Searching in encrypted data

or ”How your tax-evasion will only be seen by you! (and us)”

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Agenda

1. Assignment
2. Requirements
3. Design
4. Implementation details
5. Demo
6. Conclusion & Questions

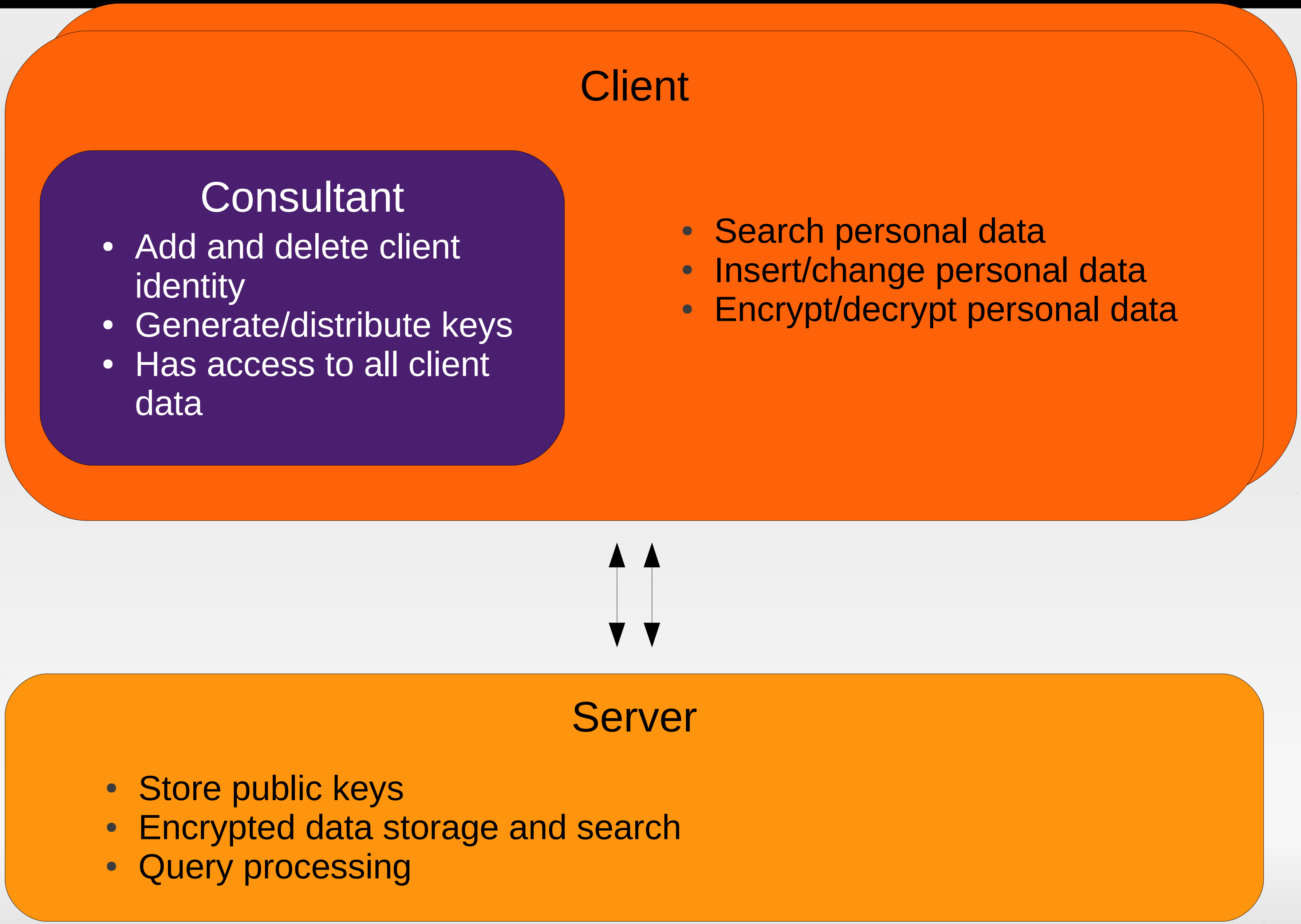
Assignment

- Consultant that stores (financial) data of his clients on a storage server
- Both he/she and the clients should be able to access and search in the data
- How to ensure data privacy when the server is honest but curious?

Requirements

- The consultant must have access to all data
- The clients may only access their own data
- Insertion and searching should be supported
- Storage server should not be able to learn about the actual data

Design



Client

Consultant

- Add and delete client identity
- Generate/distribute keys
- Has access to all client data

- Search personal data
- Insert/change personal data
- Encrypt/decrypt personal data

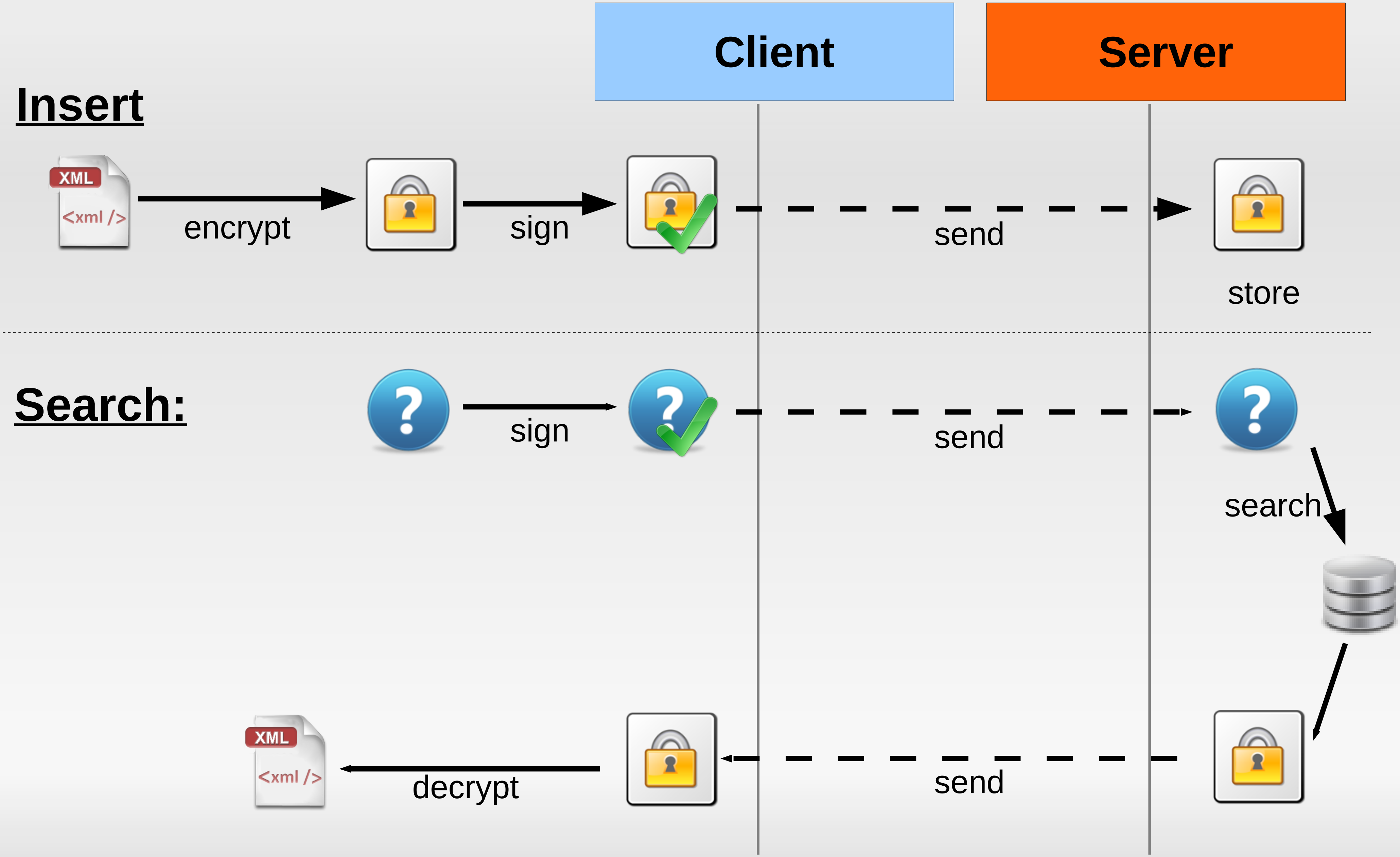
Server

- Store public keys
- Encrypted data storage and search
- Query processing

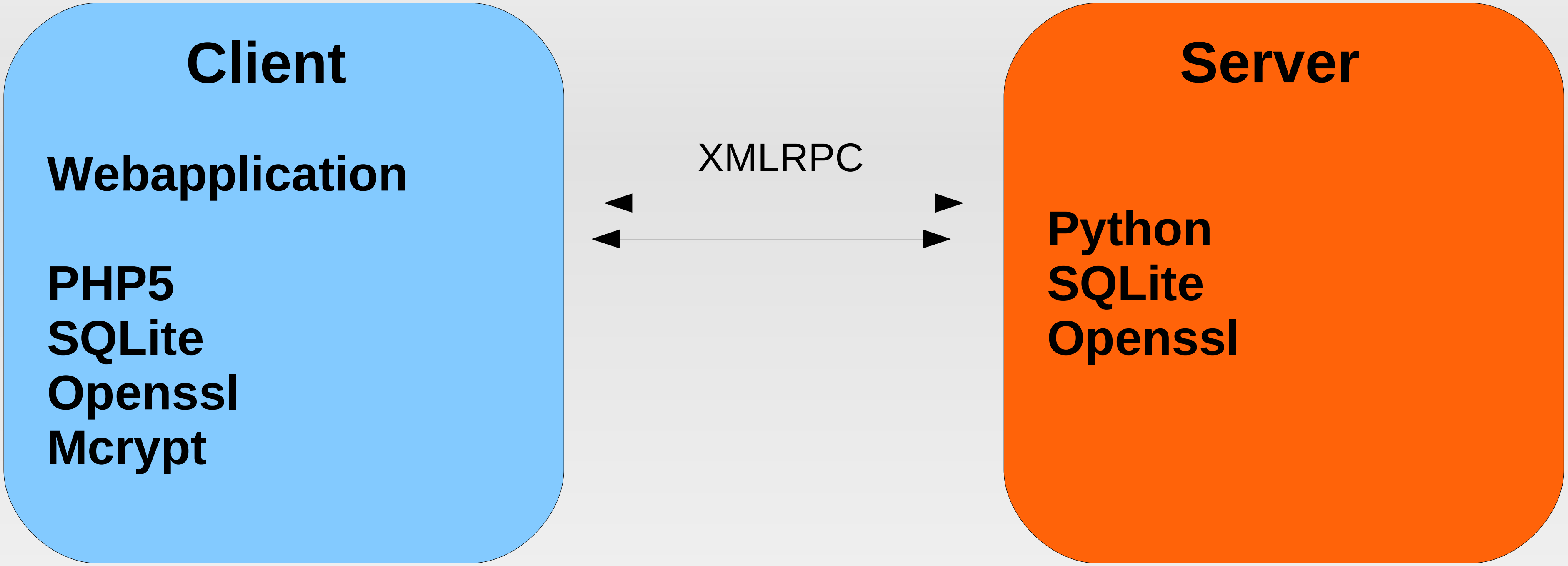
Design

- Every client has three keys associated with his identity
  - Encryption key
  - Hash key
  - RSA private key
- The consultant has a private RSA key
- The server has all public keys

Design


Client
Server
Insert
XML
<xml />
encrypt
sign
send
store
Search:
sign
send
search
send
XML
<xml />
decrypt

Implementation Details



Client

Webapplication

PHP5
SQLite
Openssl
Mcrypt

XMLRPC

Server

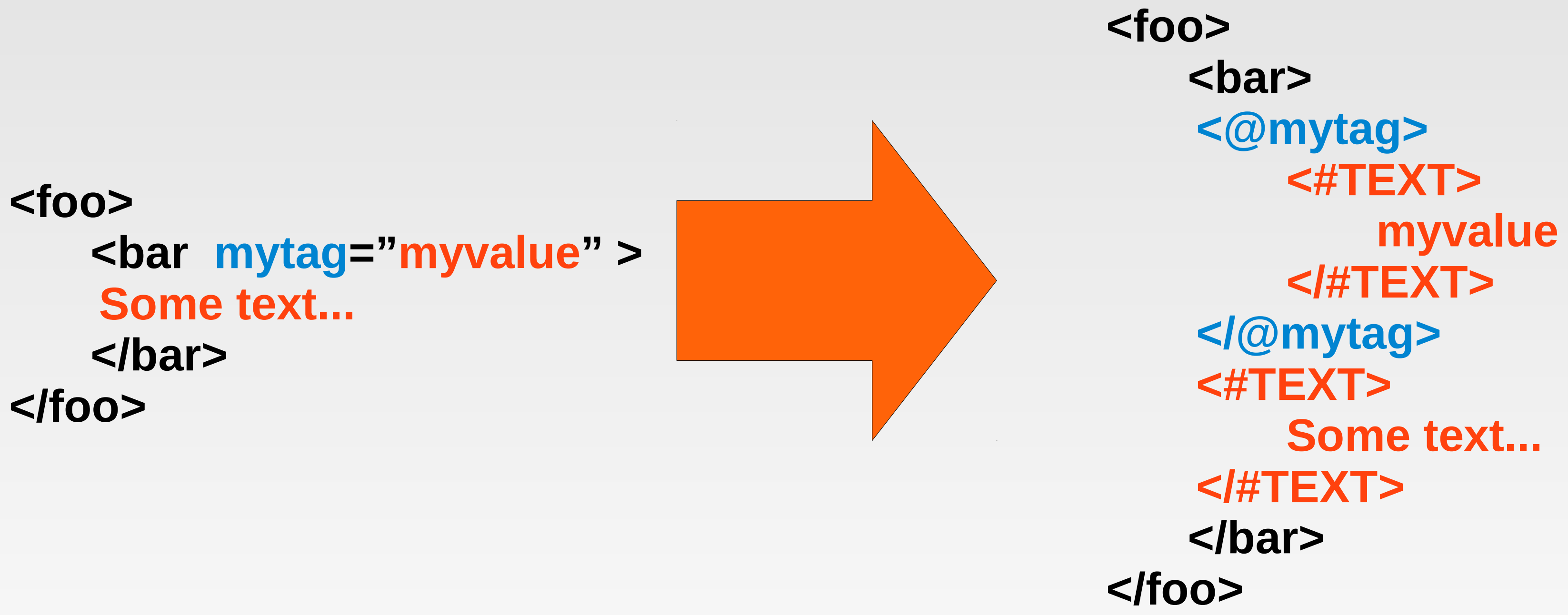
Python
SQLite
Openssl

Implementation Details

- Searchable encryption approach from paper ”Efficient Tree Search in Encrypted Data”
- XML document is converted so it can be stored in a relational database.
  - One row per XML node
- Each row is encrypted by the client according to the algorithm.
- Server can execute XPath queries on the data without learning about the XML tags or values.

Implementation Details

- Preprocess XML so everything is a node with a tag and value.



```
<foo>
    <bar  mytag="myvalue" >
     Some text...
    </bar>
</foo>
```

```
<foo>
    <bar>
     <@mytag>
         <#TEXT>
             myvalue
         </#TEXT>
     </@mytag>
     <#TEXT>
         Some text...
     </#TEXT>
    </bar>
</foo>
```

Implementation Details

- Convert XML nodes to pre-post-parent format.

	pre	post	parent
<foo>	0		-1
<bar>	1		0
<@mytag>	2		1
<#TEXT>	3		2
myvalue			
</#TEXT>		0	
</@mytag>		1	
<#TEXT>	4		1
Some text...			
</#TEXT>		2	
</bar>		3	
</foo>		4	

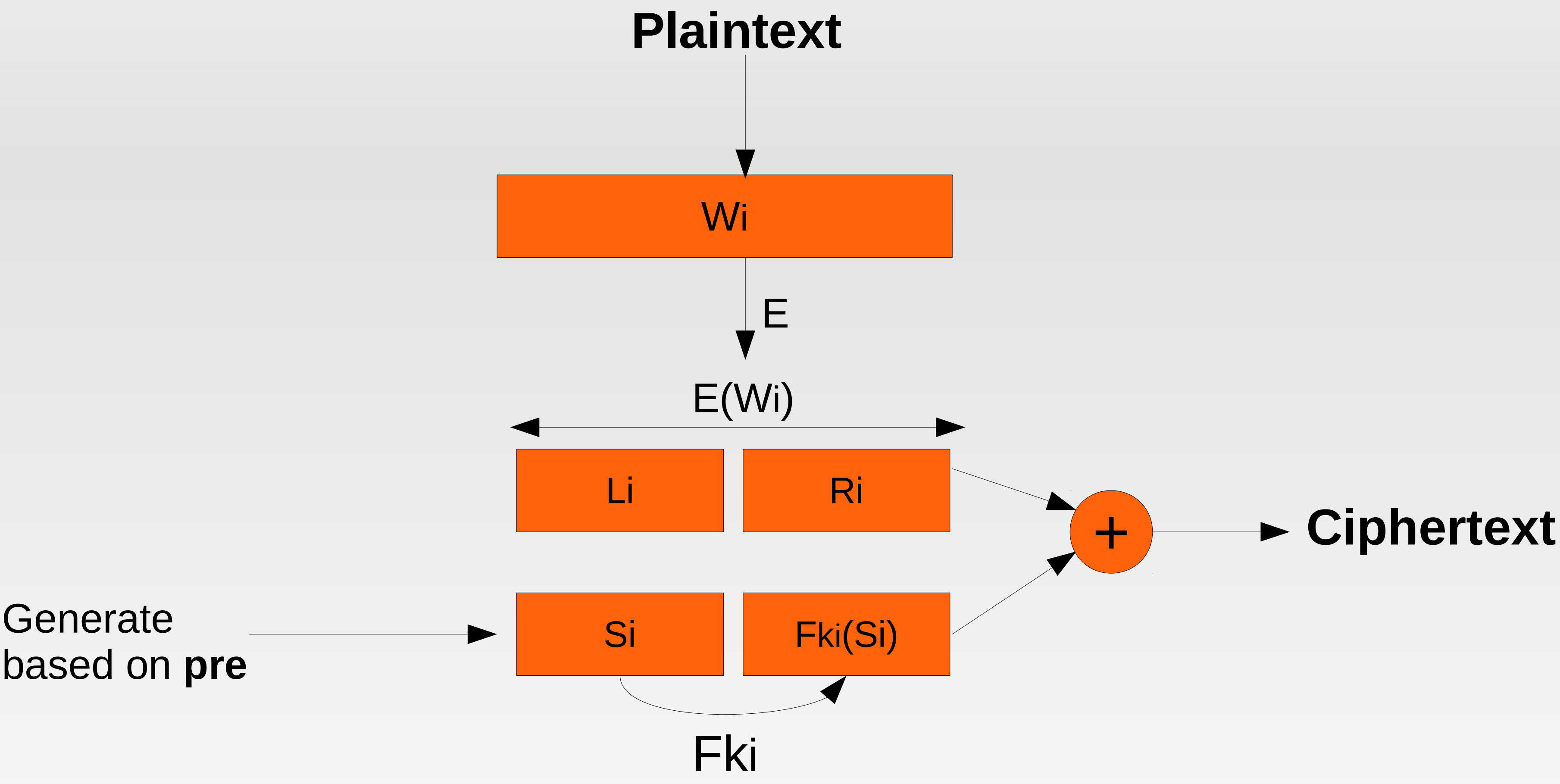
Implementation Details

- The resulting SQL rows then need to be encrypted by the client

```
<foo>
    <bar  mytag=”myvalue” >
     Some text...
    </bar>
</foo>
```

pre	post	parent	tag	value
0	4	-1	foo	
1	3	0	bar	
2	1	1	@mytag	
3	0	2	#TEXT	myValue
4	2	1	#TEXT	Some text...

Encryption Scheme



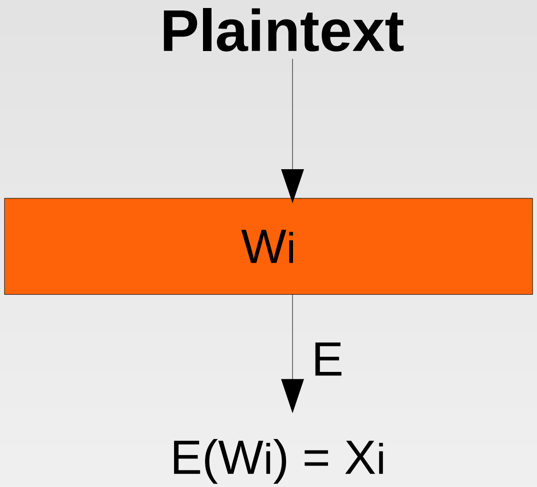
E = 128 bit AES
F = 128 bit AES
Signing (not displayed) = 1024 bit RSA

Encryption Scheme

- Recall: every client has three keys associated with his identity
  - Encryption key
  - Hash key
  - RSA private key

Encryption Scheme

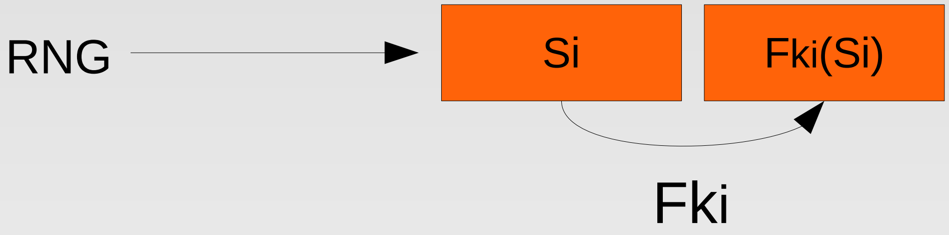
- **Encryption key**



- E is AES-128 keyed with the encryption key
- The encrypted plaintext is called Xi

Encryption Scheme

- **Hash key**



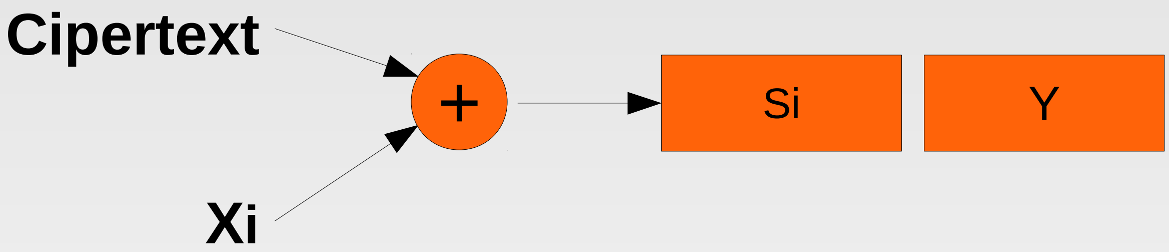
- F is AES-128 keyed with ki
- ki is the elements' unique hash key
- ki is calculated by encrypting Si with Hash key

Search Scheme

- XPath query: **/foo**
- Client reproduces **<ki, Xi>** from the plaintext
- Plaintext terms in the Xpath query are substituted with these tuples.
- Query is sent to the server.

Search Scheme

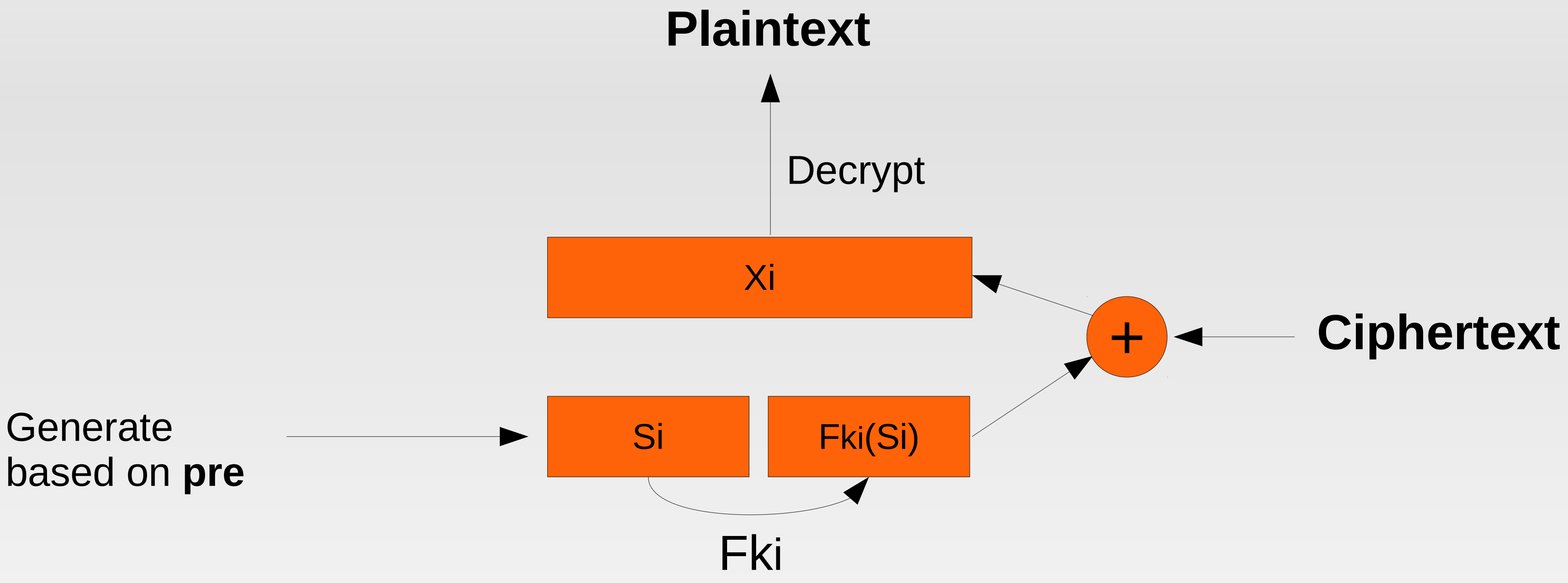
- The server checks the relation using the element-specific hash key ki.



$$Y = F_{ki}(Si) \;\; ?$$

- The node is a match when the hash matches Y.

Decryption Scheme



Demo

Conclusion & Questions

- Questions?