An efficient installation for applets to be post-issuance of Java Card system using an IC chip

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Abstract: Most smart cards based on the Java Card need an installer for deploying a new applet into its memory after the cards were issued. Installing the applet takes lots of time because of unique components downloading and hardware limitations. An efficient installation for applets in the Java Card platform is investigated. The proposed scheme could improve applet installation time significantly compared to the conventional scheme by fully utilizing available RAM space and could present the best a block size to be transferred between a terminal and JCRE.

Keywords: IC card, Java Card, JCRE, installation, resolution, post-issuance

Classification: Integrated circuits

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1 Introduction

Java Card has recently been recognized as a dominating platform for smart cards and SIM/USIM cards using an Integrated Circuit (IC) chip [1, 2, 3, 5, 6, 8]. The Java Card system is issued with previously made applets and is also able to download a new applet whenever users or vendors need after it is issued. These methods are called pre-issuance and post-issuance [1, 2, 3]. In order to download a new applet is different from a standard Java platform because the Java Card platform runs a tiny Java Card Runtime Environment (JCRE) optimized for an embedded device with limited memory and computing power in the IC chip. There are some reasons why the Java Card consumes much time in installing a new applet. First of all, applets and its objects are stored into Flash memory of the JCRE in the IC chip. The cost of RAM for the Java Card is still expensive, so many manufacturers more use Flash as storage. However, writing data to Flash cells is more 1,000 times slow than RAM memory [7]. Second of all, applets to be post-issuance need a process of memory mapping. References in the applet code to be developed must be resolved and updated to refer to direct references in the JCRE memory space during the installation process. The reference resolution performed during an applet installation creates significant memory copy overhead incurred by writing data into Flash multiple times.

We have investigated an efficient installation for an applet in the Java Card platform using an IC chip. The major scheme of the installation is to fully utilize available RAM buffer size to significantly reduce memory copy overhead during reference resolution processes. It exploits efficient block sizes for transferring components with reduced acknowledgement APDU messages.

2 Experimental

In the conventional Java Card platform, because of limited RAM space, the installer applet in the on-card platform first downloads the target applet CAP file components into Flash and copies them into RAM when reference resolution is performed. In general, because Flash memory writing speed is more than 1,000 times slower than that of RAM, the reference resolution performed during an applet installation creates significant memory copy overhead incurred by writing data into Flash multiple times.

The proposed efficient installation scheme is summarized as like that the scheme fully utilizes available RAM buffer size to significantly reduce memory copy overhead incurred by the redundant Flash copies during reference resolution processes. Our scheme exploits efficient mode for transferring components with reduced acknowledgement APDU messages. Based on the statistical characteristics of an applet being installed, the scheme empirically

Fig. 1. The resolution and linking processes of the proposed efficient installation scheme. It uses available RAM space instead of Flash to resolve references for objects, static fields, variables and array. All data of component is transferred by a block that is 256 bytes.

identifies optimal block size suitable for reducing installation time. Fig. 1 shows our efficient scheme that is fully utilization of RAM space instead of Flash memory.

In order to evaluate the efficiency of the proposed installation scheme, we have conducted a series of experiments in the S3FS9QB, ARM 32 MCU smart card development environment. This single-chip CMOS micro-controller enabled development environment is specifically designed and packaged for Java Smart Card applications. The S3FS9QB has 8K bytes ROM for built-in boot loader, 256K bytes program Flash, 8K bytes RAM, and serial I/O interfaces [10].

3 Result and discussions

The installation process requires component downloading, resolution, and allocation. Hence the installation process should be evaluated in terms of communication time, between off-card and on-card, and of CPU processing time. In order to accurately estimate the CPU processing time of the on-card platform, we developed a new API that can be easily invoked to get CPU processing time by the Installer applet.

As we can see from Table I, the overall installation time required by the proposed our efficient scheme was significantly reduced as compared to the conventional scheme. Our scheme could reduce 38% of the communication time compared to the conventional scheme. The communication time reduction is more significant when the applet size is larger.

Table II shows the CPU processing time required for various applet installations. CPU processing time is mainly used for handling address resolutions. Using the RAM more efficiently during the resolution processes could out-

Table I. Total installation time for the various applets (times in milliseconds).

Applets	Size(KB)	Conventional (37B)	Our scheme(256B)	Gain(%)
ChannelDemo	3.15	132040	80721	39
JavaLoyalty	2.04	127932	87222	32
JavaPurse	10.70	394675	216987	45
ObjectDeletion	5.76	285286	175727	38
PackageA	3.77	167653	96114	43
PackageB	2.13	134447	90834	32
PackageC	0.68	61022	43488	29
Photocard	2.32	118479	73785	38
RMIDemo	1.75	107322	69051	36
Wallet	2.05	99946	63096	37
EMV_Applet	6.88	204041	112410	45

Table II. Real CPU processing time for installation (times in milliseconds).

Applets	Size(KB)	Conventional (37 B)	Our scheme(256 B)	Gain(%)
ChannelDemo	3.15	44486.51	34131.47	23
JavaLoyalty	2.04	41661.39	38754.86	7
JavaPurse	10.70	147803.17	104525.17	29
ObjectDeletion	5.76	108197.91	84969.29	21
PackageA	3.77	62562.29	43403.18	31
PackageB	2.13	45441.15	41548.25	9
PackageC	0.68	15685.87	16504.98	-5
Photocard	2.32	40589.34	31009.97	24
RMIDemo	1.75	36620.01	28862.75	21
Wallet	2.05	31008.27	24950.73	20
EMV_Applet	6.88	69037.32	50101.78	27

perform the conventional Installation scheme. Address resolution is needed only for two components, namely, Method and ConstantPool components by using offset values of ReferenceLocation component. The CPU processing time depends on the file size of an applet, especially the size of Method and Constant Pool components. For example, BigApplet has the large file size and therefore has large Method and Constant Pool components. The CPU processing time for the BigApplet address resolution could be significantly reduced. However in some cases such as PackageC applet, which has smallest file size, the CPU processing time is slightly more than the processing time by the conventional scheme. The reason is that our scheme needs to parse components. The parsing time overhead for a small applet was slightly more than the performance gain obtained by effectively using the RAM for the resolution processes. Overall we could reduce about 20% CPU processing time for applet installations by using our scheme.

We also tried to identify optimal block size that could maximally reduce installation time. As shown in Table III (a) and III (b), reducing communication overhead between off-card and on-card installer by the proposed scheme could be obtained when the block size is bigger than 165 bytes. The conventional method transfers block of size 37 bytes with acknowledgment between on-card and off-card.

Therefore the communication overhead is much bigger than that used in

Table III. Applet installation time in terms of transferring block size (unit (%)).

(a) Total applet installation times

Block size(B) Applets	69	101	133	165	197	229	256
ChannelDemo	27	32	36	38	39	40	39
JavaLoyalty	25	27	30	30	31	31	32
JavaPurse	31	35	40	42	43	44	45
ObjectDeletion	30	33	35	36	38	39	38
PackageA	33	36	39	41	42	43	43
PackageB	27	29	30	31	32	33	32
PackageC	24	28	28	26	29	29	29
Photocard	27	32	35	36	37	38	38
RMIDemo	28	31	33	34	35	36	36
Wallet	26	30	33	36	36	37	37
EMV_Applet	25	34	39	42	44	45	45
Average	28	34	35	36	38	38	38

(b) CPU processing times

Block size(B) Applets	69	101	133	165	197	229	256
ChannelDemo	9	15	20	22	23	24	23
JavaLoyalty	0	1	4	5	6	6	7
JavaPurse	14	20	24	26	27	28	29
ObjectDeletion	10	15	17	19	21	22	21
PackageA	15	24	26	28	30	31	31
PackageB	2	4	5	6	8	9	9
PackageC	-9	-7	-6	-10	-5	-5	-5
Photocard	11	17	20	21	22	23	24
RMIDemo	13	16	18	19	21	21	21
Wallet	7	10	14	18	18	20	20
EMV_Applet	4	15	21	23	26	28	27
Average	7	13	16	17	19	20	20

the proposed efficient scheme. Our efficient scheme however has overhead for parsing components from the transferred data. The parsing overhead could be well offset by having block size bigger than 37 bytes. The peak performance could be obtained when the block size becomes larger than 165 bytes.

4 Conclusion

In this paper, we have investigated an efficient scheme for installing an applet efficiently in the Java Card platform. The salient features of our scheme are efficient installation of an application applet by fully utilizing available RAM space and by reducing communication overhead for downloading applet data with adjustable parameter tuning such as transferring data block size. The proposed novel installation scheme could reduce the installation time required for an applet by about 38% compared to the conventional installation scheme.

The Java Card 2.2.1 is designed with RAM size 1~2K bytes. It is projected to have an on-card platform with the RAM size of about 6~10K in near future. Our proposed scheme is therefore especially suitable and useful for improving the performance of the Java Card Platform by fully utilizing increased RAM space and asynchronous component transfer mode.

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