西安電子科技大學
XIDIAN UNIVERSITY

计算机科学与技术学院
SCHOOL OF COMPUTER SCIENCE AND TECHNOLOGY
国家示范性软件学院
NATIONAL PILOT SCHOOL OF SOFTWARE ENGINEERING

应用案例

主讲人：蔺一帅 讲师

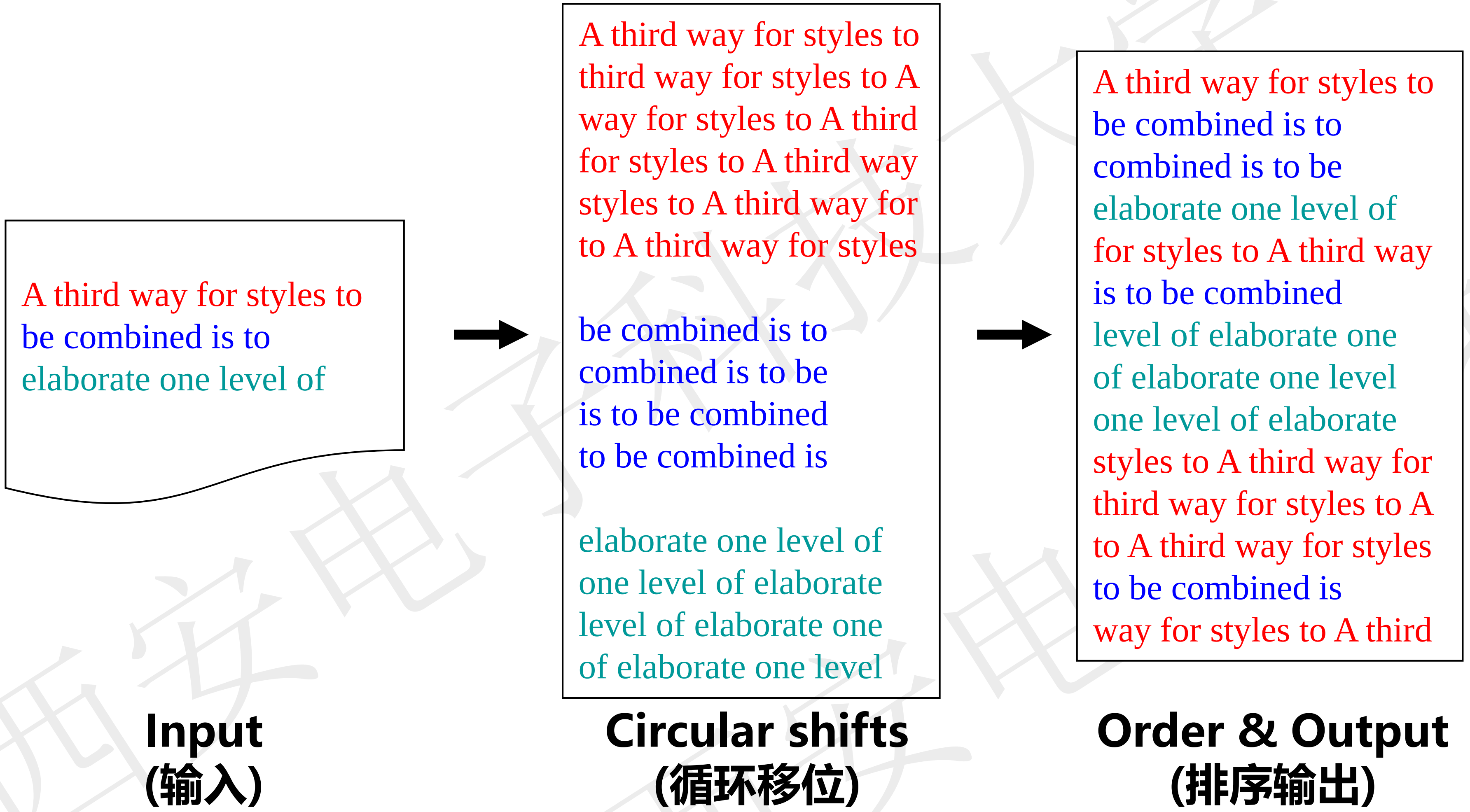
本节内容

KWIC-Functional Requirements

- In 1974, Parnas proposed the following problem,The KWIC(keyword-in-context) index system (KWIC索引系统) 软件体系结构研究的经典案例
  - ✓ accepts an ordered set of lines (接受一些行)
  - ✓ each line is an ordered set of words (每行有若干词)
  - ✓ each word is an ordered set of characters (每个词由若干字符组成)
  - ✓ any line may be "circularly shifted" by repeatedly removing the first word and appending it at the end of the line (每行都可以循环移位:重复地把第一个词删除，然后接到行末)
  - ✓ The KWIC index system outputs a listing of all circular shifts of all lines in alphabetical order. (KWIC把所有行的各种移位情况按照字母表顺序输出)

Mary Shaw, David Garlan. Software Architecture: Perspectives on an Emerging Discipline. The 3rd Chapter.

KWIC-Functional RequirementsA Case for KWIC



A third way for styles to
be combined is to
elaborate one level of

Input
(输入)

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Circular shifts
(循环移位)

A third way for styles to
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Order & Output
(排序输出)

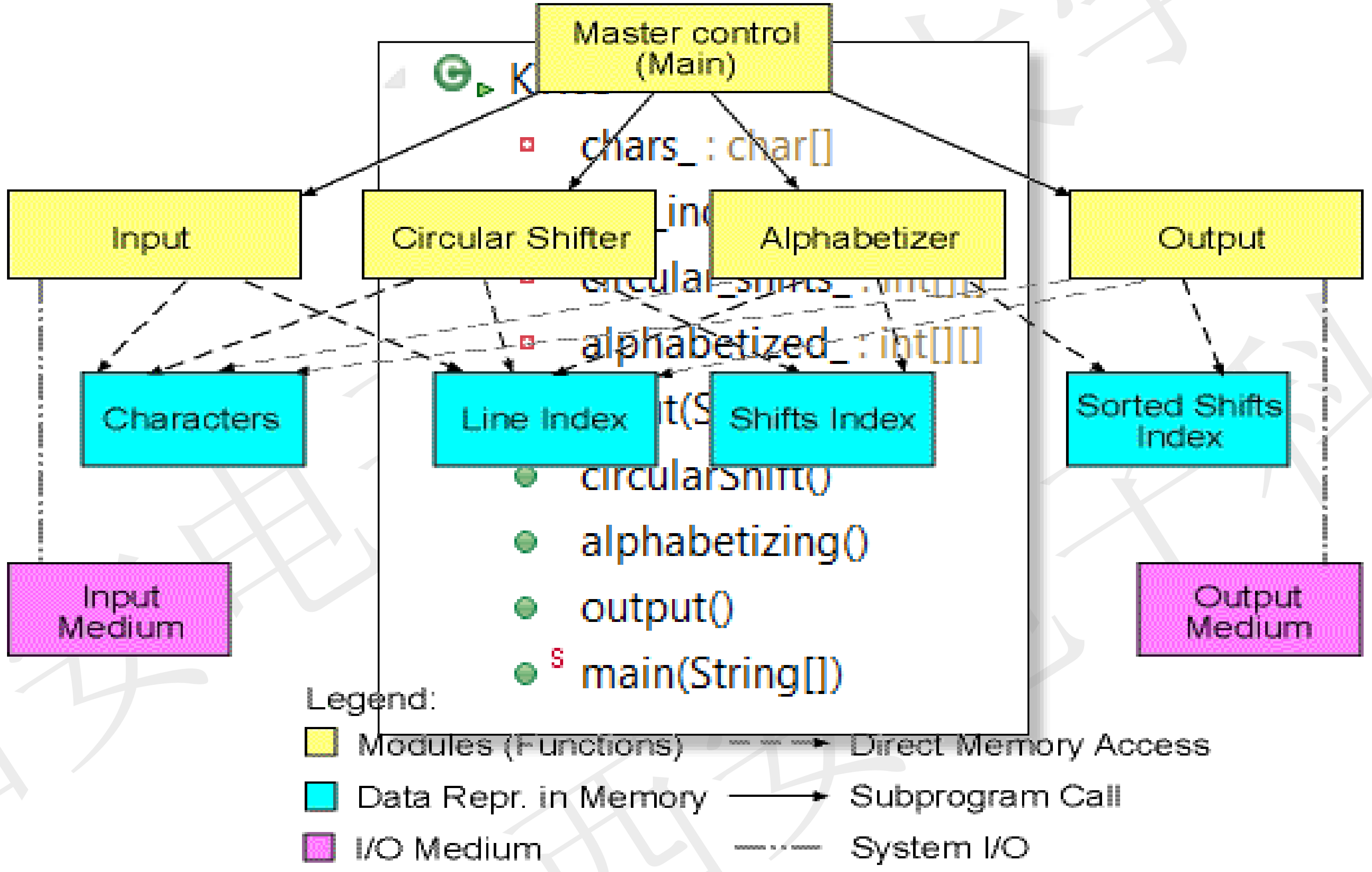
KWIC-Non-functional Requirements

- Modifiability (可修改性)
  - ✓ Change in Algorithm (算法的变化): batch vs. incremental
  - ✓ Change in Data Representation (数据表示方式的变化)
    - ✓ line storage, explicit vs. implicit shifts
  - ✓ Enhancement to system function (系统功能的可扩展性)
    - ✓ e.g., eliminate lines starting with trivial words
    - ✓ e.g., input lines from a database or from UI
    - ✓ e.g., delete, modify or add to lines from the original shifted lines
- Performance (性能): Both space and time (时空复杂性)
- Reusability (系统构件的可复用性)
  - ✓ To what extent can the components serve as reusable entities.

KWIC-Main Program/Subroutine with Shared Data

- 采用“主程序-子过程”风格、对系统进行功能分解，是最自然的想法，也是“面向过程的编程” 的主要思路。
    - Decomposes the problem according to the four basic functions performed: input, shift, alphabetize, and output. (分为四个基本功能：输入、移位、排序、输出)
    - These computational components are coordinated as subroutines by a main program that sequences through them in turn. (主程序按次序调用这四个模块)
    - Data is communicated between the components through shared storage with an unconstrained read-write protocol. (通过共享的数据存储和无约束的读-写协议在模块之间进行数据交换)

KWIC-Main Program/Subroutine with Shared Data



KWIC-Main Program/Subroutine with Shared Data

Data Presentation

- char[] chars_
  - ✓ Characters from the input file are stored in a character array named chars_. Words are delimited by a single space character.
- int[] line_index_
  - ✓ An integer array, which keeps indices of characters from the character array. Each index kept in the line index array is the index of the first character of a particular line.
- int[][] circular_shifts_
  - ✓ Two dimensional array that stores the original line number and all of its circular shifts, stored as indexes of the original character array
- int[][] alphabetized_
  - ✓ Two dimensional array that stores alphabetized circular shifts

KWIC-Main Program/Subroutine with Shared Data

Process

- The input function is called to read and parse the lines from an input file and represents it by means of the character (chars_) and line index (line_index_) array. (首先调用input函数来读取和解析输入文件并将其写在chars_和line_index_数组中)
- The main function calls the circularShift function, which produces circular shifts of each particular line and stores it in the circular shifts array (circular_shifts_). (然后调用circularShift函数，产生移位结果并写入circular_shifts_数组中)
- The main function calls the alphabetize function, which sorts circular shifts alphabetically. The result is stored in the alphabetized array (alphabetized_). (然后调用alphabetize函数对其进行排序，结果写入alphabetized_数组中)
- Finally, the main function calls the output function, which prints the sorted lines. (最后调用output函数，输出结果)

KWIC: Key Algorithm - input

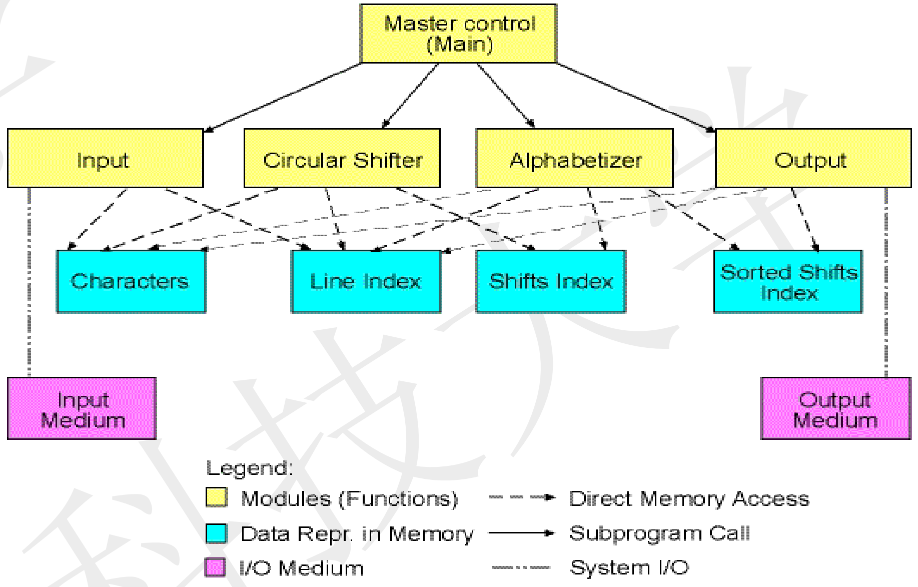
- The format of raw data is as follows.
  - ✓ Lines are separated by the line separator character(s) (on Unix '\n', on Windows '\r\n'). Each line consists of a number of words. Words are delimited by any number and combination of the space chracter (' ') and the horizontal tabulation chracter ('\t').
- The entered data is parsed in the following way.
  - ✓ All line separators are removed from the data, all horizontal tabulation word delimiters are replaced by a single space character,
  - ✓ and all multiple word delimiters are replaced by a single space character.
- Then the parsed data is represented in core as two arrays.
  - ✓ The first array is a char array (char[] chars_), which keeps all words seprated by a single space character. Since we removed line separators from the data the second integer array (int[] line_index_) keeps indexes of the chars_ array where lines start.

KWIC: Key Algorithm - circularShift

- ➢ circularShift function processes the two arrays prepared by input function.
  - ✓ It produces all circular shifts of all lines stored in core.
  - ✓ A circular shift is a line where the first word is removed from the begin of a line and appended on the end of the line.
  - ✓ To obtain all circular shifts of a line we repeat this process until we can't obtain any new lines.
- ➢ We represent a circular shift of a line as a pair of indices.
  - ✓ The first part of the pair is the index in the chars_ array, where the first word of the shifted line starts(在_array中的index).
  - ✓ To be able to determine the boundaries of the original line, the second part of the pair keeps the index of the original line in the line index array(在_line_index中的index). Thus, all circular shifts are represented as an array of such pairs, i.e., as two dimensional integer array int[][] circular_shifts_.

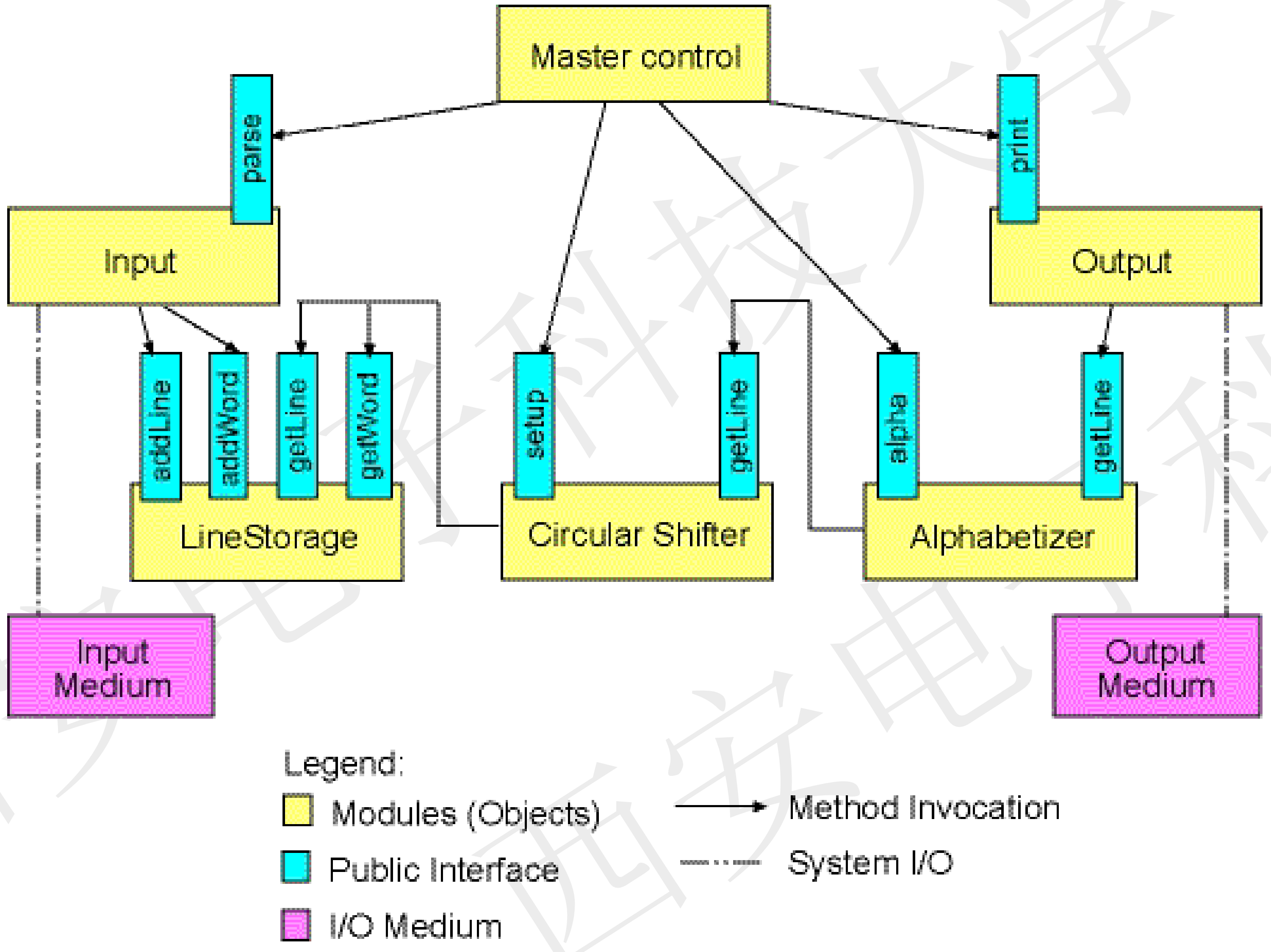
KWIC-Main Program/Subroutine with Shared Data

- **Advantages:**
  - ✓ Data can be represented efficiently, since computations can share the same storage. (模块之间的数据共享)
  - ✓ Distinct computational aspects are isolated in different modules (不同的计算功能被隔离在不同的模块中)



- **Disadvantages:**
  - ✓ A change in data storage format will affect almost all of the modules. (对数据存储格式的变化将会影响几乎所有的模块)
  - ✓ Changes in the overall processing algorithm and enhancements to system function are not easily accommodated. (对处理流程的改变与系统功能的增强也很难适应，依赖于控制模块内部的调用次序)
  - ✓ This decomposition is not particularly supportive of reuse. (这种分解也难以支持有效的复用)

KWIC-Abstract Data Types

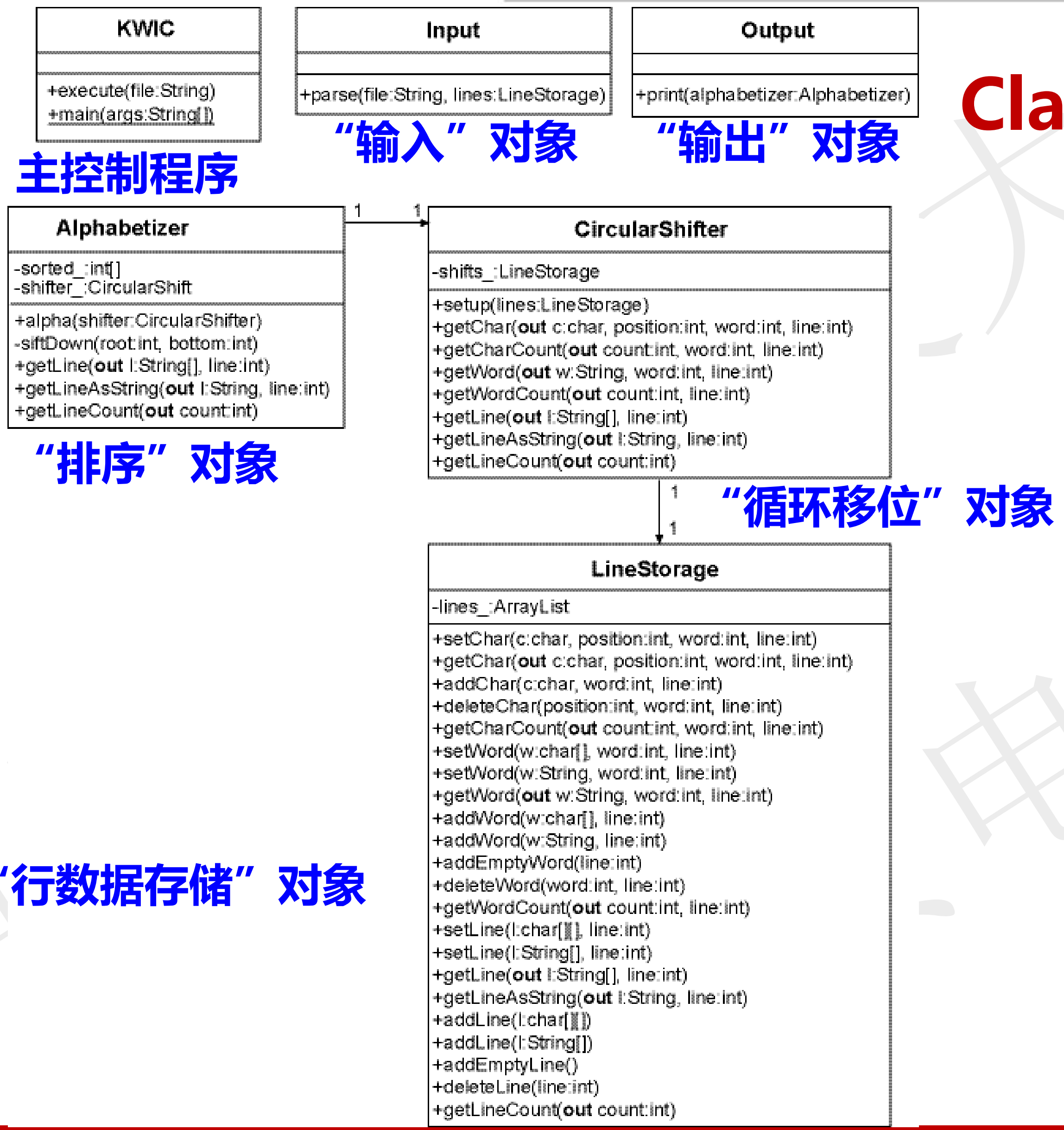


KWIC-Abstract Data Types

- 采用OO的思想，数据和作用在数据上的读写操作被封装为object，主程序调用这些object，形成控制流程；
  - Data is no longer directly shared by the computational components. (数据不再被构件直接共享，而是被封装在了Object中)
  - Each module provides an interface that permits other components to access data only by invoking procedures in that interface. (每个对象提供了一个接口，允许其他对象通过该接口调用对该对象内封装的数据的操作)

KWIC-Abstract Data Types

Class Diagram: System Statics



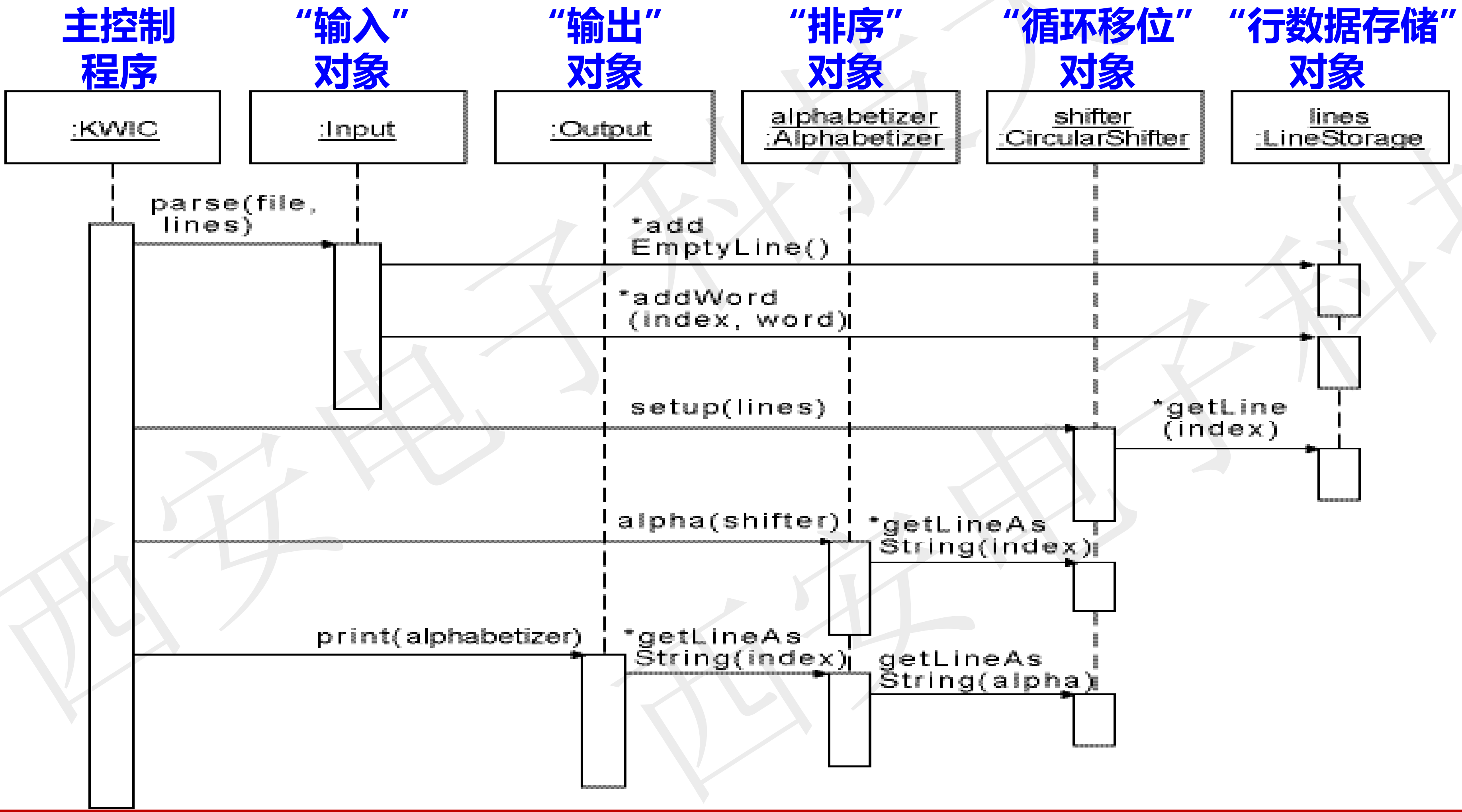
```
KWIC
+execute(file:String)
+main(args:String[])

Input
+parse(file:String, lines:LineStorage)

Output
+print(alphabetizer:Alphabetizer)

Alphabetizer
-sorted_:int[]
-shifter_:CircularShift
+alpha(shifter:CircularShifter)
-siftDown(root:int, bottom:int)
+getLine(out l:String[], line:int)
+getLineAsString(out l:String, line:int)
+getLineCount(out count:int)

CircularShifter
-shifts_:LineStorage
+setup(lines:LineStorage)
+getChar(out c:char, position:int, word:int, line:int)
+getCharCount(out count:int, word:int, line:int)
+getWord(out w:String, word:int, line:int)
+getWordCount(out count:int, line:int)
+getLine(out l:String[], line:int)
+getLineAsString(out l:String, line:int)
+getLineCount(out count:int)

LineStorage
-lines_:ArrayList
+setChar(c:char, position:int, word:int, line:int)
+getChar(out c:char, position:int, word:int, line:int)
+addChar(c:char, word:int, line:int)
+deleteChar(position:int, word:int, line:int)
+getCharCount(out count:int, word:int, line:int)
+setWord(w:char[], word:int, line:int)
+setWord(w:String, word:int, line:int)
+getWord(out w:String, word:int, line:int)
+addWord(w:char[], line:int)
+addWord(w:String, line:int)
+addEmptyWord(line:int)
+deleteWord(word:int, line:int)
+getWordCount(out count:int, line:int)
+setLine(l:char[][], line:int)
+setLine(l:String[], line:int)
+getLine(out l:String[], line:int)
+getLineAsString(out l:String, line:int)
+addLine(l:char[][])
+addLine(l:String[])
+addEmptyLine()
+deleteLine(line:int)
+getLineCount(out count:int)
```

KWIC-Abstract Data Types

- Input object (负责从输入文件中读取数据并将其存储在LineStorage对象中)
- LineStorage object (存储和处理字符、单词、行)
- CircularShifter object (负责对LineStorage对象中存储的数据进行循环移位)
- Alphabetizer object (负责对循环移位后得到的数据进行排序)
- Output object (负责打印输出排序后的数据)
- Master control object (主控制对象：负责控制其他各对象中方法的调用次序)

KWIC-Abstract Data Types

Sequence Diagram: System Dynamics



KWIC-Abstract Data Types

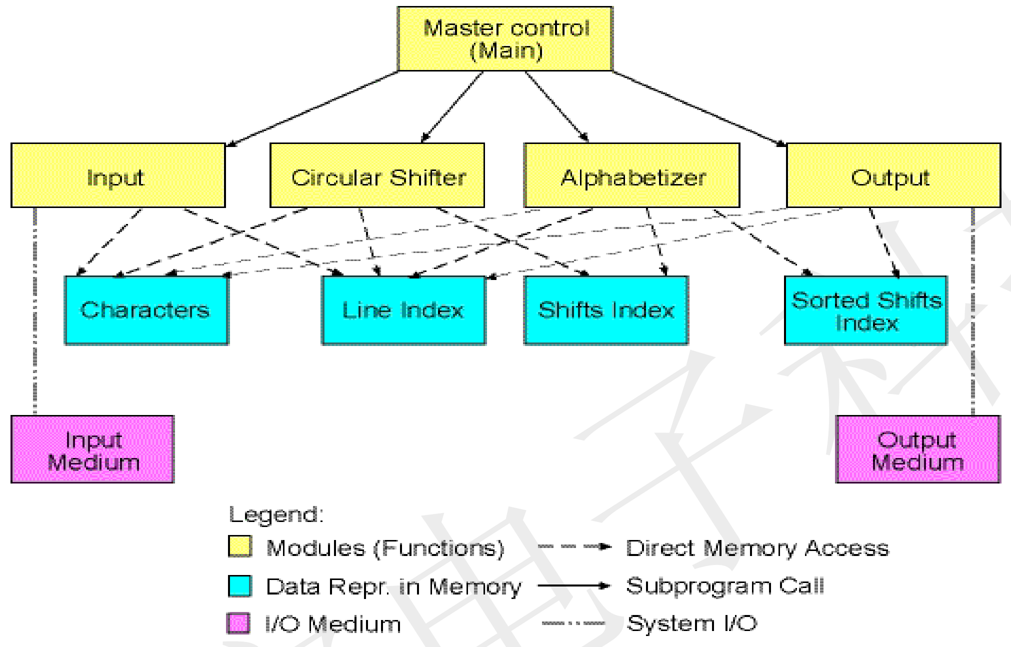
Class KWIC

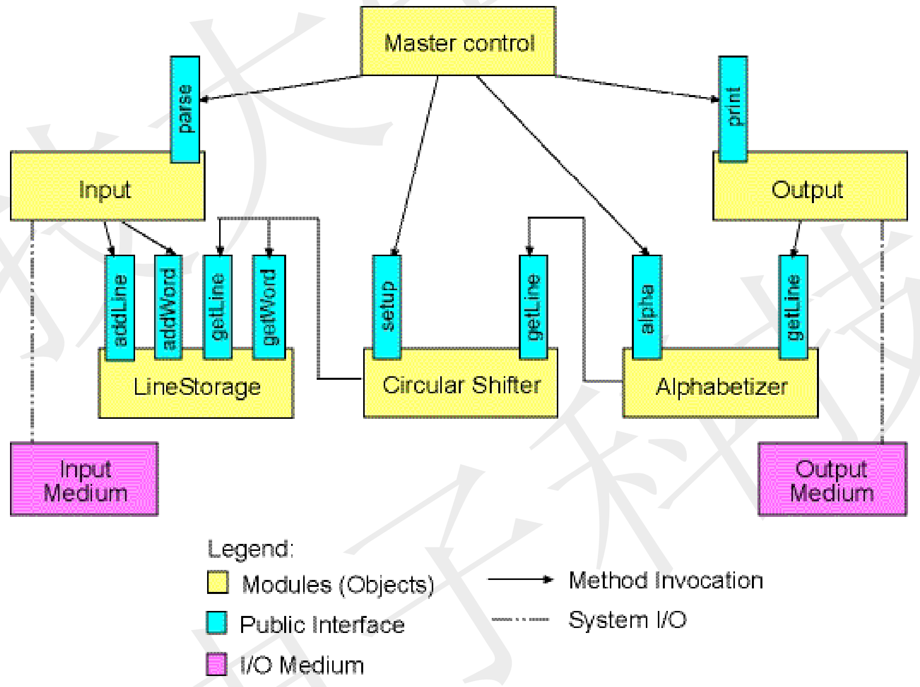
```
//主对象KWIC构造五个对象实例
LineStorage lines = new LineStorage();
Input input = new Input();
CircularShifter shifter = new CircularShifter();
Alphabetizer alphabetizer = new Alphabetizer();
Output output = new Output();
//然后分别调用这五个对象实例的某些方法
input.parse(file, lines);
shifter.setup(lines);
alphabetizer.alpha(shifter);
output.print(alphabetizer);
```

KWIC-Abstract Data Types

- **Advantages:**
  - ✓ Both algorithms and data representations can be changed in individual modules without affecting others. (某一构件的算法与数据结构的修改不会影响其他构件)
  - ✓ Reuse is better supported than in the first solution because modules make fewer assumptions about the others with which they interact. (构件之间依赖性降低，提高了复用度)
- **Disadvantages:**
  - ✓ The solution is not particularly well-suited to enhancements. (不是特别适合功能的扩展)
  - ✓ For adding new functions to the system, the implementor must either modify the existing modules or add new modules that lead to performance penalties. (为了增加新功能，要么修改已有的模块，要么就加入新的模块)

KWIC-M/S vs Abstract Data Types





从架构观点看，OO优于Main Program/Subroutine

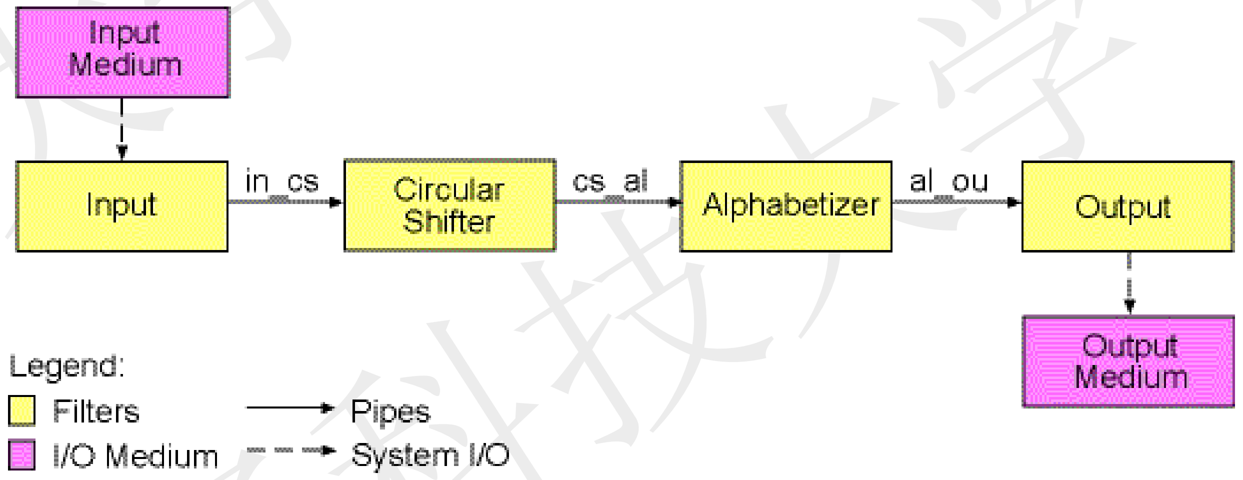
依赖减少 易于理解 易于维护 易于复用

KWIC-Pipes and Filters

- ➢ Uses a pipeline solution. (使用管道-过滤器风格)
  - ✓ There are four filters: input, shift, alphabetize, and output.（四个过滤器：输入、移位、排序、输出)
  - ✓ Each filter processes the data and sends it to the next filter. (每个过滤器处理数据，然后将结果送至下一个过滤器)
  - ✓ Control is distributed: each filter can run whenever it has data on which to compute.（控制机制是分布式的：只要有数据传入，过滤器即开始工作)
  - ✓ Data sharing between filters is strictly limited to that transmitted on pipes. (过滤器之间的数据共享被严格限制在管道传输)

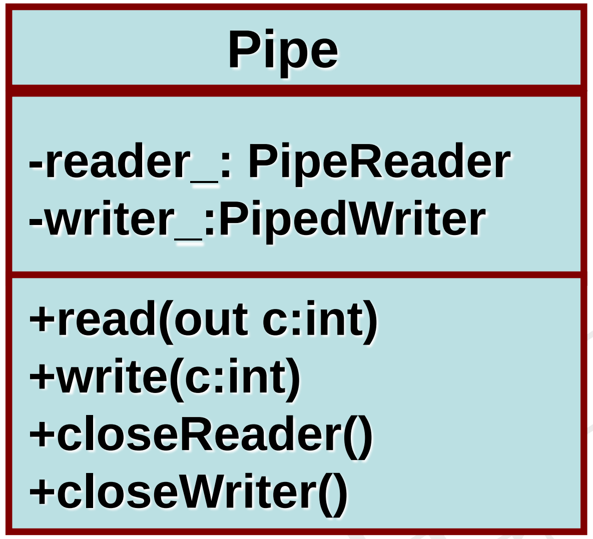
Solution : Pipes and Filters

- Filters：
  - ✓ Input filter (“输入”过滤器：从数据源读取输入文件，解析格式，将行写入输出管道)
  - ✓ CircularShifter filter (“循环移位”过滤器)
  - ✓ Alphabetizer filter (“排序”过滤器)
  - ✓ Output filter (“输出”过滤器)
- Pipe：
  - ✓ in_cs pipe
  - ✓ cs_al pipe
  - ✓ al_ou pile



KWIC-Pipes and Filters

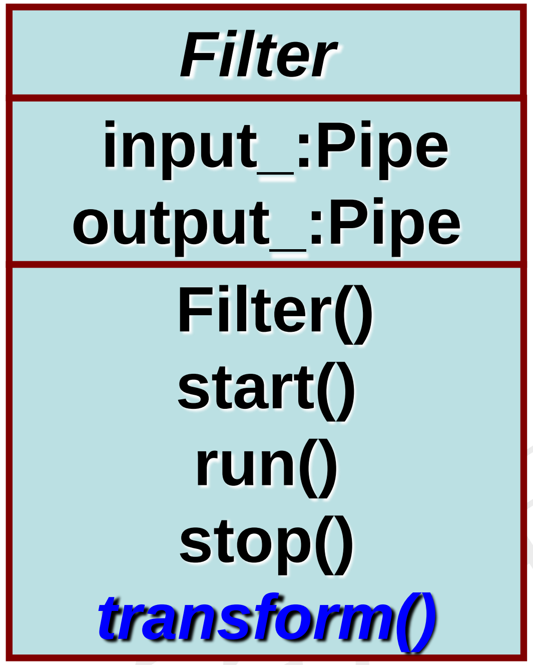
Pipe



```
import java.io.PipedReader;
import java.io.PipedWriter;
import java.io.IOException;

public class Pipe {
          private PipedReader reader_;
          private PipedWriter writer_;

          public Pipe() throws IOException {
                    writer_ = new PipedWriter();
                    reader_ = new PipedReader();   / let this piped writer to be connected to the piped reader
                    writer_.connect(reader_);
          }.    // Writes char to the piped output stream
          public void write(int c) throws IOException {
                    writer_.write(c);
          }
          //  Reads the next character of data from this piped stream
          public int read() throws IOException {
                    return reader_.read();
          }

          public void closeWriter() throws IOException {
                    writer_.flush();
                    writer_.close();
          }
          public void closeReader() throws IOException {
                    reader_.close();
          }
}
```

KWIC-Pipes and Filters

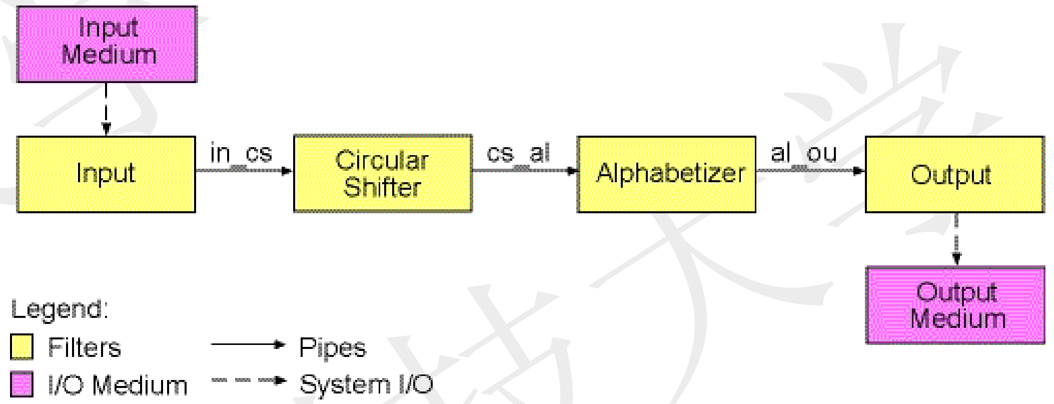
Filter



```
public abstract class Filter implements Runnable {
          protected Pipe input_;
          protected Pipe output_;
          private boolean is_started_ = false;

          public Filter(Pipe input, Pipe output) {
                    input_ = input;
                    output_ = output;
          }
          public void start() {
                    if (!is_started_) {
                              is_started_ = true;
                              Thread thread = new Thread(this);
                              thread.start();
                    }
          }
          public void stop() {
                    is_started_ = false;
          }
          public void run() {
                    transform();
          }/*
           * This method transforms the data from the input pipe and writes the
           * transformed data into output pipe.
           */

          abstract protected void transform();

}
```

KWIC-Pipes and Filters

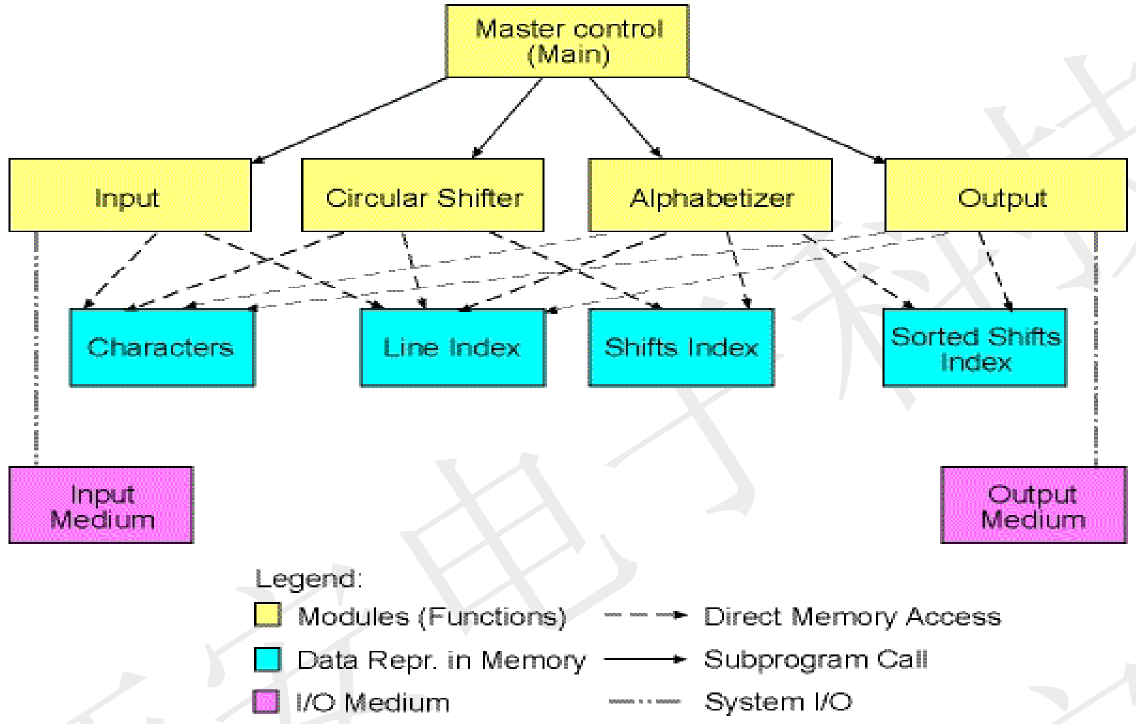
```
...

FileInputStream in = new FileInputStream(file);

Pipe in_cs = new Pipe(); // create three objects of Pipe
Pipe cs_al = new Pipe(); // and one object of type
Pipe al_ou = new Pipe(); // FileInputStream

Input input = new Input(in, in_cs);
CircularShifter shifter = new CircularShifter(in_cs, cs_al);
Alphabetizer alpha = new Alphabetizer(cs_al, al_ou);
Output output = new Output(al_ou); // output to screen
input.start();
shifter.start();
alpha.start();
output.start();

...
```

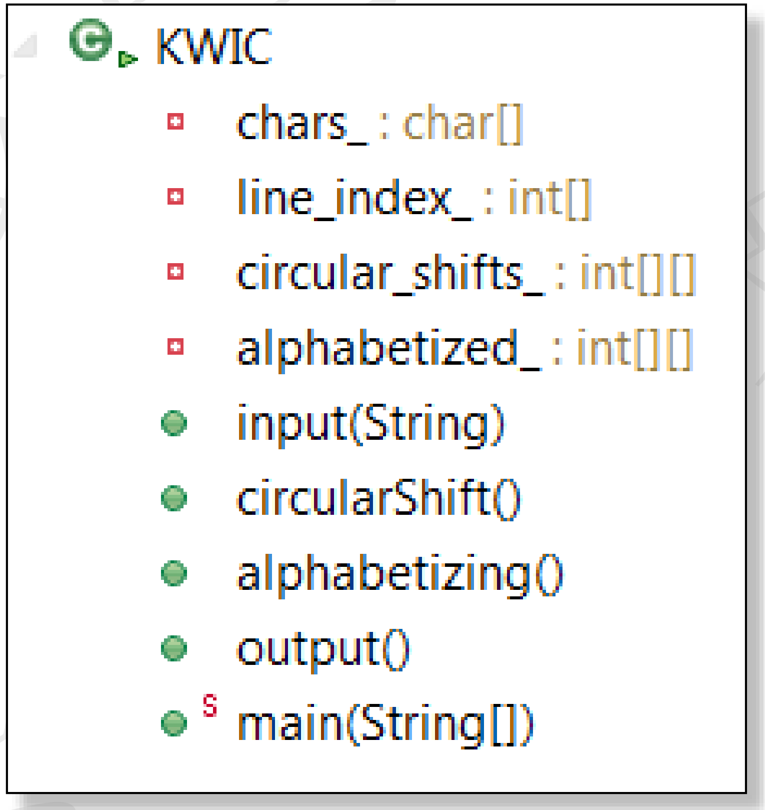


对象之间没有直接耦合

KWIC-Pipes and Filters

对比Main program/subroutine风格实现





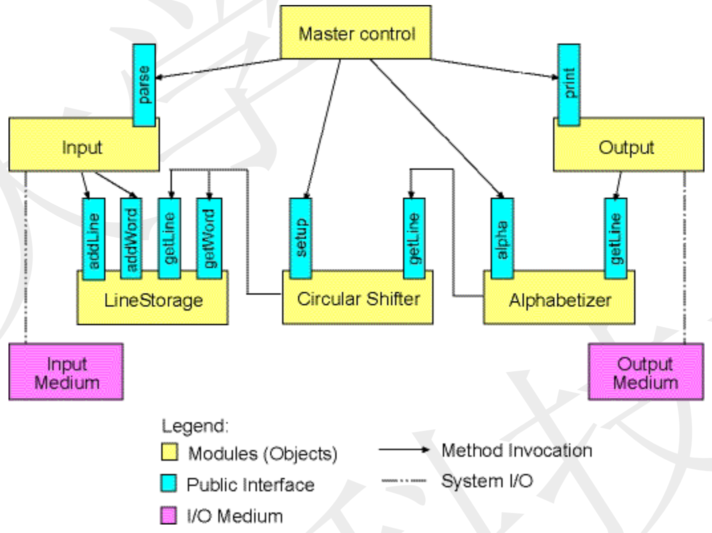
KWIC
- chars_ : char[]
- line_index_ : int[]
- circular_shifts_ : int[][]
- alphabetized_ : int[][]
- input(String)
- circularShift()
- alphabetizing()
- output()
- S main(String[])

很多很复杂的数据依赖!!!

KWIC-Pipes and Filters

对比OO风格实现

```
//主对象KWIC构造五个对象实例
LineStorage lines = new LineStorage();
Input input = new Input();
CircularShifter shifter = new CircularShifter();
Alphabetizer alphabetizer = new Alphabetizer();
Output output = new Output();
//然后分别调用这五个对象实例的某些方法
input.parse(file, lines);
shifter.setup(lines);
alphabetizer.alpha(shifter);
output.print(alphabetizer);
```



input对象依赖lines对象
Shifter对象依赖lines对象
alphabetizer对象依赖Shifter对象
output对象依赖alphabetizer对象
除此之外，还有一些间接依赖关系！

Pipes and Filters的优势

- It maintains the intuitive flow of processing. (过程流非常直观)
- It supports reuse (支持复用!!)
- It supports ease of modification, since filters are logically independent of other filters. (容易修改!!)
  - ✓ Each filter can function in isolation (provided upstream filters produce data in the form it expects).（过滤器的功能相互隔离)
  - ✓ New functions are easily added to the system by inserting filters at the appropriate point in the processing sequence. (新功能容易加入)

Pipes and Filters的不足

- It is virtually impossible to modify the design to support an interactive system. (无法支持交互式系统，局限性较大!)
  - ✓ For example, in order to delete a line, there would have to be some persistent shared storage, violating a basic tenet of this approach.
- The solution is inefficient in terms of its use of space, since each filter must copy all of the data to its output ports. (空间复杂性高)

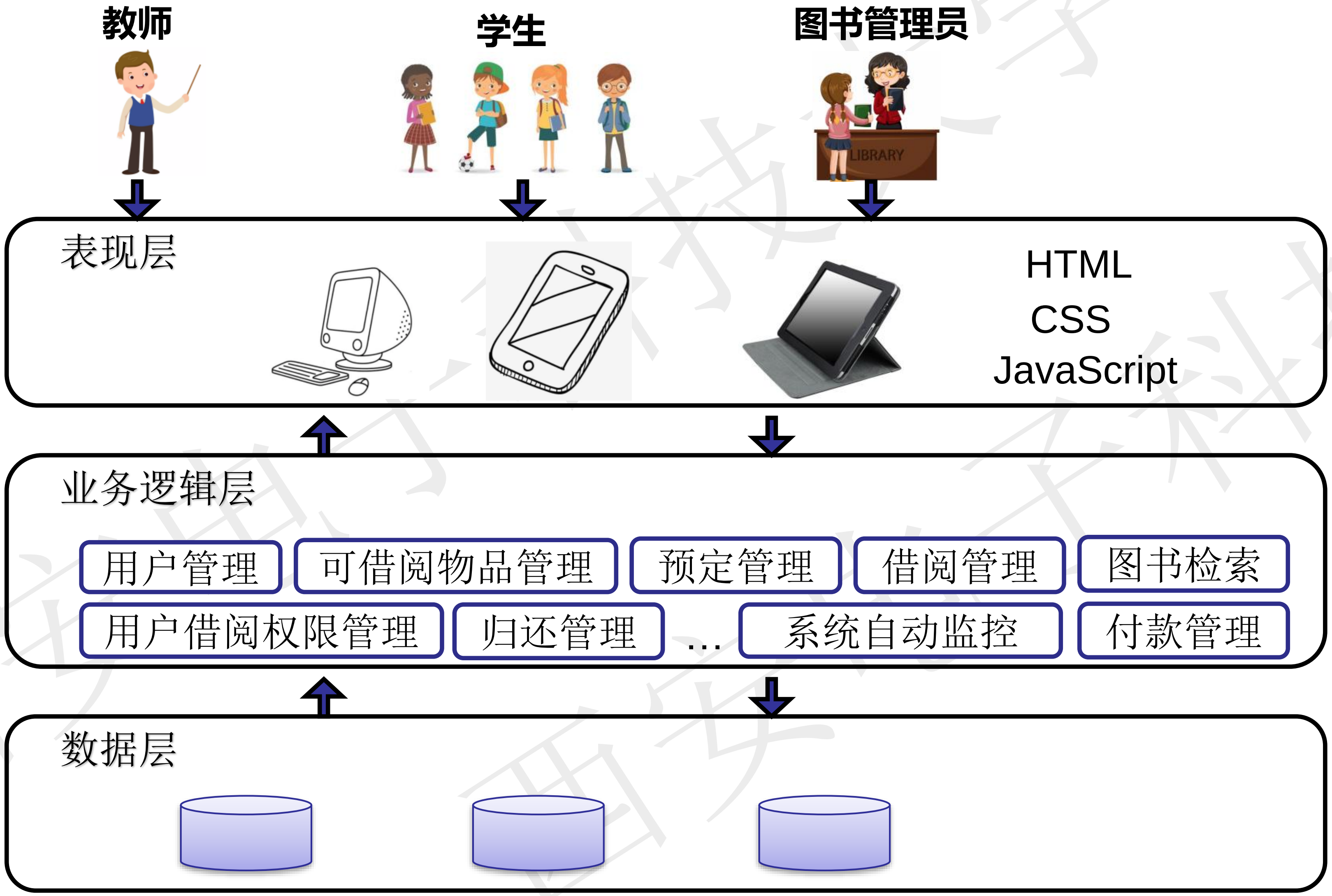
思考：有没有其他更好的架构风格呢？ Event system?

本节内容

图书借阅系统-高校图书馆系统需求

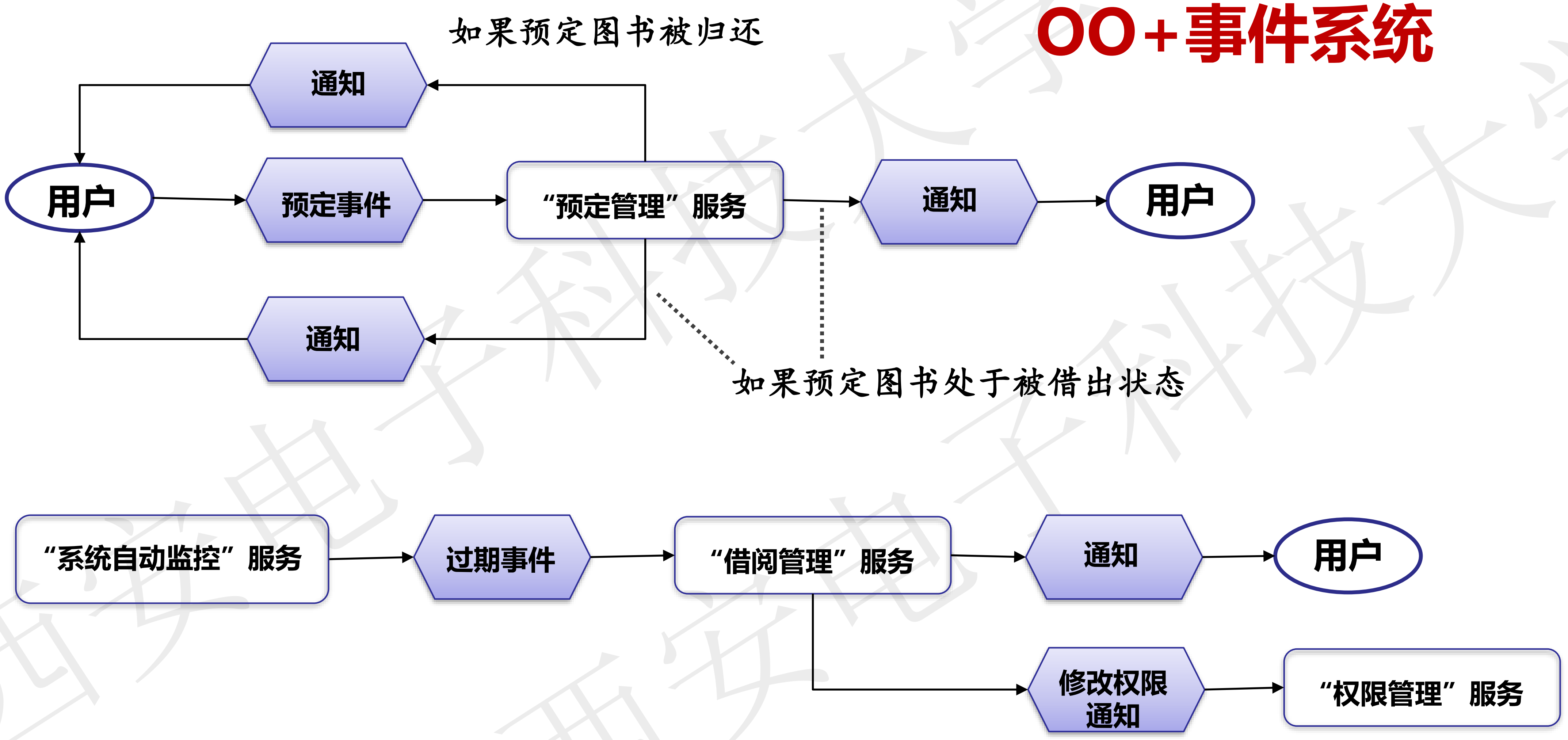
该系统向西安电子科技大学的师生提供图书借阅服务；有南校区和北校区两个图书存储地点(即2个分馆)，图书索引应能查询所有的分馆的信息；分馆之间不支持馆际借阅；学生一次可借阅16本书，1个月内归还；教师一次可借阅任何数量的书，2个月内归还；学生和教师均可以预定图书，如预定图书处于可借阅状态，预定有效期为1天；如果预定的图书正处于被借出状态，系统需要向借阅者发出一封email进行提醒；如果借阅的图书过期2周、6周、10周，则向借阅者发出email进行提醒；当过期未还时，该借阅者无法再借阅其他图书，而且当过期超过1个月后，每本书每天罚款1元；如果有未付清的罚款，借阅者也无法再借阅其他图书；除了图书之外，还提供杂志的借阅服务，借阅规则同图书相同。

图书借阅系统-架构设计


教师
学生
图书管理员
LIBRARY
表现层
HTML
CSS
JavaScript
业务逻辑层
用户管理
可借阅物品管理
预定管理
借阅管理
图书检索
用户借阅权限管理
归还管理
…
系统自动监控
付款管理
数据层

图书借阅系统-架构设计

OO+事件系统



图书借阅系统-连锁书店借阅系统需求

该系统为某连锁书店的图书借阅系统，向书店会员提供图书借阅服务；该市共有分布在不同地点的5家连锁书店，图书索引应能查询所有分店的信息；分店之间不支持跨店借阅与归还；普通会员一次可借阅10本书，3个月内归还；高级会员一次可借阅任何数量的书，6个月内归还；所有会员均可以预定图书，如预定图书处于可借阅状态，预定有效期为1周；如果预定的图书正处于被借出状态，系统会向借阅者发出一封email进行提醒；如果借阅的图书过期，系统将从过期之日起，每天向借阅者发出email进行提醒；当过期未还时，该借阅者无法再从任何分店借阅其他图书，而且当过期超过1周后，每本书每天罚款1元，从会员押金中自动扣除；如果有未付清的罚款，借阅者也无法再借阅其他图书；此外，还为高级会员提供杂志的借阅服务。

图书借阅系统-架构设计

"基于规则的系统"风格

"权限管理"服务

规则定义：

```
IF  用户类别="…" AND 项目类别="…"
THEN
    每次借阅的最大数目="…"
    最多借阅天数="…"
    超期后是否提醒="Y/N"
    超期后是否可再借阅="Y/N"
    超期是否罚款="Y/N"
    超期罚款标准="…"
    是否可预定="Y/N"
    预定请求的过期期限="…"
    预定是否付费="Y/N"
    预定的付费标准="…"
```

"用户管理"服务

规则定义：

```
IF  用户类别="…"
THEN
    需要交费成为会员="Y/N"
    费用标准="…"
    会员有效期="…"
```

图书借阅系统-借阅产品线

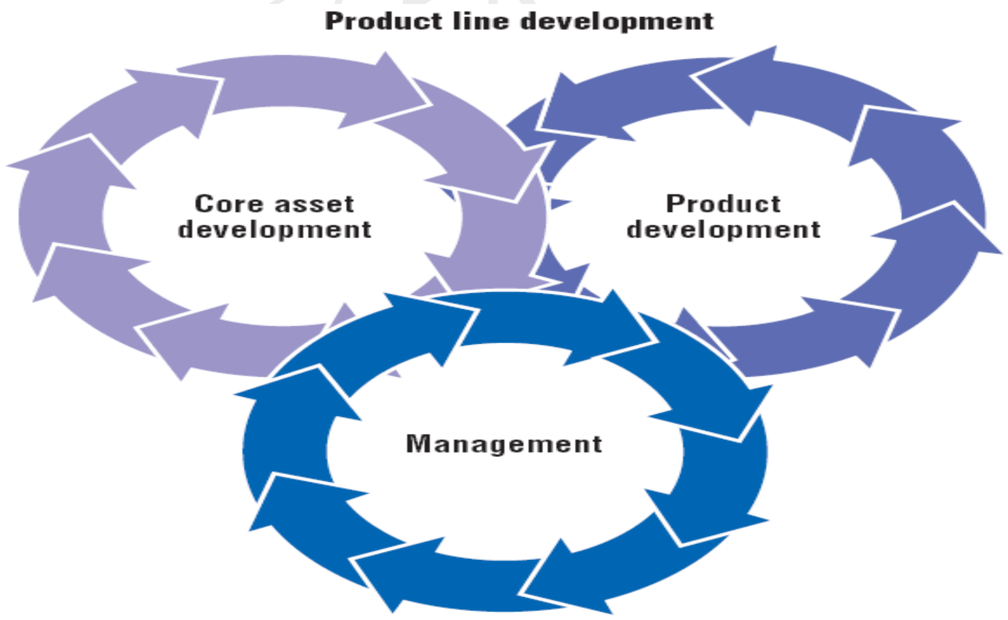
- Consists of a large number of items stored at one or more locations; (包含多个可借用的项目和多个存储位置)
- A library has customers; (有多个客户)
- Four primary actions which are performed: (主要操作)
  - 1) Removal of an item from the library by a customer (用户从库中借出某些项目)
  - 2) A customer can return an item. (用户向库还回某些项目)
  - 3) Allow customers to search for a given item by keywords; (允许用户通过关键字查询库中所拥有的可借阅项目)
  - 4) Auxiliary operations: (其他辅助操作)
    - Adding and deleting customers (注册或删除用户);
    - Adding and deleting items (增加或删除可借阅的项目);
    - Customers pay money (用户支付借阅的费用);
    - A customer may not be allowed to borrow an item (某个用户可能不允许借用某些项目);
    - A customer may place a hold on an item (用户可预定某些项目);
    - A customer can request an interlibrary loan (用户可请求一个馆际借阅);

图书借阅系统-产品线

A software product line is a set of software-intensive systems that share a common, managed feature set satisfying a particular market segment’s specific needs or mission and that are developed from a common set of core assets in a prescribed way. (软件产品线是一组软件系统，共享一组通用的特征集合，通过使用一组预先开发的/通用的核心资产来满足不同产品的研发需求)

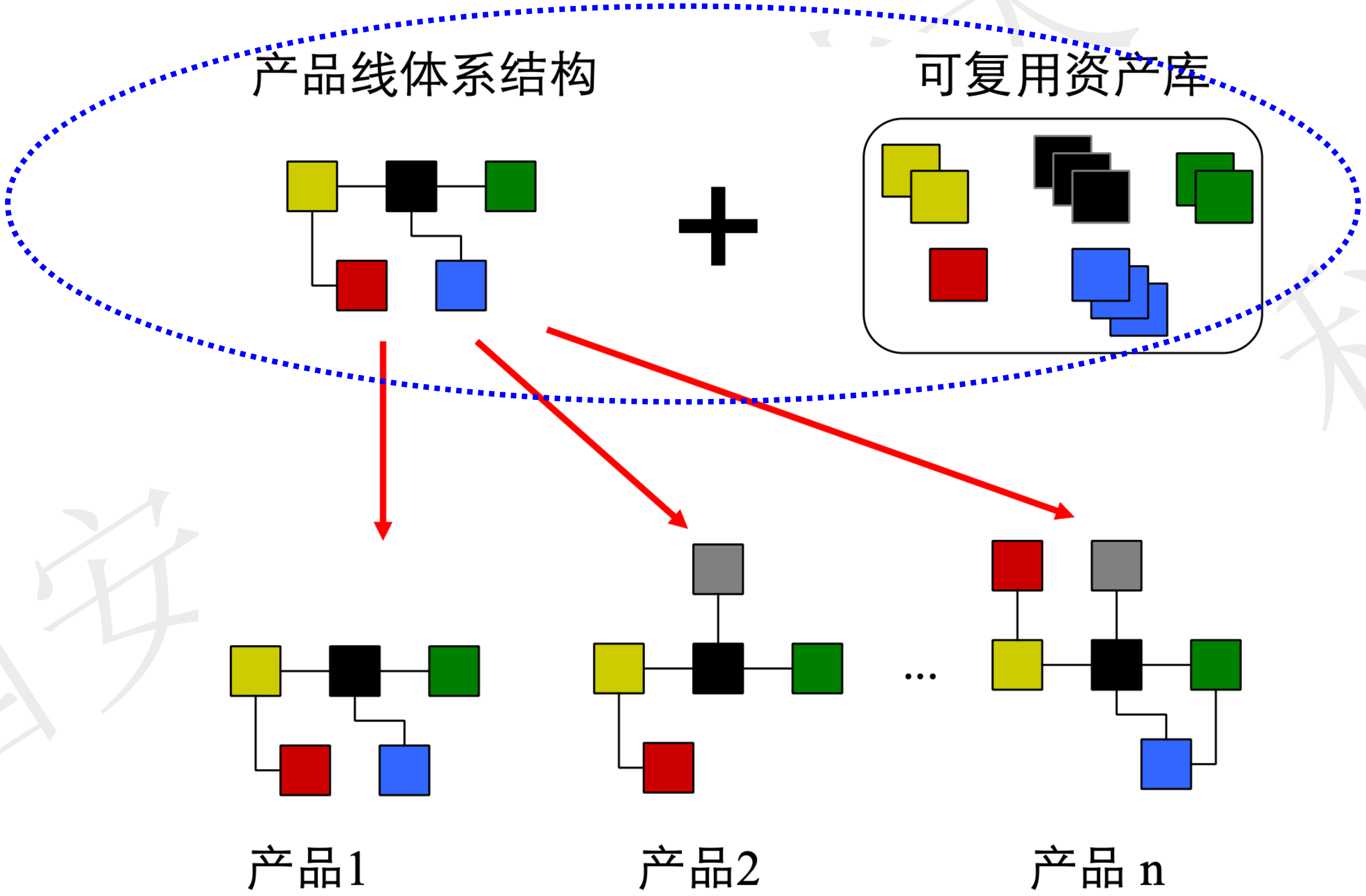
图书借阅系统-产品线

- Core asset development (核心资产开发)
- Under the aegis of technical and organizational management (核心资产管理)
- Product development using the core assets (产品开发)



图书借阅系统-产品线

Core asset development (核心资产开发)



图书借阅系统-产品线

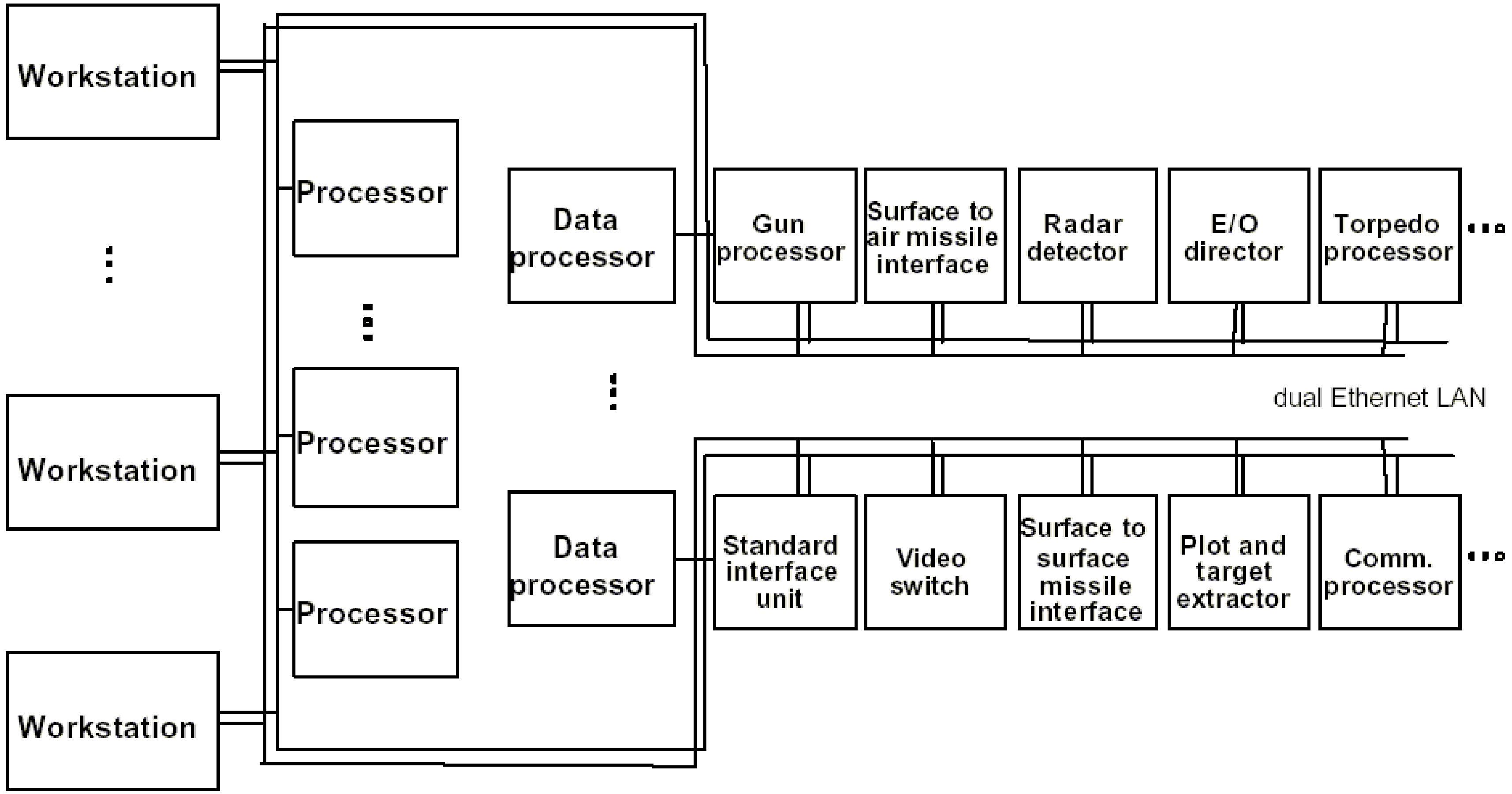
产品线的若干实践案例

- Mobile phones (移动电话)
- Command and control ship systems (舰船控制系统)
- Ground-based spacecraft systems (飞船地面控制系统)
- Avionics systems (航空系统)
- Engine control systems (引擎控制系统)
- Billing systems (帐务系统)
- Web-based retail systems (零售系统)
- Printers (打印机)
- Consumer electronic products (个人电子消费产品)

图书借阅系统-产品线

CelsiusTech的产品线

SS2000 Architecture



图书借阅系统-音像借阅系统

课后思考

有多个音像店，通过网络连接，搜索引擎需要能够搜索所有音像店的产品信息；系统支持多个店之间的互借；顾客需交纳年费才能成为会员，当会员资格即将过期时，系统向其发出缴费通知；如果会员资格过期，不允许再次借阅；音像产品按类别进行组织，但发行日期在三个月内时，将被看作“新片”；系统每天进行检索，将“新片”里不再是“新片”的video归到特定的类别里；借阅video的收费策略为：按天借阅：3元/天，但新片5元/天；按周借阅：12元/周；打包借阅：25月/3片/周；当video被归还时才开始计费，如果超期归还，按照收费标准进行额外的计费；在同一时间，一个顾客手头借阅的video最多为7片。

本案例来源于网络

西安电子科技大学
XIDIAN UNIVERSITY

计算机科学与技术学院
SCHOOL OF COMPUTER SCIENCE AND TECHNOLOGY
国家示范性软件学院
NATIONAL PILOT SCHOOL OF SOFTWARE ENGINEERING

计算机科学与技术学院微信

课程讨论群

蔺一帅 讲师 硕导

邮箱：yslin@xidian.edu.cn

主页：https://web.xidian.edu.cn/yslin/