Ubiquitous Environmental Control System (UECS)

Basic Communication Protocol Book

For version 1.00

June 9, 2012 (English revision) (Based on
June 10, 2010 Japanese version)

Contents

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1. Introduction

The Ubiquitous Environmental Control System (UECS) was proposed for further development of Japanese protected horticulture. The system is a decentralized greenhouse environmental control system for exchanging a stylized communication message described by Extensible Markup Language (XML). Due to the interest in our information-oriented society, requests have been received for worldwide use of the UECS technology outside the Japanese greenhouse environmental control field. To answer these requests, the Basic Communication Protocol Book for UECS version 1.00 (hereafter, called the "Book") was published as an open infrastructure for an information exchange standard in agriculture. We strongly expect that the UECS technology will contribute to the development of agriculture information.

The stylized communication message in the UECS is called the Common Communication Message (CCM). Each component of the UECS uses the CCM to exchange information. The Book defines only a top-level communication protocol that has been subjected to various interpretations. Therefore, it is not practical to adopt a system using only the Book. When one uses the UECS technology in other domains, we recommend defining an application protocol that expands the contents of the Book for each domain. In the greenhouse environmental control field, we strongly recommend using the Application Protocol Book for greenhouse environmental control (version 1.00-E10).

The Book was edited for the person who would like to understand the central theory of the UECS technology and to use the Application Protocol Books for each domain. If someone develops an application system that is not based on the Book, the application system may not necessarily operate in cooperation with other UECS family systems. We strongly recommend using the established specific Application Protocol Book based on this Book.
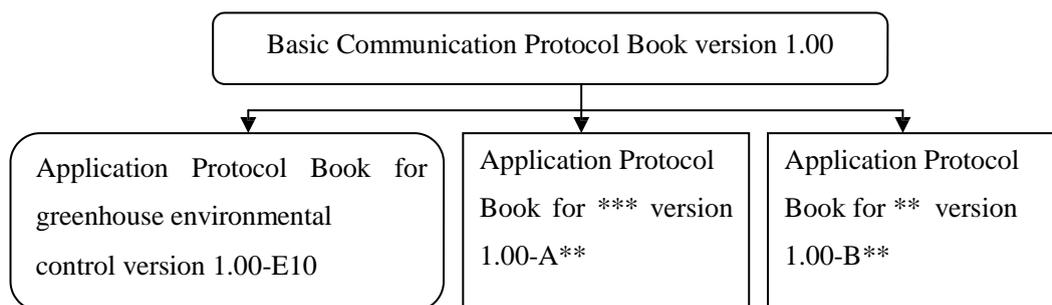

Fig. 1-1 Hierarchy of UECS communication protocols.

As the infrastructure of the information exchange standard in the field of agriculture, the Basic Communication Protocol Book version 1.00 was created. The UECS consortium has the copyrights of the Basic Communication Protocol Book version 1.00 and Application Protocol Book for greenhouse environmental control version 1.00-E10.

2. UECS-CCM schema

The CCM describes the numerical values for measurement and control, such as actual measurements, conditions, orders, set-points, and goals. We refer to a "CCM communication" as the exchange of CCMs, including special CCMs for history information and node information, where a node is each component in the UECS. The CCM was written in Extensible Markup Language (XML), created by the World Wide Web Consortium (W^{3}C). The basic outline of the CCM is shown as follows:

```
<?xml version="1.0"?>
<UECS ver="1.00">
  <!— specific descriptions -->
</UECS>
```

A specific description in CCM communication must be described within the UECS tag. Descriptions inside the UECS tag are only accepted as the correct information on the receiver side. The use of plural UECS tags is permitted in the Basic Communication Protocol Book. However, it may be limited in some Application Protocol Books.

The character code of the CCM is 8 bit US ASCII code (ISO 646-1991, with the addition of a "0" bit to the most significant bit). Other character codes longer than 2 bytes, such as UTF, Shift JIS, etc., are not available. The UECS nodes distinguish between upper case characters and lower case characters. We can use CR (Carriage Return) and/or LF (Line Feed) characters to insert line feeds in the descriptions in CCM communication. The UECS nodes ignore these characters and also consider characters greater than two spaces as space characters. As a general rule, 0x20 (hexadecimal value) to 0x7f plus CR and LF characters are used.

The "1.00" value of the "ver" attribute in the UECS tag denotes CCM communication based on the Basic Communication Protocol Book. A specific identifier description with a hyphen character was added to denote CCM communication based on the Application Protocol Book, as shown:

```
<?xml version="1.0"?>
<UECS ver="1.00-E10">
<!— specific descriptions -->
</UECS>
```

This example shows that the CCM is based on the Basic Communication Protocol Book version 1.00 and the Application Protocol Book for greenhouse environmental control version 1.00-E10.

Attributes within the UECS tag are freely available; however, no one can use the ver="1.00" attribute without the UECS consortium permission. For interoperability with the provisional communication protocol of the UECS, CCM communication without the "ver" attribute is available; however, functionality conforming to the Book is thus not guaranteed. The specific correspondence of the CCM communication without the "ver" attribute depends on the implementation by each application developer. In some Application Protocol Books, use of any attributes within the UECS tag may not be permitted.

3. Reserved attribute values in the CCM Tags

In CCM communication, some tags (for example, the DATA tag to send data, discussed in Section 4) are used to exchange information. Some of the attributes reserved in these tags are shown in Table 3-1.

Table 3-1 Reserved attributes in CCM tags

Attribute Name	Definition	Description
Type	Type identifier	Uses more than 3 alphanumeric characters. CCM compatibility is secured by the identifier being standardized. It is not omissible.
Room	Room number	Room number The highest division, a number to distinguish rooms (greenhouses). Integer 0 to 128. The number 0 indicates whole rooms. It is omissible. In the case of omission, the attribute Room number value is 0.
Region	Region number	A number to distinguish some regions or systems in a room. Especially, the attribute is used to distinguish a measurement control system. Integer 0 to 30000. The number 0 indicates whole regions or systems. It is omissible. In the case of omission, the attribute value is 0.
Order	Order number	A number to distinguish some divisions in a region. Especially, the attribute is used to distinguish the same kind of components in a region. Integer 0 to 30000. The number 0 indicates whole divisions or components. It is omissible. In the case of omission, the attribute value is 0.

The "type" attribute is used to identify the kind of communication data itself, and "room", "region" and "order" attributes indicate each effective area. We must use these attributes according to the guidelines of Table 3-1. The attributes "room", "region" and "order" are omissible. All of the components in the UECS deem values of each attribute as 0, if they receive the CCM with these attributes omitted. More detail is given in the next section.

4. Data tag for sending data

The data tag for sending data is the only CCM tag defined by the basic communication protocol. The data tag is primarily used to exchange information among the nodes. In the data tag, the description of the type, room, region, and priority attributes is necessary. As a general rule, the CCM packet including the data tag is transmitted through the UDP 16520 port in an Ethernet LAN. Plural data tags in a single CCM packet and optional attributes except reserved attributes (Section 3) are permitted in the basic communication protocol. The order of attributes in the data tag is also optional. However, these rules may be restricted by an application protocol. The use of sub-level tags in the data tag is prohibited. Only a numeric value can describe the value of the data tag. An example of the use of the data tag that has the type attribute of "Temperature" is shown in Table 4-1. The example indicates the temperature value is 23.5°C.

Table 4-1 An example of a data tag in the CCM

CCM type	CCM for sending data
Purpose	To exchange information among the nodes
Protocol	Broadcast packet using UDP 16520 port as a general rule
Example	<?xml version="1.0"?> <UECS ver="1.00"> <DATA type="Temperature" room="1" region="1" order="1" >23.5</DATA> </UECS>
Note	Attributes of <DATA> tag 　　　Type: Type identifier. It is not omissible. 　　　Room: Room number. It is omissible. 　　　Region: Region number. It is Omissible 　　　Order: Order number. It is omissible. (Caution) Use the alphanumeric character code of US ASCII 8 bits.

Decentralized autonomous and cooperative performance in the UECS is possible by communicating with the CCM. Each component transmitting and receiving the CCM is called a node. For environmental control, each node has room, region and order attribute values (shown in Table 3-1). The node accepts the received CCM that has the same attribute values. If each attribute value is 0 (including abbreviated cases), the node is considered to have the same attribute value of the received CCM.

The order of acceptance priority of the attribute values in the received CCM is shown in Table

4-2. We strongly recommend that a data tag having the same type, room, region and order attribute values is transmitted by only one node at a time. If more than two nodes simultaneously transmit the data tag having the same attribute values simultaneously, the behavior of the UECS will be unpredictable.

Table 4-2 Order of acceptance priority by the attribute values in the received CCM

Order of priority[*2]	Room attribute value	Region attribute value	Order attribute value
1	Accordance[*1]	Accordance	Accordance
2	Accordance	Accordance	0
3	Accordance	0	Accordance
4	Accordance	0	0
5	0	Accordance	Accordance
6	0	Accordance	0
7	0	0	Accordance
8	0	0	0

*1 "Accordance" means that the node's attribute value is in accordance with the
   attribute value of the received CCM.

*2 If the CCM does not apply the priority, the receiving node disregards the
   CCM.

For the example below, a heating node has these attribute values: the room is 3, the region is 2, and the order is 1.

A heating node: room="3" region="2" order="1"

In the following three CCMs, those having "InAirTemp" as the type attribute value are received by the node simultaneously, so the priority of the upper-line data tag is higher than the lower-line one.

<DATA type="InAirTemp" room="3" region="2"order="1">14</DATA>
<DATA type="InAirTemp" room="3" region="0"order="1">15</DATA>
<DATA type="InAirTemp" room="0" region="2"order="1">16</DATA>

In this case, if the heating air temperature set-point of the heating node is 15°C, the node sees 14°C as the present air temperature, and it starts heating.

5. Remarks

It is possible to construct a decentralized autonomous environmental control system by applying the contents of the UECS Basic Communication Protocol Book only. However, the approach is impractical, because the rules of data freshness control, descriptions of the data unit, etc., are not defined by the Basic Book. To develop a practical UECS application system, we recommend also using the UECS Application Protocol Book in one's system. Please note again that the Basic Book was described with the assumption of making the Application Book.