Warehousing Systems Design

Marc Goetschalckx, Michael Amirhosseini, Doug Bodner, T. Govindaraj, Leon McGinnis, Gunter Sharp,

Industrial and Systems Engineering
Georgia Institute of Technology
Atlanta, GA 30332-0205
(404) 894-2317

Credits

* Industry
  • M. Amirhosseini (UPS WWL)

* Faculty
  • L. McGinnis, T. Govindaraj, D. Bodner, M. Goetschalckx, G. Sharp

* Graduate Students
  • E. Blanco, M. Insalaco, P. Bellur, A. Parfenov

* Sponsors
  • NSF, Ford Motor, UPS WWL, Keck Foundation
Distribution Warehouse
Functional Areas Illustration

Changing Warehousing Requirements

✯ Faster Turns, Shorter Life Cycles
  • Warehouse operations
  • Warehouse design
✯ Proliferation of Information Technology
  • WMS, tracking
✯ Design-As-Usual
The goal of warehouse design is to minimize the discounted present value of the costs of establishing and operating the warehouse over some horizon specified by the decision-maker, subject to a number of resource and performance constraints.

State-of-the-Art in Warehousing Design

- Reviews and Bibliography
  - Rouwenhorst, Goetschalckx (www)

- Analysis of Isolated Components
  - Numerous, focussed, uneven
  - Detailed simulation and animation
  - Clearly suboptimal
  - No impact on the practice of warehousing design
State-of-the-Art in Warehousing Design continued

- **No Structured, Integrated Design Methodology**
  - No model for warehousing operations
  - No explicit design theory

- **Consulting-University Cooperatives for DSS and Education**
  - Twente, Dortmund, Darmstadt, Georgia Tech

Warehousing Design Methodology Needs

- **Integration of Isolated Research and Methods**
- **Rich Empirical Data Sets**
- **Rigorous Mathematical Models**
- **Synthesis and Design Tools**
Warehousing Design and Operations Education Status

- Mirrors State-of-the-Art
  - Focussed, uneven, analysis
- High Demand
  - Bachelors, Graduate, and Professional
- Few Educational Materials
  - MHI and CICMHE
  - Several books in preparation

Warehousing Design Education Effort at Georgia Tech

- Asynchronous Education
  - www (http://www.isye.gatech.edu/warehousing)
    - standard software (html, vrml…)
  - client-server architecture
    - common and private components
- Rich, Industry-Grade Case Studies
Warehousing Design
Development at Georgia Tech

- Functional Flow Network
- Object Oriented Data Base
- Mathematical Design Models
- Visualization

Warehousing Functions

- Receiving
- Storage - Holding
- Order Picking - Retrieval
- Consolidation - Sorting
- Shipping
Functional Flow Network for Basic Warehousing Functions

Every Warehouse Has a Different Functional Flow Network
Different Products Can Follow Different and Multiple Paths
Functions are Mapped to Areas, Areas are Mapped to Material Handling and Storage Equipment
**Object Classes in Warehouse Design**

- **Project Object** (Design Control)
- **Warehousing Objects** (Common Building Blocks)
  - **Functional Flow Objects** (Requirements and Products)
  - **Operation Objects** (Warehouse Configuration and State)

---

**Object Classes**

- **Design Object**
  - Design project status
- **Warehousing Objects**
  - Equipment and policies and protocols
- **Functional Flow Objects**
  - Products and flows requirements
- **Operations Objects**
  - Design specification
Warehousing Objects Structure (Equipment and Personnel)

Operations Object Structure (Warehouse State)
**Design Optimization Model**

- Global Decisions
- Receiving Decisions
- Bulk Store Decisions
- Shipping Decisions

- Total Cost Function
- Global Constraints: Space, Budget, etc.

**Optimization Model Characteristics**

- **Optimization Decomposed by Functional Areas**
- **Joint Space (Area), Manpower, Budget Constraints**
- **Economic Analysis Joint Objective Function**
Block Stacking Example: Software Program Interactions

1. User Inputs the Region Information (VISIO)
2. Block Stacking Algorithm
3. Display Results (VISIO + VRML)

Department Block Layout in Visio
Access Tables and Relations

Block Stacking Layout in Visio
Block Stacking Layout in VRML

Rotated Block Stacking Layout in VRML
Warehouse VRML Visualization:
Side View with Storage Systems

Warehouse VRML Visualization:
Top View with Storage Systems
Warehouse VRML Visualization:
Side View with Floor Stacking

Warehouse VRML Visualization:
Interior View
Warehouse VRML Visualization: Inside the Aisle View

Warehouse VRML Visualization: Truck View Animation
Warehouse VRML Visualization: Top View with All Elements

Warehouse VRML Visualization: Interior View without Stock
Thank You
Can I Answer Any Questions?