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CS 106A

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String Processing Slides

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Enigma

Cryptography at Bletchley Park

I have twice taught courses at Stanford in Oxford when we have visited Bletchley Park, which served as the headquarters for the British decryption effort during the war.

The museum at Bletchley contains working models of the decryption machines designed by Alan Turing, just as they appeared in the *Enigma* trailer.

The first time around, we were lucky to have Jean Valentine, who worked in Hut 6 during the war, as our host at Bletchley.

Stanford's Contribution to Cryptography

- Stanford has always been in the forefront of cryptographic research. In 1976, Professor of Electrical Engineering Martin Hellman and his students Ralph Merkle and Whitfield Diffie developed public-key cryptography, which revolutionized the process of coding messages.
- Although Hellman, Diffie, and Merkle were granted a U.S. patent for their work, it turns out that much the same technology was invented in England by the successor to the Government Code and Cipher School at Bletchley Park. That work, however, remained classified until the 1990s and had no commercial impact.

Merkle/Hellman/Diffie in 1976

Encryption

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
L Z D R X P E A J Y B Q W F V I H C T G N O M K S U

Twas brillig, and the slithy toves,
Did gyre and gimble in the wabe:
All mimsy were the borogoves,
And the mome raths outgrabe.

Twas brillig, and the slithy toves,
Did gyre and gimble in the wabe:
All mimsy were the borogoves,
And the mome raths outgrabe.

Creating a Caesar Cipher

```
public void run() {
private String encodeCaesarCipher(String str, int key) {
   if (key < 0) key = 26 - (-key % 26);
   String result = "";
   for (int i = 0; i < str.length(); i++) {
      char ch = str.charAt(i);
      if (Character.isUpperCase(ch)) {
         ch = (char) ('A' + (ch - 'A' + key) % 26);
      }
      result += ch;
   }
   return result;
}
```

ch	i	result	str	key
'B'	11	MDEEHUZRFNB	JABBERWOCKY	3

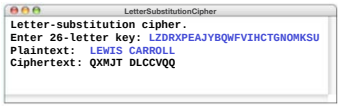
CaesarCipher

```
This program implements a Caesar cipher.
Character positions to shift: 3
Enter a message: JABBERWOCKY
Encoded message: MDEEHUZRFNB
```

Exercise: Letter Substitution Cipher

One of the simplest types of codes is a ***letter-substitution cipher,*** in which each letter in the original message is replaced by some different letter in the coded version of that message. In this type of cipher, the key is often presented as a sequence of 26 letters that shows how each of the letters in the standard alphabet are mapped into their enciphered counterparts:

```
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
| | | | | | | | | | | | | | | | | | | | | | | | | | |
L Z D R X P E A J Y B Q W F V I H C T G N O M K S U
```



A Case Study in String Processing

Section 8.5 works through the design and implementation of a program to convert a sentence from English to Pig Latin. At least for this dialect, the Pig Latin version of a word is formed by applying the following rules:

1. If the word begins with a consonant, you form the Pig Latin version by moving the initial consonant string to the end of the word and then adding the suffix *ay*, as follows:

   scram ⟶ *amscray*

2. If the word begins with a vowel, you form the Pig Latin version simply by adding the suffix *way*, like this:

   apple ⟶ *appleway*

Starting at the Top

- In accordance with the principle of top-down design, it makes sense to start with the **`run`** method, which has the following pseudocode form:

```
public void run() {
   Tell the user what the program does.
   Ask the user for a line of text.
   Translate the line into Pig Latin and print it on the console.
}
```

- This pseudocode is easy to translate to Java, as long as you are willing to include calls to methods you have not yet written:

```
public void run() {
   println("This program translates a line into Pig Latin.");
   String line = readLine("Enter a line: ");
   println(translateLine(line));
}
```

Designing `translateLine`

- The **`translateLine`** method must divide the input line into words, translate each word, and then reassemble those words.
- Although it is not hard to write code that divides a string into words, it is easier still to make use of existing facilities in the Java library to perform this task. One strategy is to use the **`StringTokenizer`** class in the **`java.util`** package, which divides a string into independent units called ***tokens***. The client then reads these tokens one at a time. The set of tokens delivered by the tokenizer is called the ***token stream***.
- The precise definition of what constitutes a token depends on the application. For the Pig Latin problem, tokens are either words or the characters that separate words, which are called ***delimiters***. The application cannot work with the words alone, because the delimiter characters are necessary to ensure that the words don't run together in the output.

The `StringTokenizer` Class

- The constructor for the **`StringTokenizer`** class takes three arguments, where the last two are optional:
  - A string indicating the source of the tokens.
  - A string which specifies the delimiter characters to use. By default, the delimiter characters are set to the whitespace characters.
  - A flag indicating whether the tokenizer should return delimiters as part of the token stream. By default, a **`StringTokenizer`** ignores the delimiters.
- Once you have created a **`StringTokenizer`**, you use it by setting up a loop with the following general form:

```
while (tokenizer.hasMoreTokens()) {
   String token = tokenizer.nextToken();
   code to process the token
}
```

The `translateLine` Method

- The existence of the **`StringTokenizer`** class makes it easy to code the **`translateLine`** method, which looks like this:

```
private String translateLine(String line) {
   String result = "";
   StringTokenizer tokenizer =
     new StringTokenizer(line, DELIMITERS, true);
   while (tokenizer.hasMoreTokens()) {
      String token = tokenizer.nextToken();
      if (isWord(token)) {
         token = translateWord(token);
      }
      result += token;
   }
   return result;
}
```

- The **`DELIMITERS`** constant is a string containing all the legal punctuation marks to ensure that they aren't combined with the words.

The `translateWord` Method

- The **`translateWord`** method consists of the rules for forming Pig Latin words, translated into Java:

```
private String translateWord(String word) {
   int vp = findFirstVowel(word);
   if (vp == -1) {
      return word;
   } else if (vp == 0) {
      return word + "way";
   } else {
      String head = word.substring(0, vp);
      String tail = word.substring(vp);
      return tail + head + "ay";
   }
}
```

- The remaining methods (**`isWord`** and **`findFirstVowel`**) are both straightforward. The simulation on the following slide simply assumes that these methods work as intended.

The `PigLatin` Program

```
public void run() {
private String translateLine(String line) {
private String translateWord(String word) {
   int vp = findFirstVowel(word);
   if ( vp == -1 ) {
      return word;
   } else if ( vp == 0 ) {
      return word + "way";
   } else {
      String head = word.substring(0, vp);
      String tail = word.substring(vp);
      return tail + head + "ay";
   }
}
```

vp	head	tail	word
1	l	atin	latin