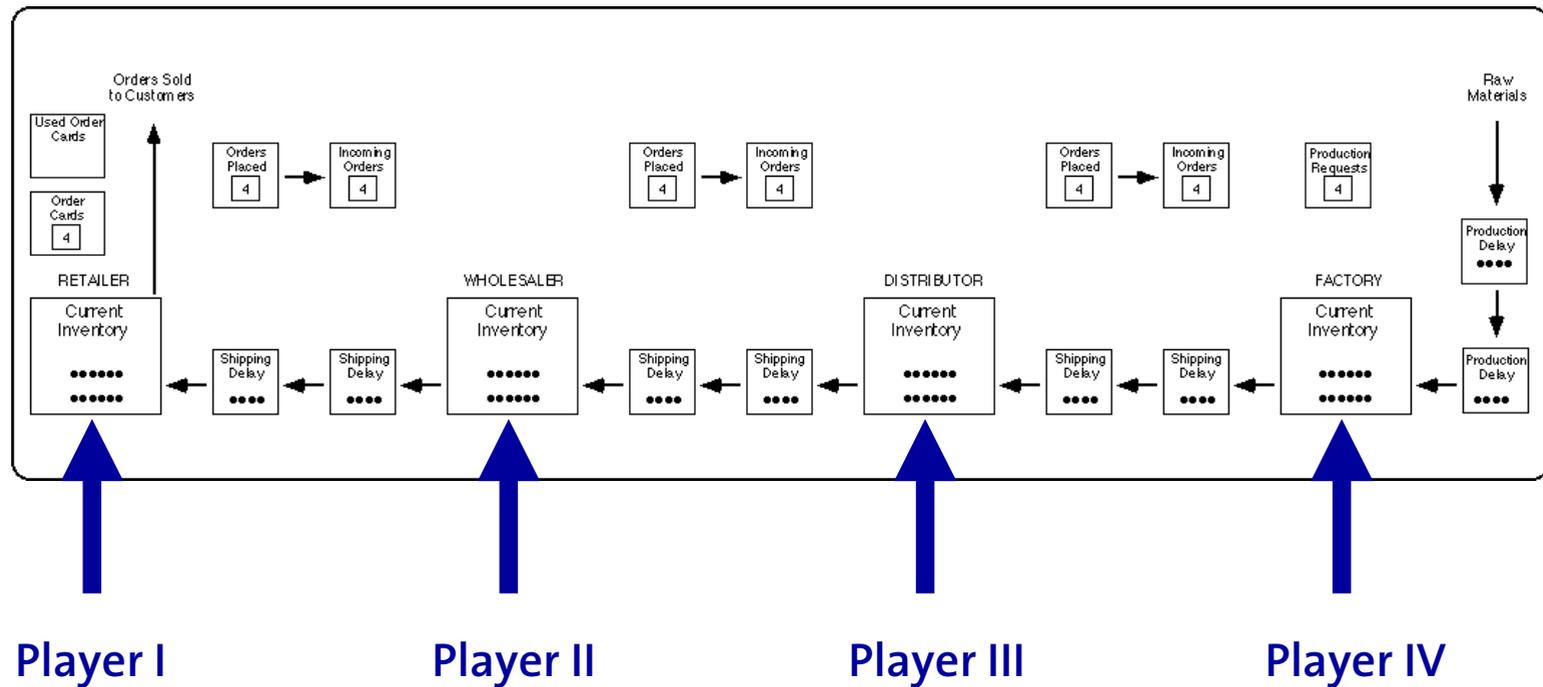
Beer Game Rules

- Order processing is delayed by 1 week
- Shipments are delayed by 2 weeks
- Total fulfillment of order: 3 weeks
- Inventory is to be kept at desired inventory level because inventory costs cash, but not being able to fulfil an order costs cash as well
- Goal of player: Minimize costs

Beer Game Rules cont.

- Each player has good local information, but severly limited global information (they are not allowed to communicate with each others – information is passed through orders and shipments !!!)
- Only the retailer discovers customer demand as the game progresses
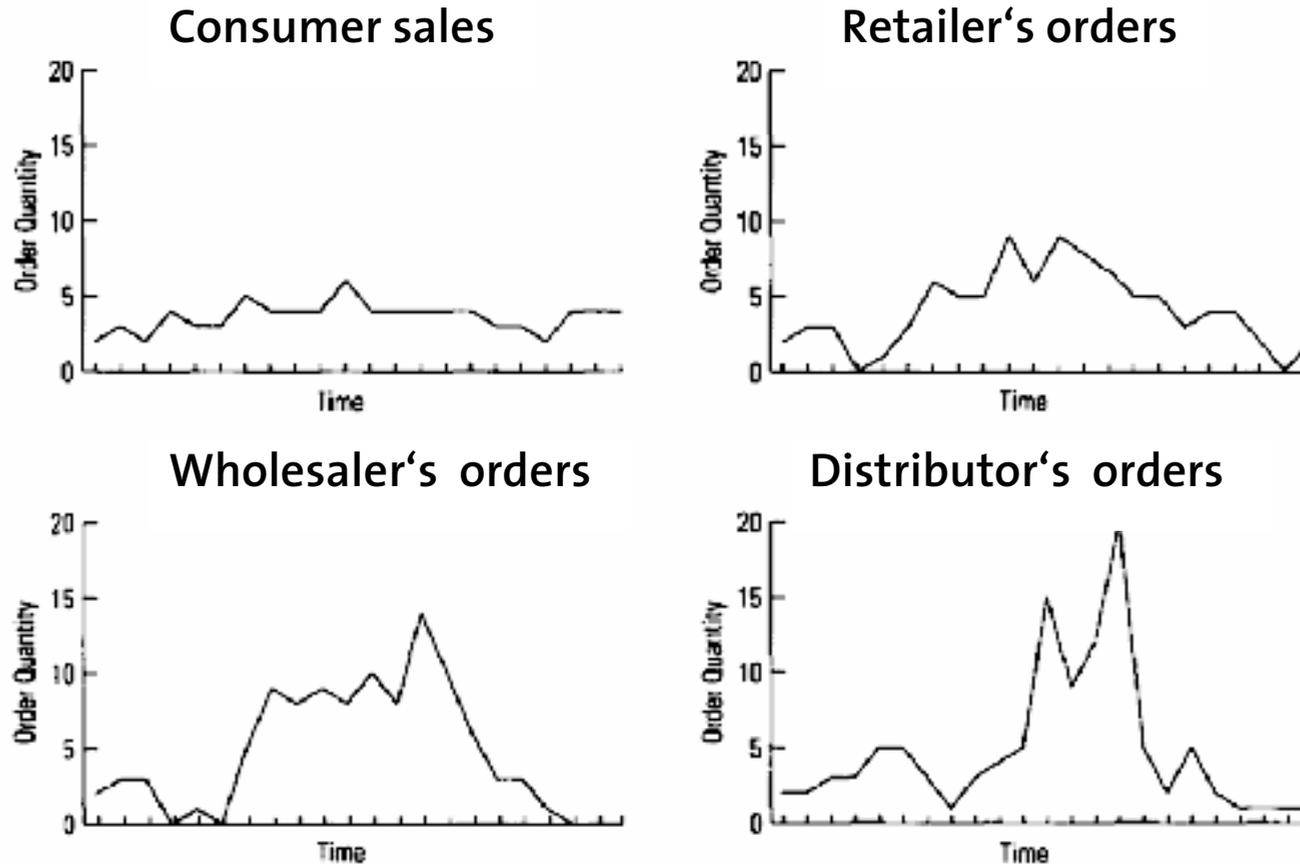- The others learn only what their own customer orders

Beer Game cont.

Source: J. Sterman MIT

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Beer Game in real life

Figure 1 Increasing Variability of Orders up the Supply Chain

Consumer sales

Retailer's orders

Wholesaler's orders

Distributor's orders

Source: J. Sterman MIT

Quote

- „After all, it isn't my fault", people tell me (Prof. J. Sterman, MIT), „if a huge surge in demand wiped out my stock and forced me to run a backlog. Then you tricked me – just when the tap began to flow, you made the customer go on the wagon, so I got stuck with all the excess inventory."

Simulation & Visualization

Show Matlab&Simulink Simulation

Analysis

- Oscillations
- Amplification
- Phase Lag

Conclusions

- People have great difficulty appreciating the multiple feedback loops, time delays and non-linearities in the system

- Players are unable to coordinate their decisions even though the objective of each team is to minimize costs

Conclusions cont.

- Transparency in the supplied chain achieved by (among others) the use of Auto-ID technology could provide a great benefit