Master Thesis: Automating the Byzantine Typikon.

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Chapter 1: Introduction

Rationale

The starting point for this research is succinctly stated in the *Guidelines for Research in Orthodox Studies, 2010,* for this course: "The key characteristic of Orthodox Studies is the application of theological reflection to solve real-life problems" (p. 3). It goes on to state: "The point of departure is always a problem in the real world."

The real-world problem, for which I seek an improvement or correction, is the availability of the Byzantine Typikon to all clergy and faithful, especially for the preparation and service of the Divine Liturgy.

Most clergy studied the Typikon and other liturgical books thoroughly during their formation period. However, modern parish or missionary life leaves them little time to determine accurately the intricacies of Byzantine liturgy. There are few clergymen in each eparchy or diocese, who are capable of preparing the texts for the Divine Liturgy with confidence. There are even fewer cantors and readers who are capable of preparing in advance for a Divine Liturgy. This results in poor liturgy, and separates that local church from the greater Church, as it is no longer praying as one body.

For much of the year, the choice of texts is quite clear. Preparing the Divine Liturgy for many Sundays of the year is also reasonably straightforward. The difficulties arise especially in the periods of the Triodion and the Pentecostarion, when there is a feast, which coincides with the normal weekday or Sunday – or most confusing of all, when a Sunday occurs within the preparation or service period of a feast. Each of these bring their own

complexities – from the point of view of preparing the Divine Liturgy – and their own beauty

to celebrations according to the Byzantine tradition.

Statement of the Problem

In order to manage this problem, its analysis, and solution, the scope will be limited to

the automated preparation of the correct texts (or references to them) for the celebration of

the Divine Liturgy on any day, for any year. A perpetual Ordo, if you like, to borrow a term

from the Latin tradition.[1]

Definition of the Typikon.

The term 'Typikon' comes from the Greek word 'Τυπικόν', which means 'according to,

or following, the right order [of things]'. It is a term that is used in several different senses in

the Church today:

1. The list of rules for performance of the Divine Liturgy and prayers of the

    hours, most especially when there is a coincidence of feasts, seasons, and or

    Sundays. The one in current use by the Ecumenical Patriarchate (edited by

    Violakis) is entitled: *Τυπικόν της του Χριστού Μεγάλης Εκκλησιάς* (Violakis,

    1888).[2]

2. A short list – or 'cheat sheet' – published by various patriarchates or eparchies

    for use by their clergy and faithful in preparation of the Divine Liturgy. These

    sometimes include information for other prayers such as Vespers and Orthros.

    It is sometimes called a 'Typikon' because it represents an interpretation of the

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1   The Ordo, or more fully the *Ordo Recitandi*, also called the *Directorium* or Directory, is a book usually

2   That is, 'Typikon of the Great Church of Christ'

Typikon as mentioned above for a particular year (and location). It is often also called an 'Ordo', which is the Latin term applied to a similar document. An example of this can be found on the web site of the Ecumenical Patriarchate: http://www.ec-patr.org/gr/typikon/ . This example does indeed provide guidelines for the correct celebration of Vespers and Orthros. The Antiochian Orthodox Church offers several of these summaries or Ordos, http://www.antiochian.org/liturgical_calendar_2011 and http://www.antiochian.org/liturgical-guide, are two examples giving information for a specific year. The Antiochian Church has also provided a table to assist in celebrating its liturgies and prayer services in any year, an example of which can be found here: http://www.dowama.org/content/typikon.

3. The name 'typika' is also given to the prayer service that usually follows the service of the Ninth Hour especially on those days, on which the Divine Liturgy is not celebrated. It is so called, because it includes the typical psalms (Psalms 102, 145) usually found in the Divine Liturgy according to Slavic, Antiochian, and earlier Greek usage. The word 'typika' is the plural form of 'typikon'.

The goal of this research is to produce a system allowing the generation of typical data, i.e., taken from the Typikon, for the Divine Liturgy on any single day – thus, a Byzantine Ordo. This information may be realised in a number of ways.

Hypothesis

The automation of the Byzantine Typikon will greatly facilitate the preparation of Divine Services for clergy, cantors, and servers.

Seven times a day, I praise you.

The psalmist says: "Seven times a day, I praise you for your righteous ordinances." (Psalms 119:164). In accord with this statement, Byzantine tradition developed seven canonical prayers of the hours: Vespers, Compline, Orthros, First Hour, Third Hour, Sixth Hour, Ninth Hour. (The Mesonyktikon or 'Prayer of Midnight' was later added in monasteries; apart from Easter, it is rarely prayed in parishes.) Encouraged by Saint Paul's exhortations to "pray without ceasing" (1 Thessalonians 5:17) and to "persevere in prayer" (Romans 12:12), we follow the psalmist's example.

Saint Maximos has raised the simple following of the psalmist's and Saint Paul's exhortations into a liturgical theology:

> Every Christian should be exhorted... to frequent God's holy church and never
> to abandon the holy synaxis accomplished therein because of the holy angels
> who remain there and who take note each time people enter and present
> themselves to God, and they make supplications for them; likewise because of
> the grace of the Holy Spirit which is always invisibly present, but in a special
> way at the time of the holy synaxis. This grace transforms and changes each
> person who is found there and in fact remoulds him in proportion to what is
> more divine in him and leads him to what is revealed through the mysteries
> that are celebrated. (Tribe, 2009, para. 5)

Following the Typikon is not optional.

The current Ecumenical Patriarch stated in his enthronement address:

Moreover, it is our intent … to reinforce the observance of the special

liturgical practice of the Great Church. The promotion of liturgical life, in

following the *Typikon* of our Church, will be an object of special concern for

us, because this is the centre of our Christian existence and life.

(Bartholomew, 1991, para. 24)

As each patriarchate or language group publishes its liturgical books, they are

commended for use throughout the churches of the respective patriarchate. For example, the

following comes from the forward to the new Book of Liturgies in English and Arabic by the

Melkite Patriarch Gregorios III:

Therefore we deem the text of the Divine Liturgy in Arabic and English to be

an official Church text approved by ecclesiastical authority.

And furthermore we decree by our Patriarchal authority that this text be used

without exception in all our parishes using the English language, namely in the

Melkite Greek-Catholic eparchies in Canada, the USA, Australia & New

Zealand, in our parishes in the United Kingdom, and in all places where the

Divine Liturgy is celebrated in English. (Common English Translation

Committee, 2009, p. iv)

Another example is from the Forward to the new *Apostolos* by Patriarch Maximos IV:

"نأمر باستخدام هذه الطبعة الجديدة في جميع كنائسنا الطائفية، ليكون كل شيء فيها لائقًا وجميلاً" (Paulists, 1967, p.

ii).[3]

Also from the Forward to the Violakis Typikon: "τούτο έργον έτυχε της πλήρους

εγκρίσεως και επιδοκιμασίας ημών" (Violakis, p. iii).[4]

As Saint John Maximovitch says: "Our Church typikon is not a compilation of dead

rules and it is not the fruit of some abstract desk work, it was imprinted on the spiritual

experience of holy ascetics who came to fully understand the depths of the human spirit and

the laws of the spiritual life" (1951, para. 1).

Most importantly, of course, each bishop promises to uphold the faith, traditions, and

the Typikon at his ordination (cf. Service of Ordination of a Bishop).

The Typikon in current use in the Melkite Church is that of Archimandrite Cyril Rizq,

in Arabic, and which follows the Typikon of Constantinople, as does the Typikon of

Moulouk (Couturier, 1912–1930, vol. 1, p. 55). It was decreed for use throughout all

eparchies, monasteries, and religious orders in the Synod of Ain Traz, 1909. The Typikon

itself was published in 1911.

Expert System – a solution to varying rules.

The Patriarchate of Antioch, the Ecumenical Patriarchate, the Patriarchate of the

Russian Orthodox Church, and most other patriarchates all make some variations to the

calendar and liturgical rules as liturgy is celebrated and realised within each of those

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3   "We decree that this new edition be used in all the churches of our rite, so that all things may be fitting and
    beautiful".

4   "This project has received our full approval and praise."

respective patriarchates. Within each jurisdiction, with its own additions or localisations of the Typikon, the rules can become quite complex.

There are many exceptions, even for the general classifications. It would be naïve to group all class 4 feasts together, for example. The mere occurrence of a class 4 feast on a Sunday adds complexities that vary within the group of class 4 feasts. If that Sunday were a Sunday within the period of the Triodion or the Pentecostarion, then additional rules/complexities might arise. Unfortunately, a liturgist in the Byzantine rite soon learns that not all class 4 feasts are the same – and this represents only a small sample of the complexities within the liturgy of the Byzantine tradition! How then, does one prepare the texts for a Divine Liturgy – the correct readings from the Epistles and the Gospels, the correct troparia and kontakia, etc. – amidst all this complexity? How might one automate this preparation, so that the result is always accurate according to the particular typikon, and the process is easy for a user, who may be neither a specialist in Byzantine liturgy nor an experienced user of technology.

An expert system would support this enterprise. Expert systems consist of a knowledge base of facts or information, and an inference or rules engine, which computes results or derives actions based on the rules and the facts. Such a system gathers rules together and thereby makes them easier to maintain. An expert system makes it easier to see patterns within, to see gaps that have not been covered by any rules, and felicitously keeps the technical dross of the programming and presentation code away from the rules. Feigenbaum of Stanford University defines an expert system as: "an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult

enough to require significant human expertise for their solutions" (quoted in Giarratano and

Riley, 1998, p. 1).

Thesis Statement

Thesis: it is possible to automate the Byzantine Typikon such that an Ordo – a

specific expression of the Typikon for a particular Church for a given calendar year – may be

produced, giving the liturgical instructions for any day of any year, or indeed all days of any

year.

It is assumed that a simple expert system will facilitate this process, and allow not

only its maintenance, but also its extension to other Typika, for example those belonging to a

different patriarchate or for Churches following a different Typikon or calendar.

Having produced such an Ordo, producing a liturgical run-sheet with the full texts and

readings for a specific day covered by the Ordo should also be possible.

Background and Literature Review

Automation.

There are several examples, where attempts have been made at automating the

Typikon. In all cases that have been reviewed, though, they limit themselves either to a

perpetual calendar of feasts, with very little other information, or to a calendar of feasts for a

given year, together with readings. Unfortunately, most examples of automated typika only

provide readings according to the Menaia, and sometimes also from the Triodion or

Pentecostarion – i.e., only a basic interpretation of the liturgical books is provided: there is no

allowance for concurrence of feasts or service periods of feasts. The situations where feasts

occur at the same time as another feast, a Sunday, or season are not always resolved. If an

attempt has been made to resolve these conflicts, these systems generally restrict themselves

to a single Typikon and do not allow generalisation.

Examples are:

- CyberTypicon[5] (v4) from the Melkite Church: http://www.typicon.com/

- Menologion[6] (3.0) from the Russian tradition:

    http://saintjohnwonderworker.org/menologion.htm .

Among the semi-automated, or those providing fixed information for the given year

are:

- Typikon for the Church of Greece: http://www.typikon.gr/ ;

- On-line Liturgical Guide from the Antiochian Orthodox Church in the USA:

    http://www.antiochian.org/liturgical-guide .

Typika.

In analysing the specific case of the usage of the Patriarchate of Antioch, it is most

appropriate to make reference to those Typika printed in Arabic – the main liturgical

language of that patriarchate. There are three. In order of publication, they are the Typika of:

- Moulouk, Beirut – 1896;

- Rizq, Beirut – 1911;

- Arman, Beirut – 1986 (original edition: 1951).

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5   It would appear that further development is occurring. The web site has announced a newer version,
    CyberTypicon 2010, which "has a different design and concept than 'CyberTypicon V4'". As recently as
    August 2011, this new version is still not available.
6   Although the web site states that "Menologion 3.0 is in active development", the web page has not been
    updated since 12 February 2009.

The Typikon declared as normative for the Ecumenical Patriarchate (Violakis, 1888) will also be consulted.[7] The Arman Typikon mentioned above is an Arabic rendering of the Violakis Typikon. Also to be consulted is the recent translation into English of the Arman Typikon by Bishop Demetri Khoury (2011), who has presented the information within the Typikon in a more systematic form.

Reference will also be made to the following texts, especially to clarify interpretation and/or practice:

- The Typikon of Saint Sabbas. Although available on line, I shall refer to the recently printed edition from the monastery of Panagias Tatarnis (2009).
- The *Systema Typikou* of Papagianni (2006).
- The Typikon of Riga (1994).

As a means of checking that the automation is correct over a period of several years, patriarchal Ordos from 1996 to 2011 have been consulted. Most of the 19-year (Metonic) cycle of lunar epacts has thus been covered within this material.

Expert systems.

For the sake of research, the decision was made to restrict possible software solutions to freely available, often 'open source' solutions, and where possible to choose the most commonly available and supported.

The Expert System tool chosen is CLIPS (C Language Integrated Production System), which was originally developed at the NASA-Johnson Space Centre in 1985. CLIPS is

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7   The Typikon of Constantinople was introduced into the Patriarchate of Antioch by Makarios III, Patriarch of Antioch in the seventeenth century (Laham, 2009, p. 16).

widely used (Giarratano & Riley, 1998, p. 328), and has formed the basis of many subsequent

efforts in the Expert Systems area. Many of the alternatives, both free and licensed, import

CLIPS directly or offer a simple migration path from it. Thus, work developed in CLIPS will

be portable to other systems. The World Wide Web Consortium (W3C) has recently

announced (22 June 2010) the Recommendation of the Rule Interchange Format – Production

Rule Dialect, or RIF-PRD (http://www.w3.org/TR/rif-prd/). W3C Recommendations hold the

weight of standards, and so this standard might be an appropriate way to store facts and rules

required for an Expert System tool such as CLIPS. This standard (RIF-PRD) is not yet

broadly enough supported – nor are two-way translations from languages such as CLIPS yet

common. The suitability of RIF-PRD should be re-evaluated at a later date, when tools and

transformations using it may have developed further.

The choice of CLIPS has led us then to texts, which specialise in discussing CLIPS or

the RETE algorithm, on which its engine is based. The pre-eminent example of which is:

Expert Systems Principles and Programming by Giarratano (1998), who has also authored

the latest documentation on CLIPS.

Definition of Relevant Terms and Concepts

Concepts and terms relevant to the research may be found below.

Table 1: Definition of Terms and Concepts

Term	Definition
Apostolos	The book of Epistles, which includes the readings from the Epistles and the Acts of the Apostles, as used throughout the liturgical year of the Byzantine Churches. It includes some minor rubrics, specific to those readings.

Term	Definition
Evangelion	The book of Gospels, as read through the liturgical year of the Byzantine Churches. It includes some minor rubrics, specific to those readings.
Expert System	Expert Systems are in the domain of Knowledge Management within the field of Computer Science. They consist of a software system that uses a knowledge base, which consists of human experiences that have been codified for automated problem solving, and an inference engine or rules engine, that processes the rules. They represent the automated solving of problems, given certain facts and rules, where a human *expert* might otherwise have been required.
Explicit	From the Latin 'it ends' is the brief phrase used to terminate a selection of Scripture. Explicits are not required as often as incipits.
Incipit	From the Latin 'it begins' is the brief phrase used to introduce the selection of Scripture to help the listener put it into context. An example of a common incipit used with a Gospel passage is: "At that time, ..." (τω καιρώ εκεινώ).
Lection	A single reading from a lectionary; in Byzantine liturgy, a reading from the *Aposotolos*, *Evangelion*, or the *Prophetologion*, or similar.
Pericope	An extract or story taken from the text of the Sacred Scriptures. A Lection would consist of a pericope, an incipit, if required, and an explicit, also if required.
RDBMS	A system for managing data on computers using a relational model.
Rete Algorithm	Rete is the Latin word for 'net'. The Rete algorithm is a pattern-matching algorithm designed by Charles L. Forgy of Carnegie Mellon University in 1979 (cf. Doorenbos, 1995). It is used in many rules engines.

Term	Definition
Scripting Language	A Scripting Language is a programming language that is usually interpreted and not compiled. It is therefore often used for prototyping or as 'glue' binding several applications or data stores together.
Typikon	Book of rules for the celebration of the Divine Liturgy and other prayer services. It contains details for the concurrence of various feasts and seasons.

Aims and Delimitation of the Study

The aim of the study is to undertake the research to develop an automated system based on the Typikon in use by the Melkite Church, i.e., based on the liturgical customs and rules of the Patriarchate of Antioch.

This automated realisation of the Typikon will, for this research, be limited to the development of an Ordo (for any given year) and a liturgical run-sheet for the Divine Liturgy for any given day covered by the Ordo (which will also include the readings).

The research will also aim to provide the Ordo and texts in the following three languages: Arabic, English, and Portuguese. This will raise at least some of the issues of generalising the automated Typikon across other languages that are in liturgical use within the Byzantine Churches.

The research will also include a review of the forms and media, by which the resultant Ordo and referent texts might be best made available for the target audience (clergy and faithful of the Byzantine Churches, who prepare liturgies).

It is expected that this research might form the basis of further research, having as its goal the development of similar tools, but including all the prayers of the Church's day, i.e.,

including Vespers, Orthros, the Complines, and the other hours. Further research might also develop a means where specific Typika may be chosen, such that an Ordo could be produced for another Church, whose liturgical regulations follow the Byzantine rite.

Methodology

Rules are required to determine which Epistle reading (lection) or which Troparia (and in what order they are chanted) are required. These rules presume a requirement for the basic data.

The first step will be to record the basic names of the fixed and movable feasts, as required to describe a given liturgical day. Associated with each of these feasts – or their liturgically significant parts (e.g. preparation period, service period, leave-taking) – are the data that become the basic building blocks of any liturgical system. These must be recorded and associated with their feasts in a way to make them useful.

A translation of the Sacred Scripture must be chosen, and then the pericopes extracted, and incipits and explicits added, where required. A system for recording and applying the liturgical rules (as expressed in the Typikon, but also found in the *Hierologion*, *Apostolos*, *Evangelion*, etc.) must also be developed.

Lastly, formats and media are required to expose the result of the automated Typikon. For example, a calendar of feasts and readings for the given year, a run-sheet containing readings, and variable parts of the day.

Researcher's Background and Interests

The researcher has a background in theology, languages and linguistics, computer science, and management. Pertinent to this research, he has completed recognised degrees

and studies, in several languages, in the areas of theology, scripture, linguistics, and liturgy. Other areas of specialisation include Computer Science and Pure Mathematics.

The researcher is currently filling a management and consulting role within the IT industry, and serves his local (Byzantine) church in a diaconal role.

Chapter Outline and Dissemination of Research

The Master's thesis will contain the following information, broken down by chapter.

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This chapter.

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This chapter will discuss the source of information about the feasts, fixed and movable, as well as all information relating to them: for example, troparia, class of feast, etc. This necessarily includes a brief description of the main liturgical books of the Byzantine Church. Calculations for other liturgical information required for an Ordo will also be discussed; for example: calculations of Easter (according to the various calendars), calculation of the cycle of Eight Tones, of the Eothinon Cycle, etc.

Storing texts and names of feasts in several languages also raises issues not seen when operating in a single language, especially English. Many languages, including Greek and Arabic, decline their nouns depending on their place and role in the sentence. Some languages, for example, Arabic, count single, dual, and plural quantities. Portuguese, for example, uses different forms of fused articles and prepositions, depending on the gender and number of the noun.

The creation of Byzantine lectionaries from the base Scriptural texts will also be reviewed, and what information must be recorded for incipits, explicits, including the one or two instances where verses are modified for clarity within a given lection.

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In this chapter, the complexities that might arise are discussed, for example: the Feast of the Annunciation falling on a Sunday within the Great Fast – or as is the case this year (2011), the feast of the Great Martyr Saint George falling on Great and Holy Saturday. In the case of the feast of Saint George in 2011, even when the Typikon rules for a concurrence of the feast with Great and Holy Saturday are followed, another collision occurs.

In order to automate the Typikon, a third classification of feasts is required. The usual breakdown is to discuss (i) Fixed Feasts, which come from the Menaia and are celebrated on a fixed day each year; and (ii) Mobile Feasts, which are found in the books of the Triodion and Pentecostarion, and consist of those feasts, whose dates vary around the date of Easter. There is, however, a third group of feasts, whose dates vary, but not necessarily around Easter. These are usually special Sundays (or Saturdays), for example the Sunday after the Nativity of Our Lord, or the Sunday of the Fathers of the First Six Ecumenical Councils. This section will conclude with some discussion about how these complexities are best stored, so that they can be used in liturgical calculations.

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This chapter will discuss some of the mechanics of storing the information (called 'facts' in knowledge management), and designing rules to support the realisation of the

automated Typikon. Examples of data schemas will be given, so that the types of information

that must be stored may be shown, and how that information might be used. General rules

will be proposed, where possible, in order to render the system both efficient and easy to

understand. However, there are many exceptions – otherwise there would not be a need for a

liturgical book such as the Typikon. There will also be some discussion about how some of

these exceptions might be expressed in a rule or a set of rules.

Lastly, a brief discussion of the choice and implementation of the system itself will

examine issues such as scripting, portability (potential users will not all use the same

computer), mobility and connectedness (a connection to the Internet cannot be assumed).

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As mentioned above, in order to create a database of the necessary texts, the

production of an *Apostolos*, *Evangelion*, and a *Prophetologion* is also made possible.

Today, an Ordo is often found as a flexibly bound book, usually left open at the

current day within the sacristy or diaconicon, so that servers and clergy may prepare the

liturgy or prayers. Producing an Ordo in this format only is not a requirement. In today's

world, wall calendars, electronic diaries, and even ways of making the information more

portable on smart phone devices, for example, would perhaps be at least as useful as a printed

book. Some of these modern formats are described by standards. A discussion of the

importance of these standards and how they have been implemented will also be included.

This chapter will conclude the Master's Thesis and will propose ways of gaining

patriarchal approval (or at least that of the patriarchal liturgical committees) and how these

Ordos and other products of the automation might be made available or published in an

accessible way.

Chapter 2: Sources of Information

Types of Feasts within the Byzantine Liturgy

Generally, one speaks of two types of liturgical feasts and commemorations: fixed feasts and movable feasts. Details and texts for the fixed feasts are found in the Menaia – i.e., the books of liturgical prayers and rubrics for each day of each month (of any given year). The movable feasts are those feasts, the date of whose occurrence varies because they depend on a fixed relationship between themselves and the date of the feast of Easter. Texts and rubrics for the movable feasts can be found in the Triodion – for those dates falling before Easter – and the Pentecostarion – for Easter itself and those dates following it.

The great feast of the Resurrection (i.e., Easter or Pascha) thus holds a pivotal role within the Byzantine liturgical calendar, just as the event it represents (Christ's rising from the dead) is definitive for Christianity.

In order to automate these movable feasts, it is thus important to be able to calculate the date of Easter. The date of Easter, however, is not a simple thing to determine. In today's Byzantine Churches, some calculate the date of Easter according to the Gregorian Calendar (e.g. the Orthodox Church of Finland); some calculate the date of Easter according to the Julian Calendar, but express this date according to (what appears to be) the Gregorian calendar (e.g. the Ecumenical Patriarchate, the Antiochian Orthodox Church), and some calculate Easter and express the resultant date wholly according to the Julian calendar (e.g. the Russian Orthodox Church).

It is important to review this situation in more detail, and determine how one might automate any calculations based upon Easter.

Calendar systems

A brief description follows of the calendar systems of interest to our research topic, to

wit the Julian and the Gregorian calendars. A fuller history and the details of each system and

their respective relationship to the solar year can be found elsewhere.[8] The average tropical

year – the average time it takes the earth to complete a circuit around the sun – is

365.2421982 days.

Julian calendar.

In 46 BC, Julius Caesar decreed that the year should consist of 365 days, and that

every fourth year, an additional day would be added (Couturier, 1912–1930, vol. 1, p. 94).

The initial leap years appear to have occurred every three years, and it is not until the leap

year of AD 8 that the Julian Calendar may be said to be in effect (Tøndering, 2008). The

tropical year according to the Julian Calendar is 365.25 days, which gives an error of about 1

day after 128 years.

Gregorian calendar.

The Julian Calendar was reformed by Pope Gregory XIII by the bull *Inter*

Gravissimas, which was promulgated 24 February 1582 (Parry, Melling, Brady, Griffith, &

Healey, 2001, p. 353.). This reformation of the calendar, called the "Gregorian Calendar" was

opposed by the Orthodox; however following an inter-Orthodox conference in 1923, the

Ecumenical Patriarch, Meletios IV, instituted a calendar that is similar to the Gregorian

Calendar, but is slightly more accurate (Parry, Melling, et al., 2001, p. 311). This new

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8   Further information may be found at the US naval web page "Julian Date Converter"
      http://aa.usno.navy.mil/data/docs/JulianDate.php, among others.

Calendar was eventually accepted by all Orthodox Churches except Russia, Jerusalem, and

the monks of Athos (Parry, Melling, et al., 2001, p. 311). The tropical year according to the

Gregorian Calendar is 365.2425 days, which gives an error of about 1 day after 3,300 years.

Orthodox calendar.

The calendar decreed by the Ecumenical Patriarch in 1923 defines the tropical year as

365.24222 days, and is thus more accurate than the Gregorian Calendar. This method will not

differ from the Gregorian Calendar until AD 2800, which is not a leap year in the Orthodox

Calendar. Because dates in the Orthodox Calendar are the same as those in the Gregorian

calendar (at last until AD 2800), we must expect some confusion in the Orthodox Churches

following the new or Orthodox Calendar, when the year 2800 arrives. (That is, some may, in

ignorance or through decision continue to follow the Gregorian Calendar.)

Easter

In AD 325, the Council of Nicaea decided that 21 March would be the date of the

equinox to be used, when calculating the date of Easter. (This equinox, called the vernal

equinox in the northern hemisphere, corresponds to the autumnal equinox in the southern

hemisphere.) This date is termed the 'Paschal Full Moon' date. It does not always correspond

with the astronomical full moon, although it does not differ from the astronomical full-moon

date by more than two days (Montes, 2001).

The Calculation of the date of Easter.

In order to calculate the date of Easter, the following cycles are in use:

1. lunar or (Metonic) cycle (with the *golden number*)

2. cycle of the Epact

3. solar cycle

4. the Sunday letter (see Couturier, 1912–1930, vol. 1, p. 97).

The Golden Number is so called because it was once written in Athenian temples in golden digits. It represents the fact that new moons were seen to appear on the same date, after 19 years. The Golden Number of any given year is given by the formula: *GoldenNumber* = (year modulo 19) + 1 (Tøndering, 2008).[9]

The Epact is the age of the moon at a given point in the year. For the Julian Calendar, the date of this given point is 22 March; for the Gregorian Calendar it is 1 January. The formula to calculate the Epact for a given year in the Julian Calendar is as follows, and assumes that the Golden Number is known for that year: *Epact* = (11×(*GoldenNumber*-1)) modulo 30 (Tøndering, 2008). If the result of this calculation is zero, it is changed to 30, and was also noted with an asterisk in the old calendars. Three corrections were made to the calculation of the Epact as part of the adoption of the Gregorian Calendar.

Tables of Paschal Full Moon dates and Epacts were required in order to calculate the date of Easter. There are several formulae that have been developed to calculate the date of Easter, but it was the tables that were used in most monasteries and parishes. One common formula is the Hartmann formula, published in *Cosmos* April 1911 (p. 344, as cited by Couturier, 1912–1930, vol. 1, p. 134). An example of another formula, the Oudin formula, can be found in Appendix A, p. 81 (Oudin's formula quoted in Seidelmann, 1940, *Explanatory Supplement to the Astronomical Almanac*, in Tøndering, 2008).

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9   The modulo operation is the integer remainder after dividing the first integer by the second integer using integer division. Thus (7 modulo 3) = 1

Automating the calculation of the data of Easter.

In order for our automation of the Byzantine typikon to be useful, it must calculate the

date of Easter both according to the Julian and the Gregorian Calendars. To provide only one,

necessarily limits the usefulness of any derived data to a subset of the Byzantine Churches.

The method to use for the calculation of Easter, must therefore be one of the primary

parameters in all calculations. To this end, the algorithm defined by Ronald Mallen of the

Astronomical Society of South Australia has been implemented (Mallen, 2002). Examples of

the algorithm in Tcl, Python, and CLIPS may be found in Appendix B, p. 82. As expected,

this algorithm calculates the date of Easter according to the Julian Calendar, the Gregorian

Calendar, and the Julian Calendar date expressed as a date according to the Gregorian

Calendar.[10]

Fasting Regulations

Although fasting is not strictly a liturgical phenomenon, instructions for fasting and

abstinence are found scattered throughout the liturgical books – especially the Triodion and

the Menaion – and usually appear in yearly Typika and Ordos.

Written regulations and guidelines are scant, however. Partly at fault for this

confusion is the fact that there is only one word in Greek – and also in Arabic – which does

double duty for both fasting and abstinence: νηστεία [nıst'ia]. The corresponding Arabic term

is: صَوْمٌ [sˤaʊm] (Couturier, 1912-1930, volume 1, p. 127).[11]

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10 As stated above, p. 24, the Orthodox Calendar will not differ from the Gregorian Calendar until the year
   2800. For the purposes of this research, the Gregorian and Orthodox Calendars will be assumed equal.
11 Lately more precise terms for abstinence are used, but these terms did not appear in liturgical books before
   the 1900s.

Traditional Fasting Rules for the Patriarchate of Antioch.

The details of fasting regulations for the Antiochian Orthodox and Melkite Churches can be found in Appendix C, p. 88, and Appendix D, p. 89. In attempting to automate the indication of fasting and abstinence for those Churches of the Patriarchate of Antioch, the following interpretation from the aforementioned rules has been chosen. It must be noted that various editions of the Menaia, the most recent Anthologion, and also the recently published (2006) Liturgicon, do differ on some small points. These will be noted below, as they occur. Fasting instructions, as mentioned above, often consist of a single word or short phrase, which most often refers to abstinence. In order to itemise the regulations for fasting and abstinence within a given patriarchate, one must mostly rely on tradition for the details of interpreting these scant notations. Those traditions that are kept within the monasteries are assumed to be accurate interpretations of the fasting regulations –more so if these traditions are common throughout the patriarchate or across patriarchates.

Of the four fasting periods (i.e., the Great Fast or Lent, the Apostles Fast, the Dormition Fast, and the Nativity Fast), all but the Great Fast are essentially periods of abstinence, not of true fasting.

Fasting Regulations for the Patriarchate of Antioch.

- 29 August and 14 September: fast and abstinence from all foods, but allowing oil and wine, unless falling on a Saturday or Sunday, which are days on which we do not fast, but only abstain. Returning to strict abstinence, should they fall on a Wednesday or a

Friday.[12] Interpretations for Wednesday, Friday, Saturday, and Sunday follow general

Byzantine practice; they are not noted specifically anywhere to my knowledge.

- Wednesday and Friday of the Week of Abstinence (or Cheesefare) are days of fast,

  but abstinence from only meat and meat products. Although strict abstinence is the

  norm for all Wednesdays and Fridays of the year, the common practice in the

  Patriarchate of Antioch has been to extend the mitigated fast (i.e., only abstaining

  from meat and meat products) to the Wednesday and Friday (Couturier, 1912–1930,

  vol. 1, p. 129).

- Apostles Fast: oil and wine are always permitted, except on Wednesdays and Fridays.

  Fish is permitted on Saturdays and Sundays.[13]

- The Dormition fast is similar to the pattern of abstinence followed during the Great

  Fast. Fasting is stipulated only on Wednesdays and Fridays.

- The Nativity Fast is similar to the Apostles Fast from 15 November until 12

  December, whereafter it follows the pattern of the Dormition Fast.[14] This is the

  current interpretation in the Greek Church, but I can, however, find no evidence in

  Antiochian sources for these two patterns of abstinence during the Nativity Fast.

  Either this pattern of abstinence existed, but was never considered extraordinary

  enough to note, or it was never a custom in Antioch. However, to maintain

  conformance with current Greek Orthodox usage, the patterns of abstinence are

  followed as noted here. This interpretation accords with that currently practised by the

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12 Agrees with Couturier, Charon, the Anthologion, and the Liturgicon. However, the Orthodox Menaion states strict abstinence for 14 September, but no mention of fast or abstinence for 29 August.

13 This maintains the Antiochian usage of Wednesdays and Fridays, but includes finer details from current Greek Orthodox usage (compare: Villis, n.d.).

14 This is the usual interpretation following Greek Orthodox resources.

Antiochian Orthodox Church in America (n.d., *Nativity Fast*). The date, upon which

the stricter fast begins, is variously defined as 13 December

(http://www.stspyridon.org.au/ourFaith.php?articleId=137&subMenu=Orthodoxy), 17

December, 18 December (see: http://www.stgeorge.nh.goarch.org/orthodox-

resources/seasonal-guidelines/), and 20 December

(http://www.antiochian.org/node/18518).

Byzantine Liturgical Books

There are eleven books required to complete the celebration of the Divine Liturgy or

the canonical prayers in the Byzantine Rite. These books can be found in Table 2.

Table 2: Byzantine Liturgical Books.

Name of Book	Function or Contents
Aposotolos or Book of Epistles	Contains the readings (lections) from the Epistles and the Acts of the Apostles arranged according to the liturgical year. Verses of the Prokeimena and Alleluia are also usually included.
Euchologion	The contents of this book vary, but it generally comes in two forms: the Great Euchologion and the Small Euchologion.
	The Great Euchologion contains all the prayers for the Divine Liturgy, the basic prayers (i.e., those parts that do not vary) for each of the canonical hours, as well as the remaining six sacraments, and many other blessings.
	The Small Euchologion does not contain the prayers for Divine Liturgy and the canonical prayers. It is usually printed in the form of a pocket book for clergy, to allow celebration of the sacraments and blessings, wherever these might occur.
Evangelion or Book of Gospels	Contains the Gospels lections arranged according to the liturgical year.

Name of Book	Function or Contents
Horologion	Contains the fixed texts of the daily cycle of canonical prayers. It may also include the texts of the Paraclesis, the Akathist Prayer, and common Troparia and Theotokia.
Menaia	Contains the Propers for the feasts and commemorations that occur on fixed dates throughout the liturgical year. The Menaia are not normally printed as a single book, but rather a collection; one Menaion for each month of the liturgical year.
Oktoechos	Has two versions: one for the entire week, the other just for the Sundays. It contains the Common of the cycle of liturgical services according to the Eight Tones. The Great Oktoechos is sometimes also called the Parakletike.
Pentecostarion	Contains the Propers for the services of the Paschal season – i.e., from Easter (Pascha) until the Sunday of All Saints (the first Sunday after Pentecost).
Prophetologion	Contains the readings from the Old Testament – except the Psalms – arranged according to the liturgical year.
Psalter	Contains the psalms arranged in kathismata and stases. It usually also includes the full text of the Canticles as read in the Prayer of Orthros.
Triodion	Contains the Propers for the services of the Great Fast, or Lenten period, including the pre-Lenten period. It covers the period from the tenth Sunday before Easter until Great and Holy Saturday. Thus Great and Holy Week is also covered.
Typikon	Contains the rules for celebrating feasts as they occur throughout the liturgical year. It presupposes the existence of the other liturgical books.

There are also several other liturgical books, see Table 3, which consist of portions of the other books, either alone or collated with selections from one or other of the books, to make a more useful or portable collection of texts.

Table 3: Extracts or Collations of Byzantine Liturgical Books.

Name of Book	Function or Contents

Name of Book	Function or Contents
Anthologion	Collection of texts from the Horologion, Menaia, Oktoechos, Triodion, and the Pentecostarion brought together to form a portable book for use in chanting the canonical prayers (Vespers, Orthros, Compline, etc.). Sometimes an abbreviated form of the sections is included – e.g. perhaps not all the canons of Orthros. This book necessarily consists of several volumes.
Archhierratikon	Contains those prayers specific to a bishop for the Divine Liturgy, Vespers, and Orthros. It also contains the prayers for those sacraments and services specific to a bishop – or sometimes the complete service – for ordinations.
Hieratikon	Contains those prayers specific to a priest for the Divine Liturgy, Vespers, and Orthros. The Deacon's part is also normally included.
Liturgicon	Contains the texts of the three forms of the Divine Liturgy (the Liturgy of St John Chrysostom, the Liturgy of St Basil the Great, and the Liturgy of the Pre-sanctified Gifts, which is sometimes called the Liturgy of St Gregory). It also contains sufficient selections from the Menaia, Oktoechos, Triodion, and Pentecostarion to allow the full celebration of the Divine Liturgy. Due to its size, this book may also consist of more than one volume.

There are other books, including one for the faithful, which usually contains a selection of the texts used in the Divine Liturgy. There are also specialist books for chanting: e.g. the Sticheriarion, which contains the stichera for Vespers and Orthros; and the Hirmologion, which contains the model Hirmoi for the various canons. Today, music books

are usually printed in larger collections, containing several volumes, that make it easier to

chant without having to change books too often.

The Collection and collation of rubrics.

The definition and descriptions of the Typikon given above might lead one to believe

that codification of the rubrics and regulations found within the Book of the Typikon itself, is

all that is required to define which texts are required – and thus which texts must be

automated – to celebrate a correct Byzantine liturgy. This is not the case. Each of the basic

liturgical books contains within it rubrics specific to its content. Some of these may be

repeated in the Typikon, or summarised in it, or may merely be assumed – i.e., it may never

be mentioned in the Typikon itself, because it is assumed that the reader will have already

read and followed the directions given in another book, e.g. the Apostolos.

An example of rubrics specific to content of the particular liturgical book, is the rubric

found in the Aposotolos following the Thirty-second Sunday after Pentecost. It begins:

If the Epistles of the thirty-second week have been read before the beginning

of the Triodion, that is, before the Sunday of the Pharisee and the Publican, the

following rules are to be observed:

On Weekdays: Read the Epistle of the Saint of the Day. If there is

none, read one of the Epistles of the Common of the Saints. As for the

Epistles of the Thirty-third week after Pentecost, they are read only on the

weekdays immediately preceding the Sunday of the Pharisee and the Publican.

(Raya, 1981, p. 308)

This rubric is quite detailed and runs to two and a half printed pages in length.[15] It is not found in the Typikon.

Rubrics not present in all editions.

Some publications, for example the Arabic and English translations of the Apostolos and Evangelion from the Patriarchate of Antioch include rubrics explaining complicated scenarios. These rubrics, however, are not always found in other editions.

For example, after 29 December in the Evangelion from the Patriarchate of Antioch, one finds the Gospel of the Saturday before the Theophany, the Gospel of the Sunday before the Theophany, and then the following rubric, which is followed by the Eothinon Gospel of 1 January:

> (A) If there are two Saturdays and two Sundays between the Nativity and the Theophany, we read on the first Saturday and the first Sunday those Gospel readings for the Saturday and Sunday after the Nativity. On the second Saturday and Sunday, we read the Gospel readings of the Saturday and Sunday before the Theophany.

> (B) If there is only one Saturday or one Sunday between the Nativity and the Theophany, we read the Gospel of the Saturday after the Nativity on the Saturday and the Gospel of the Sunday before the Theophany on the Sunday. (Raya, 1979, p. 303)

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15 This rubric is found in the Aposotolos of Antioch, in both the Arabic and English translations. It is not, however, to be found in the Greek Apostolos of Constantinople (cf. *Apostolos*, 1855, p. 227).

A similar rubric is also found in the Greek Evangelion from Apostoliki Diakonia, which have been carefully re-presented by Father Leo Schefe:

Εἰ μὲν τύχωσι δύο Κυριακαὶ μεταξὺ τῶν Χριστουγέννων καὶ τῶν Φώτων ,

ἀναγινώσκεται τῇ μὲν πρώτῃ Κυριακῇ: Εὐαγγέλιον κατὰ Ματθαῖον

᾽Αναχωρησάντων τῶν μάγων ἰδοὺ ἄγγελος Κυρίου…. Τῇ δὲ ἑτέρα Κυριακῇ:

Εὐαγγέλιον κατὰ Μᾶρκον ᾽Αρχὴ τοῦ εὐαγγελίου ᾽Ιησοῦ Χριστοῦ, υἱοῦ τοῦ

Θεοῦ…

    ᾽Εὰν δὲ τύχῃ ἓν μόνον Σάββατον καὶ μία Κυριακὴ, εἰς μὲν τὸ Σάββατον

ἀναγιγνώσκεται: Σαββάτῳ μετὰ τὴν Χριστοῦ Γέννησιν. Εἰς δὲ τὴν

Κυριακὴν·Κυριακὴ πρὸ τῶν Φώτων.[16] (Schefe, 2011)

This rubric is, however, not present in the Evangelion printed in Athens in 1884, which merely lists the Gospels of the Saturday and Sunday after the Nativity and of the Saturday and Sunday before the Theophany, without any comment as to when they should be read (*Evangelion*, 1884, pp. 586-589).

In the cases, where the rubrics are not present in some editions, or their meaning is not clear, the Arabic texts of the Patriarchate of Antioch will be taken as normative. Any cases where these rubrics differ from the current practice of the Ecumenical Patriarchate will be noted.

Cycles in Byzantine Liturgy

There are several cycles found within Byzantine liturgy:

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16 In English: "In the case where there are two Sundays between the Nativity and the Theophany, on the first Sunday, we read the Gospel according to Matthew [Matthew 2:13-23]: 'Now after the wise men had left, …'. On the second Sunday, we read the Gospel according to Mark [Mark 1:1-8]: 'The beginning of the good news of Jesus Christ …'. When there is only one Saturday and one Sunday, we read the Gospel of the Saturday after the Nativity on the Saturday, and the Gospel before the Theophany on the Sunday."

- Fixed feasts. This cycle has a feast or commemoration for each day of the calendar year.

- Movable feasts. The date for these feasts, already discussed, varies according to the date of Easter.

- Eight tones or Oktoechos. This eight-step cycle also depends on Easter. It begins on Thomas Sunday – the Sunday after Easter – on Tone 1. Each successive Sunday's tone increases until Tone 8, after which point the cycle repeats – and continues to repeat until the Great Fast (Laham, 2009, p. 101).

- Eothinon Gospel. The Eothinon cycle depends on Easter as well. This cycle consists of eleven steps and begins on the Sunday of All Saints, which is the Sunday after Pentecost, and continues in a cycle until Palm Sunday of the following year (Couturier, 1912–1930, vol. 2, p. 16).

- Weekdays. On each day of the week, a dominant theme is evident; the prayers and troparia grouping around this theme.

There is one last cycle that is found mentioned within the liturgical books of the Byzantine rite, to wit the Indiction Cycle. The Indiction is a fifteen-year cycle with its beginnings in the fiscal practices of the Roman empire. Major taxes and duties were levied at the start of the Indiction (1 September of the first year of the cycle) and annually renewed each 1 September of the following fourteen years (Parry, Melling, et al., 2001, p. 256). The Byzantine Church inherited this cycle for financial and charitable administration. The only effect of the Indiction on Byzantine Liturgy is its mention at the beginning of the Church year

(1 September). The fourth year of the current Indiction cycle will begin 1 September 2011.

The current Indiction cycle itself began 1 September 2008.

Issues of Language and Grammar

The English language has shed many of its grammatical complexities over the course

of its history. It reflects a West Germanic origin that was heavily influenced by the North

Germanic languages brought from Scandinavia. Later, it was ground under the millstone of

Norman French influence. The English language has lost grammatical gender. It barely

inflects its nouns: inflection for the plural (any case) and genitive (or possessive) form of the

noun are all that exist from the earlier West Germanic number and case systems. English

nouns are not inflected to show that they are subjects or objects of verbs, nor that they are

under the influence of a preposition. The conjugation of verbs has become greatly simplified

over the centuries reaching the point where – except for the verb 'to be' – only the third

person singular, present tense form is distinguishable for all verbs.

This is not the case with many other languages. Koine Greek – the Greek of the New

Testament – has five cases: nominative, vocative, accusative, genitive, and dative (Wenham,

1981, p. 9). In the Greek verb, an array of forms that differ by person (first, second, third;

singular and plural), tense (past, present, etc.), mood (indicative, optative, etc.), voice (active,

passive, middle) is to be seen, as well as verbal participles (Wenham, 1981, pp. 10-12).

In Arabic, there are only three cases for the nouns – and these are rarely

distinguishable in unmarked text (i.e., text that does not contain the vowel signs).[17] There are

two features of Arabic grammar, however, that can make automation of the liturgy in Arabic

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17 Vowels, or more properly, short vowels are not usually marked in texts other than the Koran, the Bible, and
     childrens books. They are, however, often found in modern liturgical texts as an aid to the reader –
     especially for the pronunciation of the less common words and Biblical names.

difficult: the dual number appears in nouns and in verbs; and verbal forms distinguish gender

in all but the first person (Haywood & Nahmad, 1998, pp. 33, 40, 45).

Language affects how text is stored in the database.

Let us take the example of the Common Troparion of Martyrs. The text in English for

this Troparion, which is normally chanted in the fourth tone on Di, is:

> Your martyr, O Lord, received the crown of immortality from you, O our God,
>
> on account of his struggle. Armed with your strength, he has vanquished his
>
> persecutors, and crushed the powerless arrogance of demons. Through his
>
> supplications, O Christ God, save our souls. (*Publicans Prayer Book*, 2008, p.
>
> 231)

Chanting this Troparion for more than one martyr, is relatively simple in English:

change "martyr" to "martyrs", change "his" to "their", and the only change to a verb form

required is to change "has" to "have". In Greek, the past tense forms differ by person, so each

occurrence of a verb must be changed, where the martyrs are the subject. Additionally, in

Arabic, because there are several occasions throughout the year, where two martyrs are

celebrated, allowance must be made for the dual form of nouns and verbs, as well as for

different plural forms.

Similar complexities arise when considering the name of a feast. Languages like

Greek and Arabic change the form of the noun, if it follows a phrase like "the

commemoration of" – i.e., the noun (name of saint or feast) is found in the genitive case.

Storing the name of the saint or the feast is no longer simple. The various potential forms

must be stored, although in some grammatically more simple languages like English and Indonesian, this will lead to redundancy of storage.

If English were the only language, in which one needed to automate liturgical texts, one might store the base text once, marking up the changes that would be required, when more than one martyr is celebrated. However, because one must take account of the dual number (Arabic), verbs differentiated by number (Greek, Arabic[18]), and declension of nouns, such a system would become quite complex. The addition of each new language may require changes in the mark-up of the text, changes in the previously functioning automation and rules, and the addition of any rules specific to that new language. For the sake of this research, each different form of the entire Troparion, feast name, etc., will be stored in the database as a master or template of that particular form.

Automating the Generation of the Readings from Scripture

As explained earlier in Table 1, p. 15, a reading, or more properly a *lection*, consists of the following:

- pericope – the basic story taken from the Sacred Scriptures. The Biblical reference to a reading (e.g. John 5:17–24) refers to the pericope within the text.

- incipit – the brief phrase to introduce the reading. It is not always required, and may be required in one translation, but not in another. A common incipit for a Gospel reading is: "At that time" (Waltz, 2007, *Lectionaries*, Lectionary Incipits).

- explicit – the addition or slight modification to the last verse of a reading. It is not as commonly required as an incipit, and may often be as simple as the addition of

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18 Depending on where the Arabic verb falls in relation to its subject and the sentence, in which it is found, the form may or may not vary for number.

"Amen" to the end of the pericope. At other times, it merely indicates that the verse

terminates early to maintain the integrity of the story within the lection.

Leaving aside the topic of the division of Biblical texts into chapters and verses, a

reference to the lection in our database is still required, in order to automate the reading. This

Biblical reference would double as a unique identifier for that particular lection. The

reference, is most appropriately, the reference to the pericope. However, as has been noted

above, any incipits or explicits required for the lection must be stored as well, together with

details as to which pericopes they apply. The requirement for these will vary by translation –

i.e., within a given language (e.g. English), some of the translations of the Scriptures (e.g.

NRSV, KJV) may not require an incipit that is required in another translation. This variance

by translation within a language is equally valid without – i.e., among all the languages used

for automation.

There are some very few instances, where a lection is made up of an incipit, the first

part of a pericope, some linguistic *glue* joining the first part to the second part, the second

part of the pericope, and an explicit. This *glue* joins what may be two stories or two parts that

summarise a much longer story so that it appears as a single, logical passage. An example of

such a pericope is Acts 6:8 – 7:5, 47–60, which is read 2 August (Transfer of the Remains of

the Holy Protomartyr, the Archdeacon Stephen) and 27 December (Commemoration of the

Holy Protomartyr and Archdeacon Stephen).

Standardising the references.

The division of the Biblical texts into chapters occurred only in the thirteenth century;

the division into verses occurred later in 1550, when Robert Stephanus added verse numbers

when he printed the *Textus Receptus* (Waltz, 2007, *Divisions*, Chapters and Verses). While

the division into verses may be consistent within the Greek text of the *Textus Receptus*,

translations into other languages – and the additions, deletions, and modifications of the

Biblical texts in light of other textual evidence – means that the verse numbering seen in a

particular translation of the Bible, will not always agree with the verse numbering found in

the *Textus Receptus*. A standard to be used as a base must be agreed. It does not really matter,

which translation is used as a base, but all other translations used in the automation process

must be made to conform to the base standard. For our purposes, the NRSV Anglicised

edition has been chosen as the standard, for two reasons: it represents one of the most recent

scholarly translations of the Sacred Scriptures compiled with broad representation from the

major Churches, and it is the translation declared normative for the researcher's eparchy.

Chapter 3: Complexities arising from the Typikon

The Categories of Fixed and Movable Feasts are Incomplete

Movable feasts are those feasts, whose dates depend on the date of Easter. They are termed 'movable' because the date of Easter moves – i.e., it is not celebrated on the same date each year.

Fixed feasts are those feasts that appear on the same date each calendar year. For example, on 21 May each year, the feast of the Holy and Glorious Sovereigns, the Equals of the Apostles, Constantine and Helena is celebrated. The date of this feast does not change.

Byzantine liturgical studies speak of these two categories only. Perhaps this is because the fixed feasts are found in one collection of books, the Menaia, and because the other feasts, the movable feasts, depend on the date of Easter (and are found in the Triodion and the Pentecostarion). They thus make two easily comprehensible categories, and all feasts and leave-takings are found mentioned in either the Menaia or the Triodion and Pentecostarion. Automation of the Typikon requires the creation of a third category of feasts, however, which I shall term 'Variable Feasts'. These feasts usually appear in the Menaia, or are found in the Aposotolos and the Evangelion. One must take the variability of their dates into account, when automating the Byzantine liturgical calendar. In general, these feasts are classed among the fixed feasts, but in truth their dates of celebration vary. Examples of these variable feasts are the following:

- Sunday of the Fathers of the first six Ecumenical Councils – celebrated on the Sunday, which falls between 13 and 19 July.

- Sunday of the Holy Ancestors of Christ – celebrated on the Sunday, which falls between 11 and 17 December.

- Paramony of the Theophany, which falls on the eve of the Theophany (i.e., on 5 January), unless that day is a Saturday or Sunday.

In order to automate the Typikon, therefore, this third category of feasts is required, so that the calculations for the dates of these feasts may be accurately made, and thus added to the calendar. Some of these *variable feasts* lend only their name to the liturgical day[19], others define the Gospel lection of the day, still others affect other variable parts of the liturgy, e.g. the troparia.

The dates of the Leave-takings of certain feasts also vary, for example the Leave-taking of the Hypapante (or the Presentation of Our Lord in the Temple), which occurs somewhere between 3 February and 9 February, depending on certain factors. The actual feast occurs 2 February, and is fixed. The dates for these leave-takings are most easily handled, by placing them within the newly created category of variable feasts. During this research, it has been determined that forty such variable feasts are required, in order to automate the Typikon. These feasts, leave-takings, etc. may be found in Appendix E, p. 92.

Name of the Day or Feast

Simple days.

In order to refer to a given liturgical day, it must have a name. One could merely use the date as the name, for example 25 April 2011, but to list this feast on a calendar, church bulletin, or otherwise refer to the potentially complex choices of prayers and readings

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19. That is, they have no other affect on the liturgy.

dictated by the Typikon for this particular day, a name for the feast or the day is preferable.

For much of the year, this task is not complex. For week days and Saturdays outside of the

Triodion and Pentecostarion – and outside any preparation or service periods, the Menaion

for the month holds the name of the feast, and thus the name of our liturgical day. Continuing

our example date of 25 April, in the Menaion for April one find: تذكار القديس الرسول مرقس

الإنجيلي (Patriarchal Liturgical Commission, vol. 3, p. 1420) or from the Greek Menaion of

April: "Μνήμη τοῦ Ἁγίου Ἀποστόλου καὶ Εὐαγγελιστοῦ Μάρκου" (Dositheos, 2009, and

Schefe, 2011) – both, of course, naming 25 April as the Memorial of the Holy Apostle and

Evangelist Mark.

Sundays add an additional layer of complexity. The normal Sundays of the year are

usually named for their place in the cycle of Gospels after Pentecost (the Gospel of St

Matthew) or after the feast of the Exaltation of the Holy and Life-giving Cross[20] (the Gospel

of St Luke). For examples, see: the yearly Typikon (really: Ordo) of the Ecumenical

Patriarchate, i.a., 16 January 2011 at http://www.ec-patr.org/gr/typikon/2011/2011-01-

16.htm. Here, one sees that this Sunday is called: "Κυριακή: ΙΒ´ ΛΟΥΚΑ (τῶν Δέκα

Λεπρῶν)"[21]. The Greek Orthodox Archdiocese of America also uses the Gospel as the

naming point for this Sunday "Twelfth Sunday of St Luke".

It should be noted that the Antiochian Orthodox Church both in Syria and in the USA

refer to the Gospel of a Sunday by the number of Sundays after Pentecost only, even after the

feast of the Exaltation of the Holy and Life-giving Cross (cf.

http://www.alepporthodox.org/modules/bulletin/index.php?op=display_bulletin_issue&year_

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20 Shortened in references to "after Holy Cross".

21 That is, "the Twelfth Sunday of Saint Luke ([the Gospel pericope of] the Ten Lepers"

id=2011&id=375). For example, the Antiochian Orthodox call 16 January 2011 the twenty-ninth Sunday after Pentecost, which is also the twelfth Sunday after Holy Cross. Using the number of weeks after Pentecost is not always accurate for Gospels after 14 September, and this date, 16 January 2011, actually represents the thirty-fourth Sunday after the Pentecost 2010. The Evangelion gives both names to the Gospel lection: Luke 17:12-19 is called the "Twenty-ninth Sunday after Pentecost (Twelfth Sunday after Holy Cross)". The Melkite Church and the Ecumenical Patriarchate (and the Greek Orthodox) both use the cycle of Luke, i.e., the number of Sundays after Holy Cross, as the identifier; the Antiochian Orthodox merely uses the first part of the fuller name.

Sunday of the Canaanite woman.

Sundays of the cycle of Luke do not all appear in sequence. There are several rules within the Evangelion, which essentially allow certain Gospels to operate as journey markers. Even though the cycle depends on the movable date of Easter, some Gospels are designated to be read at fixed points of the year.

The seventeenth Gospel of St Matthew (Matthew 15:21-28), the story of the Canaanite woman, is one such example. It is read according to the normal numerical order – i.e., after the sixteenth Gospel of St Matthew, when Easter falls on 22 March. Should Easter fall between 15 April and 25 April, it is read on the Sunday preceding the Triodion period, as it was this year – i.e., 6 February 2011; Easter falling 24 April 2011 (Couturier, 1912–1930, vol. 1, Appendix, p. 8).

Concurrence brings complexities.

What does one call a Sunday, though, when a major feast falls on that day?[22] For

feasts of the first class – i.e., feasts of Our Lord and Saviour – the answer is simple: such

feasts supersede even Sundays in importance, so the day is merely named after the first-class

feast.

Feasts of the second class are similar to those of the first class, except that they do not

supersede Sundays. However, while not superseding a Sunday, it would give its name to the

liturgical day. Thus the feast of the Dormition of the Theotokos, 15 August, would give its

name to the liturgical day, even if it occurs on a Sunday. The name of the Sunday might

follow, however. See, for example, 15 August 2010 in the calendar of the Ecumenical

Patriarchate: "Κυριακή: Η ΚΟΙΜΗΣΙΣ ΤΗΣ ΥΠΕΡΑΓΙΑΣ ΔΕΣΠΟΙΝΗΣ ΗΜΩΝ

ΘΕΟΤΟΚΟΥ ΚΑΙ ΑΕΙΠΑΡΘΕΝΟΥ ΜΑΡΙΑΣ" (http://www.ec-

patr.org/gr/typikon/2010/2010-08-15.htm).

Feasts of the third and fourth classes give their names to the liturgical day, if they

occur outside the Triodion and Pentecostarion seasons. See, for example, 30 January 2011 in

the calendar of the Ecumenical Patriarchate: "Κυριακή: Τῶν ἐν Ἁγίοις Πατέρων ἡμῶν

Μεγάλων Ἱεραρχῶν καί Οἰκουμενικῶν Διδασκάλων, Βασιλείου τοῦ Μεγάλου, Γρηγορίου

τοῦ Θεολόγου καί Ἰωάννου τοῦ Χρυσοστόμου" (http://www.ec-

patr.org/gr/typikon/2011/2011-01-30.htm).

Feasts of the fifth class lend their name, after that of the Sunday, to the liturgical day

– but only if they fall outside the seasons of the Triodion and Pentecostarion. If these feasts

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22 By *major feast*, is intended feasts of the first, second, and third classes (Cf. Couturier, 1912-1930, vol. 1, p.
121). These feasts exhibit the greatest changes in the daily liturgy and prayer services.

fall within these seasons, on a Sunday, they are suppressed. See, for example, 3 April 2011 in

the calendar of the Aleppan eparchy of the Antiochian Orthodox Church: " من الصوم 4الأحد

القدّيس يوحنّا السلّمي"

(http://www.alepporthodox.org/modules/bulletin/?op=display_bulletin_issue&year_id=2011

&id=386).

In automating the Typikon, the name of the liturgical day will reflect the

aforementioned findings.

Epistle and Gospel Readings

Epistle reading when major feast falls on a Sunday.

If a feast is of the first class, then the Epistle of that feast is read.

However, if a feast of the second or third class falls on a Sunday, both Epistles are

read, one after the other, according to the Typikon of St Sabbas (Couturier, 1912–1930, vol.

1, Appendix, p. 5). The Typikon in use in the Patriarchate of Antioch, which conforms to the

Typikon of Constantinople, designates a single Epistle, usually that of the feast (Couturier,

1912–1930, vol. 1, Appendix, p. 5).

Gospel reading when major feast falls on a Sunday.

On days of the week, other than a Sunday, the Gospel of a major feast is read, and the

Gospel of the day is omitted. However, on a Sunday, the Typikon of St Sabbas indicates that

both Gospels should be read. The practice of the current Typikon, however, is that only one is

read, and that is usually the Gospel of the Sunday (Couturier, 1912–1930, vol. 1, Appendix,

p. 9).

Multiple Cases of Concurrency

An interesting case of multiple concurrency occurred this year (2011). Easter fell 24

April 2011. The feast of St George, the Great Martyr, normally falls 23 April. However, the

Typikon states that should this feast fall within Great and Holy Week, it is to be transferred to

the Monday of New Week – i.e., the Monday immediately following Easter (cf. i.a. Khoury,

2011, p. 323): '' لو وقع عيد القديس يوم الجمعة أو السبت العظيم أو أحد الفصح المجيد. في هذا الافتراض تنقل خدمته

الفصح ثاني الجديد الاثنين إلى'' (Rizq, 1911, p. 257).[23]

Moving the feast of Saint George to the Monday of New Week, however, causes an

additional clash. The current Typikon of the Melkite Church, Rizq, makes no comment about

such an occurrence. It only states: '' إذا وقع في سبة الفصح فيترك وكذا في أحد توما'' (Rizq, 1911, p.

266) – i.e., it makes no statement about moving the feast.[24] However, the Typikon of

Moulouk states that the feast is transferred to the Tuesday of Easter week, if it falls on Easter

Sunday or on the Monday of Easter week (Moulouk, 1896, "25 April"). The Typikon of

Violakis agrees (Violakis, 1888, p. 260; IMG_1434.jpg) as does the Arabic Typikon of

Arman (1986, p. 175) and the English translation of Arman by Khoury (2011, p. 347).[25]

In order to allow for the concurrence of a transferred feast (23 April) with another

feast (25 April), and this concurrence of two feasts occurring within Paschaltide – i.e., within

the season of the Pentecostarion, we must not only create rules for such concurrences, but

also define an order of precedence.

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23 That is: "If the feast of the saint should fall on Great and Holy Friday or Great and Holy Saturday or on
    Easter, the feast moves to New Monday, i.e., the Monday of Easter."
24 That is: "If it [the feast of Saint Mark] falls during the week of Easter or on the Sunday of Saint Thomas, it is
    suppressed."
25 It is not surprising that Moulouk, Arman, and Khoury agree with Violakis, as they are all based on the
    Typikon of Violakis.

Chapter 4: Databases, Facts, and Rules

In order for the results to be computed using an Expert System, a knowledge base of facts and the rules used by the inference engine is required. Those facts will be stored in a database.

Data and Databases

Choice of database type.

The type of database is not really important for automation. Little difference in performance or ease of use is recognised, whether a NoSQL database is used to store the information or a more traditional Relational Database Management System. Although the type of data and its rarely changing nature indicate a NoSQL database would be preferred, the amount of data involved in liturgical automation is not large, and thus the differences in these database systems do not become apparent. For the sake of this research, SQLite – a portable, self-contained Relational Database – has been chosen. It allows portability, is open-source, and it requires no specialised management software. Owens, in his book *The Definitive Guide to SQLite*, says that SQLite is found virtually everywhere today: on Apple Mac OS X, most versions of Linux, often on Microsoft Windows, and is found in avionics systems, smart cards and mobile cellular phones, including the Apple iPhone (2006, p. xv). SQLite is described as: "a software library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine." (http://www.sqlite.org). The version used for this automation is SQLite 3.7.7.1, which is the current version as at August 2011.

Data tables – what information is required.

There are several tables required for automation. Some of them are relatively simple,
e.g. the table containing the readings (both their Biblical references and their texts for each
language supported). Others, ostensibly simple, are actually quite complex, such as the table
containing basic information for the feasts. Table 4 below shows some of the basic
information required for each feast, in order to automate its occurrence and the liturgical rules
related to it.

Table 4: Examples of Basic Information required for Feasts

Item of Information	Description
Date	For fixed feasts, the month and the day of that month must be recorded.
Days after or before Easter	For movable feasts, their relationship to the date of Easter must be recorded.
Date of earliest and latest occurrence	Required for those feasts whose dates vary within a given period, such as the Sunday before the Theophany. The rules will be used to determine the precise date within this range.
Full name	Required for each language supported. This is the full name of the feast – fixed, mobile, or variable – as it appears in the liturgical books (e.g. Menaia, Triodion, Pentecostarion).
Short name	Required for each language supported. The short name is used, when referring to this feast and when it appears in calendars, etc., where there is insufficient room for the full name. This is the name, by which one refers to the feast colloquially.
Class of feast	The class of the feast. Most relevant for feasts of the Menaia.
Effective class of feast	Some feasts – e.g. those of Saint John the Baptist – are often treated as if they belong to a more important class. This item of information makes it possible to

Item of Information	Description
	automate precedence for such feasts – especially when they occur on a Sunday.
Number of days of Preparation	Some of the more important feasts have a fore-feast and a subsequent period of preparation, during which specific prayers are used.
Number of days of the Service period	Some of the more important feasts are celebrated longer than a single day.
Epistle and Gospel	Many feasts – both those of the Menaia, but also those of the Triodion and the Pentecostarion – have Epistle and/or Gospel readings assigned to them. These are the default readings for that day, before rules of concurrence, precedence, etc. are applied.
Type of Liturgy	The usual type of liturgy celebrated is the Liturgy of Saint John Chrysostom. On some days, the Liturgy of Saint Basil is specified, on others the Liturgy of the Pre-sanctified Gifts. During the week within the period of the Great Fast, there are many days, on which there is no Divine Liturgy at all.
Litany, Antiphon Prayer, Antiphons, Eisodikon, Troparia, Hypakoe, Final Kontakion, Trisagion, Hirmos, etc.	Some feasts have special prayers associated with them, that are either mixed with the normal cycle of such prayers, or supersede them. Again, these are the default for the particular day, before any rules are applied.

There are several items of information that must be calculated for each day of the year, or sometimes only for each Sunday. These are required in order to further calculate the appropriate Epistle, Gospel, etc.; some are required merely for automation. This, of course, implies that there are phases in the automation process; the earlier ones – e.g. the calculation of the Tone of the day – must complete before the later phases – e.g. calculating the Troparia of the day. Examples of such calculated data can be found in Table 5 below.

Table 5: Calculated Information for Automation

Item of Information	Description
Tone	The cycle of Eight Tones begins on the Sunday of Saint Thomas – i.e., the Sunday after Easter. It affects the choice of many prayers and determines the tone to be used in chanting many others.
Eothinon	The Eothinon Gospel is not used for the Divine Liturgy, only for the dawn prayer of Orthros. However, it usually appears on liturgical calendars and in yearly Ordos, and will be heard in churches before the beginning of the Sunday Divine Liturgy. As stated earlier, this cycle begins on the Sunday of All Saints – i.e., the Sunday after Pentecost.
Number of weeks after Pentecost	This cycle determines the lection from the Apostolos to be read. It also determines the Gospel to be read, up until the feast of Holy Cross (14 September).
Number of weeks after Holy Cross (i.e., after 14 September)	Used to determine the Gospel lection. This cycle does not always run in numerical order, at least for the Sundays.
Troparion of the Titular of the church	The Troparion of the titular saint or patron of the church or monastery is usually recited after the festal Troparia and Kontakia, but before the Final Kontakion. On feasts of the Lord and at some other times, it is not recited.

Discounting the variations in the liturgy that occur, when a bishop is celebrating – and especially when he is celebrating pontifically – there are many places in the Divine Liturgy where variations occur based on the feast and season – as a result of the earlier phases in the automation process. These can be found in Table 6 below. The variations that arise from celebrating the Liturgy of Saint Basil or the Liturgy of the Pre-sanctified Gifts are not included in the table.

Table 6: Parts of the Divine Liturgy that vary

Item of Information	Description
Prayer to the Holy Spirit	The prayer "O Heavenly King, Consoler ..." is not used to begin the liturgy from Easter until after the feast of Pentecost.
Opening prayers	The two prayers "Glory to God in the highest ..." and "O Lord, you shall open my lips ..." are not used from Easter until after the feast of the Ascension.
Litany of Peace	Several petitions are replaced at key times of the liturgical year, for example the Nativity and Easter.
Antiphon Prayer	This too may vary for feasts of the first and second classes.
Antiphons	The verse or refrain to be used in the Antiphons or the Psalms of the Typika vary for major feasts.
Eisodikon	The Entrance Hymn or Eisodikon varies for major feasts or ordinary weekdays.
Troparia and Kontakia	The rules for order, precedence on Sundays and during a service period, etc., are quite complex. The Troparion or Kontakion of the patron of the church or monastery is omitted on major feasts.
Hypakoe	The Hypakoe is recited only on a few important feasts of the Lord.
Final Kontakion	The Final Kontakion varies for major feasts and throughout their preparation and service periods.
Trisagion	The Thrice-holy Hymn has three variants, one of which is used depending on the feast or season.
Prokeimenon, Epistle, Alleluia Verse, Gospel	These vary for each day of the year. On Great and Holy Saturday the Alleluia Verse is replaced by Psalm 82 and the refrain "Rise up, O God, and judge the earth; for all nations belong to you!"
Cheroubikon	This prayer changes only on Great and Holy Thursday and Great and Holy Saturday.
Hirmos	The Hirmos varies for feasts of the Lord and the Theotokos.
Koinonikon	The brief verse of a psalm that is chanted to a long melody during the communion of the clergy.
Troparion after Communion	The prayer "We have seen the True Light ..." is replaced by the Troparion of the feast for feasts of the

Item of Information	Description
	Lord.
Dismissal Verse	The feast or commemoration of the day is always mentioned specifically in the Great Dismissal. However, feasts of the Lord may also make changes at the beginning of this prayer. Variations also occur depending on the day of the week.
Paschal changes	During Paschaltide, several changes occur –especially those where "Christ has risen" is chanted at various places within the liturgy.

There are several other tables of information that are required for automation, among which the following can be found:

- names of Books of the Bible and their abbreviations for all languages supported.

- Translations for all liturgical terms into the languages supported.

- Allowance for a rubric of the day or important information: for example, "The Dormition Fast begins today."

- Synaxarion of the day – i.e., a brief description of the feast or season.

- Texts of the prayers themselves – as distinct from the Scriptural texts of the readings.

Storing and using date data.

Dates are stored in the database as text in the form YYYY-MM-DD – which is the standard format defined in ISO 8601. For fixed feasts – i.e., those of the Menaia – the month is stored as an integer, as is the day of that month. The decision to store dates in this way was made for the following reasons:

- the dates are "human-readable" – and thus easily understood and maintained.

- Portability – dates are stored on different operating systems in different ways. Storing dates in this manner allows the database, scripts, and resultant data to be used on any system. For this reason, they are not stored as *date* types.

- SQLite does not have a basic data type of DATE.[26]

Date information is not stored in the same way in different operating systems. When storing dates, computer systems calculate the time passed since a given date, called an Epoch Date. For example, Linux (and Unix and Mac OS X) systems store the time as the number of seconds since midnight on 1 January 1970 UTC (Coordinated Universal Time or *Temps Universel Coordonné*). Microsoft Windows NT counts the number of 100-nanosecond ticks since midnight, 1 January 1601. Sub-second accuracy is not required to calculate events in the Byzantine liturgical calendar, so the decision was taken to convert all dates to the number of seconds since the Unix epoch (midnight, 1 January 1970 UTC) when calculations – such as the date of Easter – are required. This guarantees both accuracy and portability.

All date calculations assume a Gregorian Calendar. If a Julian Calendar or Orthodox Calendar is required, the result is converted to the that calendar at the end of the calculation.

Rules of the Road required for Navigation

Method of applying the rules.

While it might appear a reasonably simple calculation to determine the liturgical criteria for an individual day, in reality there are several background calculations, which must occur, including the date of Easter for the year sought, and the date of Easter for the previous year. These calculations are required so that key pieces of data can be determined – e.g. the

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26. The basic data types of SQLite are: Integer, Real, Text, Blob, Null (Owens, 2006, p. 137)

Tone of the week and the number of weeks after Pentecost. Once these interim data have

been found, the calculations for the particular day sought can begin.

Other issues such as concurrence of feasts, which force the transferral of a feast may

affect the day sought. For these reasons, it is usually simpler to calculate the entire year of

liturgical data, when seeking information for one day within that year. Once this year of

liturgical data has been calculated, it is stored in a database so that searches for liturgical

information for other days within that same year might be immediately available.

Several passes are made when applying the rules, gradually building up a picture of

the entire liturgical year. The multi-pass approach is not strictly necessary, but makes the

rules simpler and easier to maintain. Otherwise, any rule that even partially depends on the

date of Easter, would need that calculation within it or a clear dependency on that fact (i.e.,

the date of Easter), for example. When the rules become complex and include many decision

forks, they become difficult to maintain manually. It is also difficult to see common decision

paths that might be extracted into a more general rule or function – making the system and its

maintenance more efficient.

Functions in an Expert System.

When certain calculations are required by many rules, or would be performed by

processing these rules, it is simpler and easier to maintain, if these common calculations are

externalised from the rule and placed into functions within the Expert System. These

functions may then be called many times within a single calculation, and are easily

maintained because they are found in one place. An example of such a function can be found

in F, p. 91. This function determines whether a given year is a leap year or not.

Other examples of functions are a function to add days to a date, a function to create a date from a given year, month, and day. CLIPS does not have any in-built date functions, so this lack must be supplied by user-created functions in CLIPS (as discussed) or by linking to those functions supplied by an external (scripting) language. Of course, the most important functions created in CLIPS are those that calculate the date of Easter, an example of which may be found on p. 85.

First-pass rules.

The first rules to be processed determine the date of Easter of the year sought and the dates of Easter for the previous and following years, as well as the effective class of all competing feasts, seasons, service periods, and any Sunday that may also occur. Basic fasting (including abstinence) instructions are also calculated; these may be superseded or mitigated later by the concurrence of a leave-taking, Sunday, etc.

Second-pass and later rules.

The Epistle and and Gospel readings are then calculated, based on the effective class of the liturgical day (previously calculated). The result is the most likely reading to be chosen for that particular liturgical day. At this point, the rules found in the Menaia, the Triodion, the Pentecostarion, the Aposotolos, and the Evangelion have been applied. It is at this point, where the additional, much more detailed rules found in the Book of the Typikon must be applied.

The following code is an example, which calculates the Epistle for 1 January. The Typikon states that the Epistle of the feast for 1 January is read, even on a Saturday or a

Sunday – i.e., that it supersedes the Epistle of the Saturday or Sunday after the Nativity and

the Saturday or Sunday before the Theophany, all of which are otherwise important variable

feasts normally determining the Epistle and Gospel to be read (cf. Rizq, 1911, "1 January",

Khoury, 2011, 164).

```
(defrule rEpistleExtras0101
    (day-is 1)
    (month-is 1)
    ?f1 <- (epistleFact (epistle-is ?epistleR))
    ?f1W <- (whenceEpistleFact (whenceEpistle-is ?whenceEpistle))
    ?f2 <- (do-epistle)
    =>
    ;Epistle is read on the Saturday and the Sunday.
    (retract ?f2)
    (modify ?f1 (epistle-is "Colossians 2:8-12"))
    (modify ?f1W (whenceEpistle-is ?*fixed*))
)
```

A slightly more complicated example is the rule for the Gospel for the feast of Saint

John the Evangelist (8 May), which can fall any time between the Sunday of the Myrrh-

bearing Women and the Leave-taking of the Ascension (a Friday). Generally the Gospel of

Saint John is read, except if it falls on a Sunday, on the Mid-paschaltide feast, or on the feast

of the Ascension (cf. Khoury, 2011, pp. 363-364, Couturier, 1912-1930, vol. 2, p. 409).

```
(defrule rGospelExtras0508
    ;;;This one caters for those special rules of the typikon
    (declare (salience ?*low-priority*))
    (day-is 8)
    (month-is 5)
    ?f1 <- (gospelFact (gospel-is ?gospelR))
    ?f2 <- (do-gospel)
    ?f1W <- (whenceGospelFact (whenceGospel-is ?whenceGospel))
    =>
    (retract ?f2)
    ;Gospel is not on Sundays during Paschaltide.
    (if (= ?*dayOfWeek* 7) then
        (modify ?f1 (gospel-is ?*movable*))
        (modify ?f1W (whenceGospel-is ?*movable*))
    else
        (if (and (<> ?*daySought* (daysAdd ?*easter* 24)) (<> ?*daySought* (daysAdd ?*easter*
39))) then
            ;If the day is not a Sunday and it is not the feast of Mid-Paschaltide
            (modify ?f1 (gospel-is ?*fixed*))
            (modify ?f1W (whenceGospel-is ?*fixed*))
        )
    )
)
```

Another more complicated example may be found in Appendix H, p. 94. This rule

calculates the date of the Leave-taking of the Hypapante or the Presentation of the Lord in the

Temple. The feast itself falls 2 February each year, however the date of its leave-taking varies

depending upon the beginning of the Triodion period (i.e., in reality, it varies depending on

the date of Easter).

Tools of Choice for Automation

Storing data and rules.

As discussed above (p. 49), SQLite was chosen as the most appropriate database, in

which to store the data on Byzantine Liturgy for use in automating the Byzantine Typikon.

SQLite is relational database management system. However, a NoSQL database might well

be more appropriate, considering some of the advantages offered by these systems, for

example, the speed of access, where data do not change often (Lai, 2009). There are many

types of NoSQL databases, few of which are small, self-contained and embeddable. Metakit,

however, is a column-oriented, NoSQL database that has a small footprint and may easily be

embedded into a virtual file system (*Metakit Embedded Database Library*). Metakit has an

Application Programming Interface (API) for C++, Tcl, and Python. Both SQLite and

Metakit databases are easily ported.

For this research, SQLite has been chosen as the database to support all development

and automation. Metakit, however, has been chosen, where a database is to be embedded

within an executable. Embedding data and scripting code together allows the creation of a

single-file executable, which can be delivered to any platform – i.e., the automated Typikon

becomes an application, which does not require any special installation or system

configuration. Such features are considered advantageous as they presume no technical

expertise on behalf of the user. A script has been created to convert data in an SQLite

database to a Metakit database with full fidelity. The current version of SQLite in use for this

research is 3.7.7.1. The version of Metakit used is 2.4.9.7.

As CLIPS was chosen (see p. 14) as the Expert System tool, the rules to automate the

Typikon have been stored as CLIPS rules in standard text files.[27] No special format is

required, just valid CLIPS syntax. The current version of CLIPS in use for this research is

6.20.

Scripting language.

The Scripting Language used to automate the processing of the rules against the data,

presenting the resulting information, etc., is Tcl. Tcl was initially chosen because of its close

ties to SQLite. In fact, the SQLite web site says: "The SQLite library is designed to be very

easy to use from a Tcl or Tcl/Tk script. SQLite began as a Tcl extension and the primary test

suite for SQLite is written in Tcl. SQLite can be used with any programming language, but its

connections to Tcl run deep. (*Tcl Interface*)"

In the mid 1990s, Sun Microsystems had two next-generation programming languages

in its research labs: Java and Tcl (Flynt, 2003, p. xxvi). Flynt says: "Tcl is widely used as the

glue that allows developers to create complex systems." Tcl is a powerful multi-platform

scripting language used for rapid prototyping and in "thousands of successful commercial

applications" (Flynt, 2003, p. 1), including Cisco networking equipment. It has proven well-

suited to the task of automating the Byzantine Typikon. One of the key features of this

scripting language that is most useful is the *Tclkit* extension (see

http://equi4.com/tclkit/index.html). Tclkit is a compact, single file executable containing a

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27. CLIPS imports rules in either plain text or binary forms. It cannot import rules from within a database.

complete scripting runtime, including the scripting language (Tcl), a high-level GUI toolkit

(Tk), a virtual file system (TclVFS), and an embedded high-performance database (Metakit).

The current version of Tcl in use for this research is 8.5.10.

Another scripting language, Python, is proving to be one of the most popular, being

built into many enterprise systems. It is used by Google, IBM, Cisco, Hewlett-Packard,

NASA, ESRI, and IronPort as a scripting language, testing tool, or interface built into the

product (Lutz, 2009, p. 8). Of Python, Lutz says: "By design, Python implements a

deliberately simple and readable syntax and a highly coherent programming model" (2009, p.

4). As a means of ensuring the portability of the research work – i.e., that the tools run in

more than one scripting language, some of the functionality has been ported to Python. An

example of which can be found in Appendix B, p. 84, where the calculation of the date of

Easter is shown both in Tcl, Python, and CLIPS code. The current version of Python in use

for this research is 3.2.1.

Chapter 5: Presentation of the Ordo and other End Products

Standards Lacking or Immature

There exist no standard formats for output of liturgical documents today. A proposal

for a liturgical mark-up language,[28] LitML, was proposed in July 1999 (see

http://www.oremus.org/LitML/), but since then, there appears to have been no further

development. The stated goal of LitML – which satisfies only one of our requirements – is to

be a mark-up language for liturgical texts. However, this goal seems no longer to be relevant

since the maturing of the Text Encoding Initiative or TEI (see http://www.tei-

c.org/index.xml). To be clear, standards for the following are required:

- the texts or documents output from the automation process (Ordo, calendar, liturgical

  texts),

- data about fixed, movable, and variable feasts and other components of Byzantine

  liturgy required to describe it fully (and thus to automate it),

- data about the liturgical day that result from the automation process.

Text Encoding Initiative (TEI)

The Text Encoding Initiative is a consortium that develops and maintains a standard

for the representation of texts in digital form. The TEI standard is expressed in "Guidelines",

the current version of which is P5 (http://www.tei-c.org/Guidelines/P5/). One of the features

of TEI, is that if it is missing any tags to allow marking up of a text, the schema may be

extended or 'customised'. For this research, very few customisations were required, however a

customised schema was created for liturgical texts so that their content can be reproduced

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28 A mark-up language is a system for annotating text in such a way that the mark-up can be easily
    distinguished from that text. Examples of mark-up languages are: HTML (HyperText Mark-up Lanugage)
    and XML (Extensible Mark-up Language). XHTML is an XML application that mirrors or extends HTML.

with high fidelity to the printed liturgical books. The liturgical schema created for this

research in TEI can be found in Appendix I, p. 98. Liturgical texts produced by this research

– and encoded in TEI (using the liturgical customisation) – have been validated against the

TEI schema and wholly conform to it.[29]

The customised schema creates one new tag, "psalm", which is to act like a normal

paragraph.[30] This tag was created so that special formatting may be applied to psalm texts.

Four alternate names were added to the TEI schema for current TEI tags. For example, the

TEI tag "stage" used to show stage directions was given the alternate name of "rubric", as

this is the term used within liturgical texts for a similar function.

TEI is usually used to encode current texts or manuscripts so that the content and its

presentation or appearance may be recorded or reproduced. It may, however, also be used to

encode works that have not yet been published. The liturgical texts marked up in TEI may

then be transformed from machine-readable text (i.e., TEI's XML) into other formats better

suited to human readers. Simple transformations used in this research include creating word-

processing documents and electronic books in the EPUB format (see http://idpf.org). The

word-processing format used in this research is the Open Document Format standard

(http://docs.oasis-open.org/office/v1.1/OS/OpenDocument-v1.1-html/OpenDocument-

v1.1.html). This standard document format easily converts to other formats such as Microsoft

Word or desktop publishing formats.

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29 Validation is a means of ensuring that a document (e.g. in XML) conforms to the standard. This makes it
   more likely that all client applications will be able to parse the document correctly.
30 The additional element was not strictly necessary. Similar functionality could have been provided by
   specifying a use of the *@rend* attribute of, for example, the *p* (paragraph) element.

Standard for Feasts and Liturgical Days

While a standard for liturgical texts is required for producing liturgical texts from databases, or for encoding a facsimile of a liturgical book or manuscript with high fidelity, a standard for describing feasts or a liturgical day is also required. A selection of some of the main items of information required to be maintained for each feast or commemoration may be found in Table 4, p. 48. There is, as yet, no standard to describe or encode such data. Fortuitously, there is, however, a long-standing and widely supported set of standards to describe days or events in a calendar, and which may be used to describe a liturgical day. These standards are based around the iCalendar or iCal standard.

The iCalendar and similar standards.

The iCalendar standard is defined by the Internet Engineering Task Force (IETF) in RFC 5545, "Internet Calendaring and Scheduling Core Object Specification (iCalendar)," last updated September 2009.[31] The format of an iCalendar file is described in the aforementioned standard. These files usually have an extension of ".ics". A related standard, and one more useful to this research is the xCal standard – which is simply the XML-compliant representation of the iCalendar data. It too is defined by the IETF, in RFC 6321, "xCal: The XML Format for iCalendar". As mentioned above, XML is a useful format, as it may be transformed easily into other presentation formats. The hCalendar standard (http://microformats.org/wiki/hcalendar) should also be mentioned here. It is a micro-format standard used to display a semantic XHTML representation of iCalendar information on a web page.

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31. The iCalendar standard may be found here: http://tools.ietf.org/html/rfc5545

The iCalendar standard (and thus also xCal and hCalendar) allows for additional

elements. These may be registered, so that anyone may use them, or they may be created as

miscellaneous, non-standard properties (see RFC 5545, section 3.8.8.2). The latter may be

ignored by computer programs and user agents that do not understand them, but interpreted

by those programs that do. It is these non-standard properties that are used to extend the

iCalendar information so that it can support a liturgical day. Similar to the information

contained in Table 6, p. 50, Table 7 below shows those codes that were required to provide

the information pertinent to a Byzantine liturgical day that was not already provided in the

standard iCalendar properties.

Table 7: iCalendar Codes for a Byzantine Liturgical Day

Item of Information	*Description*	*iCalendar code*
Type of Liturgy	Shows whether the liturgy is that of Saint John Chrysostom, or Saint Basil the Great, etc.	X-LITX-LITURGY-TYPE
Prayer to the Holy Spirit	The prayer "O Heavenly King, Consoler ..." is not used to begin the liturgy from Easter until after the feast of Pentecost.	X-LITX-HOLY-SPIRIT-PRAYER
Opening prayers	The two prayers "Glory to God in the highest ..." and "O Lord, you shall open my lips ..." are not used from Easter until after the feast of the Ascension.	X-LITX-OPENING-PRAYERS
Litany of Peace	Several petitions are replaced at key times of the liturgical year, for example the Nativity and Easter.	X-LITX-GREAT-EKTENE
Antiphon Prayer	This too may vary for feasts of the first and second classes.	X-LITX-ANTIPHON-PRAYER
Antiphons	The verse or refrain to be used in	X-LITX-ANTIPHONS

Item of Information	Description	iCalendar code
	the Antiphons or the Psalms of the Typika vary for major feasts.	
Eisodikon	The Entrance Hymn or Eisodikon varies for major feasts.	X-LITX-EISODIKON
Principle Troparia Count	Some feasts require their troparia to be chanted more than once. This may vary during the service period of that feast, particularly on Sundays.	X-LITX-PRINCIPLE-TROPARIA-COUNT
Troparion or Kontakion of the Titular	We usually chant the Troparion or the Kontakion of the titular saint or patron saint of church or monastery on most days. However, this is not always the case.	X-LITX-CHANT-TITULAR-TROPARION
Troparia and Kontakia	The rules for order, precedence on Sundays and during a service period, etc., are quite complex. The Troparion or Kontakion of the patron of the church or monastery is omitted on major feasts.	X-LITX-TROPARIA-KONTAKIA
Hypakoe	The Hypakoe is recited only on a few important feasts of the Lord.	X-LITX-HYPAKOE
Final Kontakion	The Final Kontakion varies for major feasts and throughout their service periods.	X-LITX-FINAL-KONTAKION
Trisagion	The Thrice-holy Hymn has three variants, one of which is used depending on the feast or season.	X-LITX-TRISAGION
Prokeimenon, Epistle, Alleluia Verse, Gospel	These vary for each day of the year. On Great and Holy Saturday the Alleluia Verse is replaced by Psalm 82 and the refrain "Rise up, O God, judge the earth; for all nations belong to you!"	X-LITX-PROKEIMENON, X-LITX-EPISTLE, X-LITX-ALLELUIA, X-LITX-GOSPEL
Cheroubikon	This prayer changes only on Great and Holy Thursday and	X-LITX-CHEROUBIKON

Item of Information	Description	iCalendar code
	Great and Holy Saturday.	
Hirmos	The Hirmos varies for feasts of the Lord and the Theotokos.	X-LITX-HIRMOS
Koinonikon	The brief verse of a psalm that is chanted to a long melody during the communion of the clergy.	X-LITX-KOINONIKON
Communion Hymn	On the feast of Easter and its leave-taking, the communion hymn differs from the normal one.	X-LITX-COMMUNION-HYMN
Troparion after Communion	The prayer "We have seen the True Light ..." is replaced by the Troparion of the feast for feasts of the Lord.	X-LITX-POST-COMMUNION-TROPARION
Acclamation of "Blessed be the name of the Lord"	On Easter, during New Week, and on the Leave-taking of Easter this acclamation changes.	X-LITX-ACCLAMATION-BLESSED-BE-THE-NAME
Dismissal Verse	The feast or commemoration of the day is always mentioned specifically in the Great Dismissal. However, feasts of the Lord also make changes at the beginning of this prayer.	X-LITX-DISMISSAL-VERSES
Final Liturgical Rubric	Directions for processions, Paschal Stichera, etc.	X-LITX-FINAL RUBRIC
Feast Class	Class of the principle feast of the day	X-LITX-FEAST-CLASS
Fasting Type	Type of fasting relevant to the day	X-LITX-FASTING-TYPE
Abstinence Type	Type of abstinence relevant to the day	X-LITX-ABSTINENCE-TYPE
Tone	Which one of the Eight Tones is relevant to the day, if any.	X-LITX-OKTOECHOS-TONE

There are, of course, additional codes required besides those listed in Table 7, examples of which are the references – as opposed to the text – of the readings. Additionally, alternate translations in other languages may be provided.

Liturgical Data Standard

Of the three standards required specifically for this research (cf. p. 62), the only standard that is wholly missing is that required to describe raw liturgical data. The development of that standard, which would greatly facilitate the storage and interchange of liturgical data – and indeed support a generalisation of the automation processes to support any Typikon – is not within the scope of this research.

Automation Output No. 1: Daily Typikon

In Table 8 below, can be found a sample page from the Daily Ordo for Sunday, 25 September 2011, resulting from this research work. Note that those parts of the Divine Liturgy, for which we chant the usual texts do not appear in the table. The table is thus largely a table of exceptions.

Table 8: Daily Typikon for Sunday 25 September 2011
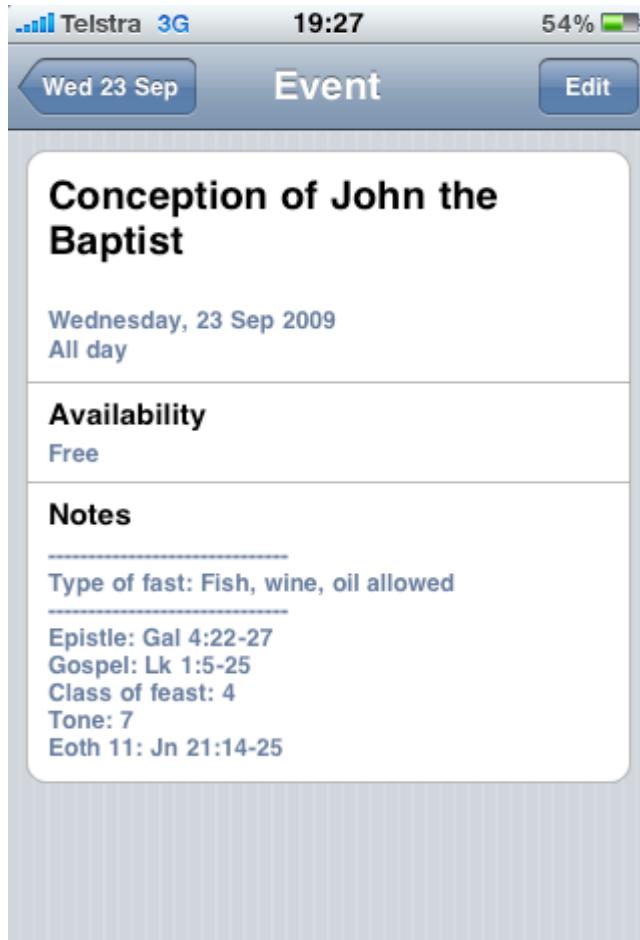
Liturgical Item	Value
Name	First Sunday after Holy Cross; commemoration of our Venerable Mother Euphrosyne.
Eothinon Gospel	No. 4 (Luke 24:1-12)
Troparia of the Day	Resurrectional troparion in Tone 6; Troparion of Euphrosyne in Tone 8
Troparion of the Titular	Chanted
Final Kontakion	O Never-failing Protectress …
Prokeimenon	Psalms 28:9,1 in Tone 6
Epistle	2 Corinthians 4:6-15 (15th after Pentecost)
Alleluia	Psalms 91:1,2 in Tone 6
Gospel	Luke 5:1-11 (1st after Holy Cross)
Hirmos	It is truly right …
Koinonikon	Psalms 148:1 (of the Sunday)

Liturgical Item	Value
Dismissal Verse	… who has risen from the dead
	… and of our Venerable Mother Euphrosyne

The data in this table are output in the iCalendar format, using, of course, the

extensions described above in Table 7, p. 63, which describe data specific to a Byzantine

liturgical day. The iCalendar file is transformed into an xCal file (i.e., in XML format). This

latter XML file may then be transformed in turn into a simple web page (XHMTL, which

might also contain hCalendar information), a word-processing document (ODF), and an

eBook (electronic book in EPUB format). The iCalendar format allows this information to be

input into an electronic calendar such as Microsoft Outlook, Hotmail, Google Mail, or the

calendar of a smart phone or tablet such as the Apple iPhone or an Android device.

A variation of this daily Typikon is also available, where the texts of the Troparia,

readings, etc., are included, to facilitate the liturgical celebration – especially when travelling.

Figure 1 below is an example of how the Daily Typikon or Ordo might appear on a

smart phone or mobile device. This example shows reduced information – i.e., it does not

contain information on the Troparia, Kontakia, etc.

Figure 1: Sample Daily Typikon on Mobile Device

Automation Output No. 2: Calendar

A liturgical calendar may be produced in a simple wall calendar format – again from the basic data formats discussed earlier. An example for the month of September 2011 can be found in Appendix J.

This calendar does not provide as much information as the Daily Typikon, but the following items of information are present:

- date and day of week

- name of feast

- class of feast

- Eothinon Gospel, where relevant

- Epistle and Gospel reading of the day

- Oktoechos tone of the week

- fasting and abstinence instructions, where relevant.

The example included in the appendix also includes the name of major and minor

feasts (i.e., those of classes 1, 2, 3, and 4) in Arabic as well as in English. This simplified

bilingual calendar has been found to be very useful for both clergy and laity.

Automation Output No. 3: Liturgical Texts

The Aposotolos and Evangelion that were produced for the automation are available

as a document (ODF), PDF for printing, or an eBook in EPUB format. So too is the basic text

for the Divine Liturgy.

The EPUB format has proven especially useful for the younger faithful, to assist them

during the Divine Liturgy, so they might follow the texts, prayers, and readings in their own

language. It has also been found convenient, for those who use it in prayerful reflection of a

Sunday or feast.

Standard Outputs Allow Flexibility

The advantage of choosing to use standards in this automation process, allows every

output of the process to be read on a web page (in XHTML format), stored as a document or

sent to a desktop publishing software for eventual publishing (ODF), printed in a pre-

formatted book or booklet (PDF), to be read using mobile and portable devices (EPUB and

other eBook formats), and incorporated into electronic calendars (iCalendar, xCal).

In this way, the fruit of the research is made available to the widest possible audience.

Summarising the Research

Determining the rules for a correct celebration of the Byzantine Divine Liturgy is not

a simple task. The rules are found spread throughout almost all the liturgical books –

including the Aposotolos and the Evangelion. It is not just the Book of the Typikon, which

must be consulted – indeed, one consults this only having first consulted the others and

constructed the first draft of the liturgical texts required for a given day.

An Expert System has proved to be a key resource in applying all of the necessary

liturgical rules – and applying them in the correct order. Without an Expert System, the rules

would need to be hard-coded in the Scripting Language – and this removes all flexibility,

vastly increases the complexity, and makes the rules themselves difficult to maintain.

One of the key decisions that makes the output of the research useful to the widest

audience is the choice to adhere to recognised standards in data storage (SQL), presentation

of information (e.g. XHTML), and end-user applications or devices (e.g. iCalendar, EPUB).

Making the output of this research available in this manner, allows it to bear more fruit.

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Appendix F: Calculation of Easter using Oudin's formula

Given:
1. G = *GoldenNumber* - 1
2. H = 23 – *Epact* (modulo 30)
3. I (days) = Paschal Full Moon date – 21 March
4. J = weekday of the Paschal Full Moon (where Sunday = 0, Monday = 1, etc.)
5. L (days) = the date of the Sunday on or before the Paschal Full Moon – 21 March
6. Thus

One calculates:
$$G = year \bmod 19$$

For the Julian Calendar:

$$J = \left(year + \frac{year}{4} + I \right) \bmod 7$$

For the Gregorian Calendar:
$$C = \frac{year}{100}$$
$$H = \left(C - \frac{C}{4} - \frac{8C+13}{25} + 19G + 15 \right) \bmod 30$$
$$I = H - \frac{H}{28}\left(1 - \frac{29}{H+1} \times \frac{21-G}{11} \right)$$
$$J = \left(year + \frac{year}{4} + I + 2 - C + \frac{C}{4} \right) \bmod 7$$

Thereafter, for both Calendars:
$$L = I - J$$
$$EasterMonth = 3 + \frac{L+40}{44}$$
$$EasterDay = L + 28 - 31 \times \frac{EasterMonth}{4}$$

Appendix G: Scripts for Calculating Easter

Tcl

```tcl
proc f15_CalcDateOfEaster {imYear imMethod} {

    # default values for invalid arguments
    set imDay 0
    set imMonth 0
    # intermediate results (all integers)
    set iFirstDig 0
    set iRemain19 0
    set iTempNum 0
    # tables A to E results (all integers)
    set iTableA 0
    set iTableB 0
    set iTableC 0
    set iTableD 0
    set iTableE 0


    # Set up default values
    set ipReturn $dERROR_DATE

    # Validate arguments
    if {$imMethod < $iEDM_JULIAN || $imMethod > $iEDM_WESTERN} {
        puts stderr "Method must be iEDM_JULIAN, iEDM_ORTHODOX or iEDM_WESTERN"
        return -code 1 $ipReturn
    } elseif {$imMethod == $iEDM_JULIAN && $imYear < $iFIRST_EASTER_YEAR} {
        puts stderr "The original calculation applies to all years from AD"
        return -code 1 $ipReturn
    } elseif {($imMethod == $iEDM_ORTHODOX || $imMethod == $iEDM_WESTERN) && (($imYear <
$iFIRST_VALID_GREGORIAN_YEAR) || ($imYear > $iLAST_VALID_GREGORIAN_YEAR))} {
        puts stderr "Gregorian calendar Easters apply for years $iFIRST_VALID_GREGORIAN_YEAR
to $iLAST_VALID_GREGORIAN_YEAR only."
        return -code 1 $ipReturn
    } else {
        #OK to proceed
    }

    #  Calculate Easter Sunday date
    # first 2 digits of year (integer division)
    set iFirstDig [expr $imYear / 100]
    # remainder of year / 19
    set iRemain19 [expr $imYear % 19]

    if {($imMethod == $iEDM_JULIAN) || ($imMethod == $iEDM_ORTHODOX)} {
        #  calculate PFM date
        set iTableA [expr ((225 - 11 * $iRemain19) % 30) + 21]

        #  find the next Sunday
        set iTableB [expr ($iTableA - 19) % 7]
        set iTableC [expr (40 - $iFirstDig) % 7]

        set iTempNum [expr $imYear % 100 ]
        set iTableD [expr ($iTempNum + $iTempNum / 4) % 7]

        set iTableE [expr ((20 - $iTableB - $iTableC - $iTableD) % 7) + 1]
        set imDay [expr $iTableA + $iTableE]

        # convert Julian to Gregorian date
        if {$imMethod == $iEDM_ORTHODOX} {
           # 10 days were # skipped#  in the Gregorian calendar from 5-14 Oct 1582
            set iTempNum  10
            # Only 1 in every 4 century years are leap years in the Gregorian
            # calendar (every century is a leap year in the Julian calendar)
```

```
        if { $imYear > 1600 } {
            set iTempNum [expr $iTempNum + $iFirstDig - 16 - (($iFirstDig - 16) / 4)]
        }
        set imDay [expr $imDay + $iTempNum]

    }

} elseif {$imMethod == $iEDM_WESTERN} {
    #  calculate PFM date
    set iTempNum [expr ($iFirstDig - 15) / 2 + 202 - 11 * $iRemain19]
    switch $iFirstDig {
        21 -
        24 -
        25 -
        27 -
        28 -
        29 -
        30 -
        31 -
        32 -
        34 -
        35 -
        38 { set iTempNum [expr $iTempNum - 1] }
        33 -
        36 -
        37 -
        39 -
        40 { set iTempNum [expr $iTempNum - 2] }
    }
    set iTempNum [expr $iTempNum % 30]

    set iTableA  [expr $iTempNum + 21]
    if {$iTempNum == 29} {
        set iTableA [expr $iTableA - 1]
    }
    if {(($iTempNum == 28) && ($iRemain19 > 10))} {
        set iTableA [expr $iTableA - 1]
    }

    #  find the next Sunday
    set iTableB [expr ($iTableA - 19) % 7]

    set iTableC [expr (40 - $iFirstDig) % 4]
    if {$iTableC == 3} {
        set iTableC [expr $iTableC + 1]
    }
    if {$iTableC > 1} {
        set iTableC [expr $iTableC + 1]
    }

    set iTempNum [expr $imYear % 100]
    set iTableD [expr ($iTempNum + $iTempNum / 4) % 7]

    set iTableE [expr ((20 - $iTableB - $iTableC - $iTableD) % 7) + 1]
    set imDay [expr $iTableA + $iTableE]

}

#  return the date
if {$imDay > 61} {
    set imDay [expr $imDay - 61]
    set imMonth 5
    # for imMethod 2, Easter Sunday can occur in May
} elseif {$imDay > 31} {
    set imDay [expr $imDay - 31]
    set imMonth 4
} else {
    set imMonth 3
```

```
    }
    # set up date field
    set sDate $imYear
    append sDate "-" $imMonth "-" $imDay
    set dDate [clock scan $sDate -format $sCLOCK_FORMAT -timezone $sCLOCK_ZONE]

    return $dDate

}
```

Python

```python
def f15_CalcDateOfEaster(iYearToFind, iDatingMethod):
    # default values for invalid arguments
    imDay = 0
    imMonth = 0
    # intermediate results (all integers)
    iFirstDig = 0
    iRemain19 = 0
    iTempNum = 0
    # tables A to E results (all integers)
    iTableA = 0
    iTableB = 0
    iTableC = 0
    iTableD = 0
    iTableE = 0

    #  Calculate Easter Sunday date
    # first 2 digits of year (integer division)
    iFirstDig = iYearToFind // 100
    # remainder of year / 19
    iRemain19 = iYearToFind % 19

    if (iDatingMethod == iEDM_JULIAN) or (iDatingMethod == iEDM_ORTHODOX):
        #  calculate PFM date
        iTableA = ((225 - 11 * iRemain19) % 30) + 21

        #  find the next Sunday
        iTableB = (iTableA - 19) % 7
        iTableC = (40 - iFirstDig) % 7

        iTempNum = iYearToFind % 100
        iTableD = (iTempNum + (iTempNum // 4)) % 7

        iTableE = ((20 - iTableB - iTableC - iTableD) % 7) + 1
        imDay = iTableA + iTableE

        # convert Julian to Gregorian date
        if iDatingMethod == iEDM_ORTHODOX:
            # 10 days were # skipped#  in the Gregorian calendar from 5-14 Oct 1582
            iTempNum  = 10
            # Only 1 in every 4 century years are leap years in the Gregorian
            # calendar (every century is a leap year in the Julian calendar)
            if iYearToFind > 1600 :
                iTempNum = iTempNum + iFirstDig - 16 - ((iFirstDig - 16) // 4)

            imDay = imDay + iTempNum
    else:
        #That is iDatingMethod == iEDM_WESTERN
        #  calculate PFM date
        iTempNum = ((iFirstDig - 15) // 2) + 202 - 11 * iRemain19
        lFirstList = [21, 24, 25, 27, 28, 29, 30, 31, 32, 34, 35, 38]
        lSecondList = [33, 36, 37, 39, 40]
        if iFirstDig in lFirstList:
            iTempNum = iTempNum - 1
        elif iFirstDig in lSecondList:
```

```
            iTempNum = iTempNum - 2

        iTempNum = iTempNum % 30

        iTableA  = iTempNum + 21
        if iTempNum == 29 :
            iTableA = iTableA - 1
        if ((iTempNum == 28) and (iRemain19 > 10)):
            iTableA = iTableA - 1

        #  find the next Sunday
        iTableB = (iTableA - 19) % 7

        iTableC = (40 - iFirstDig) % 4
        if iTableC == 3 :
            iTableC = iTableC + 1
        if iTableC > 1 :
            iTableC = iTableC + 1

        iTempNum = iYearToFind % 100
        iTableD = (iTempNum + iTempNum // 4) % 7

        iTableE = ((20 - iTableB - iTableC - iTableD) % 7) + 1
        imDay = iTableA + iTableE

    #  return the date
    if imDay > 61 :
        imDay = imDay - 61
        imMonth = 5
        # for imMethod 2, Easter Sunday can occur in May
    elif imDay > 31 :
        imDay = imDay - 31
        imMonth = 4
    else:
        imMonth = 3

    return datetime.date(iYearToFind, imMonth, imDay)
```

CLIPS

```
(deffunction f15_CalcDateOfEaster
    (?imYear ?imMethod)

    ; default values for invalid arguments
    (bind ?imDay 0)
    (bind ?imMonth 0)
    ; intermediate results (all integers)
    (bind ?iFirstDig 0)
    (bind ?iRemain19 0)
    (bind ?iTempNum 0)
    ; tables A to E results (all integers)
    (bind ?iTableA 0)
    (bind ?iTableB 0)
    (bind ?iTableC 0)
    (bind ?iTableD 0)
    (bind ?iTableE 0)
    ;Default return value indicating error.
    (bind ?ipReturn 0)

    ;validate the arguments
    (if (or (< ?imMethod ?*iEDM_JULIAN*) (> ?imMethod ?*iEDM_WESTERN*)) then
        (return ?ipReturn)
    )
    (if (and (= ?imMethod ?*iEDM_JULIAN*) (< ?imYear ?*iFIRST_EASTER_YEAR*)) then
        (return ?ipReturn)
```

```
    )
    (if (and (or (= ?imMethod ?*iEDM_ORTHODOX*) (= ?imMethod ?*iEDM_WESTERN*)) (or (< ?imYear
?*iFIRST_VALID_GREGORIAN_YEAR*) (> ?imYear ?*iLAST_VALID_GREGORIAN_YEAR*))) then
        (return ?ipReturn)
    )

    ;Calculate Easter Sunday date
    ;   first two digits of the year
    (bind ?iFirstDig (div ?imYear 100))
    (bind ?iRemain19 (mod ?imYear 19))

    (if (or (= ?imMethod ?*iEDM_JULIAN*) (= ?imMethod ?*iEDM_ORTHODOX*)) then
        ;Calulate the PFM date
        (bind ?iTableA (+ (mod (- 225 (* 11 ?iRemain19)) 30) 21))

        ;Find the next Sunday
        (bind ?iTableB (mod (- ?iTableA 19) 7))
        (bind ?iTableC (mod (- 40 ?iFirstDig) 7))

        (bind ?iTempNum (mod ?imYear 100))
        (bind ?iTableD (mod (+ ?iTempNum (div ?iTempNum 4)) 7))

        (bind ?iTableE (+ (mod (- 20 ?iTableB ?iTableC ?iTableD) 7) 1))
        (bind ?imDay (+ ?iTableA ?iTableE))

        ;Convert Julian to Gregorian date
        (if (= ?imMethod ?*iEDM_ORTHODOX*) then
            ;Ten days were skipped in the Gregorian between 5 - 14 October 1582.
            (bind ?iTempNum 10)
            ;Only one in every four century years are leaps years in the Gregorian calendar.
            ;   Every century year is a leap year in the Julian calendar.
            (if (> ?imYear 1600) then
                (bind ?iTempNum (+ ?iTempNum (- ?iFirstDig 16 (div (- ?iFirstDig 16) 4))))
            )
            (bind ?imDay (+ ?imDay ?iTempNum))
        )
    )
    (if (= ?imMethod ?*iEDM_WESTERN*) then
        ;Calculate PFM date
        (bind ?iTempNum (- (+ (div (- ?iFirstDig 15) 2) 202) (* 11 ?iRemain19)))
        (switch ?iTempNum
            (case 21 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 24 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 25 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 27 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 28 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 29 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 30 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 31 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 32 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 34 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 35 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 38 then (bind ?iTempNum (- ?iTempNum 1)))
            (case 33 then (bind ?iTempNum (- ?iTempNum 2)))
            (case 36 then (bind ?iTempNum (- ?iTempNum 2)))
            (case 37 then (bind ?iTempNum (- ?iTempNum 2)))
            (case 39 then (bind ?iTempNum (- ?iTempNum 2)))
            (case 40 then (bind ?iTempNum (- ?iTempNum 2)))
            (default none)
        )
        (bind ?iTempNum (mod ?iTempNum 30))

        (bind ?iTableA (+ ?iTempNum 21))
        (if (= ?iTempNum 29) then
            (bind ?iTableA (- ?iTableA 1))
        )
        (if (and (= ?iTempNum 28) (> ?iRemain19 10)) then
            (bind ?iTableA (- ?iTableA 1))
```

```
    )

    ;Find the next Sunday
    (bind ?iTableB (mod (- ?iTableA 19) 7))

    (bind ?iTableC (mod (- 40 ?iFirstDig) 4))
    (if (= ?iTableC 3) then
        (bind ?iTableC (+ ?iTableC 1))
    )
    (if (> ?iTableC 1) then
        (bind ?iTableC (+ ?iTableC 1))
    )

    (bind ?iTempNum (mod ?imYear 100))
    (bind ?iTableD (mod (+ ?iTempNum (div ?iTempNum 4)) 7))

    (bind ?iTableE (+ (mod (- 20 ?iTableB ?iTableC ?iTableD) 7) 1))
    (bind ?imDay (+ ?iTableA ?iTableE))
)

;Return the date of Easter
(if (> ?imDay 61) then
    (bind ?imDay (- ?imDay 61))
    ;Easter can occur in May for ?*iEDM_ORTHODOX*.
    (bind ?imMonth 5)
else
    (if (> ?imDay 31) then
        (bind ?imDay (- ?imDay 31))
        (bind ?imMonth 4)
    else
        (bind ?imMonth 3)
    )
)

(return (mkDate ?imYear ?imMonth ?imDay))
)
```

Appendix H: Antiochian Orthodox Fasting Regulations

- Pre-Lenten weeks: no fasting in the week following the Sunday of the Publican and the Pharisee, including the Wednesday and Friday of that week.

- Meatfare Sunday is the last day that meat or poultry may be eaten until Easter.

- Cheefare Sunday is the last day, on which dairy products are eaten until Easter.

- Clean Monday is a day of total fast: nothing but a little water is taken.

- If possible, no food is taken from the beginning of Clean Monday until after the Liturgy of the Pre-sanctified Gifts on Wednesday.

- The first week of Lent is especially hard.

- The remaining weeks of Lent, one does not eat meat, animal products, dairy products, and fish. On weekends, oil and wine are permitted, but on weekdays one abstains from them.

- Usually one meal is taken each day during the week; two on a weekend.

- Fish, wine, and oil may be taken on the Feast of the Annunciation and Palm Sunday.

- On other major or minor feasts that fall within this period, wine and oil may be taken.

- Holy Week again is strict.

- Holy Thursday, wine is permitted.

- Holy Saturday, oil is not permitted: the only Saturday of the year, for which this guideline holds true. (Antiochian Orthodox, n.d.)

Appendix I: Melkite Fasting Regulations

- Days of fast are Wednesdays and Fridays from Cheesefare week, and all five weekdays of the weeks of Lent and of Great and Holy Week – except the Annunciation. Saturday of Light is the only Saturday, on which one fasts.

- Days of Abstinence are all the days of Lent and Great and Holy Week, including Sundays. The exceptions are the Annunciation and Palm Sunday, on which days one may eat fish.

- Abstinence each Wednesday and Friday of the year, except Paschaltide (from Easter to Ascension), the week of Pentecost, the 12 days between the Nativity and the Theophany, and the week of the Transgressors, which follows the Sunday of the Publican and the Pharisee.

- Fast on the two Paramonies (Nativity and Theophany), or the Friday before, if they fall on the weekend.

- Fast or abstinence of the Nativity from 15 November until the eve of 25 December.

- Fast or abstinence of the Apostles from the Monday after All Saints until the eve of 29 June.

- Fast or abstinence of the Theotokos from 1 – 14 August.

- Abstinence on the feast of the Beheading of Saint John the Baptist, 29 August.

- Abstinence on the feast of the Exaltation of the Cross, 14 September.

- All the Fasts (fasting periods) are really periods of Abstinence, except the Great Fast, which includes both fasting and abstinence. (Patriarchal Liturgical Commission, 1998–2000, volume 2, part 1, pp. 713-718)

Couturier's and Charon's Instructions

- Fasting means eating only one meal in the day, and that after sunset.

    - All Wednesdays and Fridays are days of fast.

    - Paramonies of the Nativity and the Theophany or the Friday before, if the feast itself falls on a Sunday or Monday.

    - Wednesday and Friday of the week of Abstinence (Cheesefare week).

    - Each day of the Great Fast, except the Saturdays, Sundays, and 25 March, beginning with the Monday after Cheesefare Sunday.

    - Great & Holy Saturday

    - Beheading of John the Baptist (29 August)

    - Exaltation of the Cross (14 September).

- Abstinence is either strict or mitigated. The days of strict abstinence (no meat, milk products, eggs, fish, wine, or oil) are:

    - Wednesday and Friday of each week

    - the Paramonies

    - All of the Great Fast, except Palm Sunday

- The days of mitigated abstinence are as follows. On these day, only meat, eggs, and dairy products are prohibited. Wine and oil are always permitted; fish is permitted on some occasions.

    - Palm Sunday

    - 29 August and 14 September

- During the whole of the Apostles Fast, although strict abstinence applies on the Wednesdays and Fridays.

- During the Dormition Fast, although strict abstinence applies on the Wednesdays and Fridays.

- During the entire Nativity Fast, although strict abstinence applies on the Wednesdays and Fridays.

- Only meat is prohibited during the week of Abstinence (Cheesefare week).

- The following are periods, where no fasting occurs:

  - from the Nativity until the Theophany, excluding the Paramony.

  - The first week of the Triodion, which follows the Sunday of the Publican and the Pharisee.

  - The week after Easter and the week after Pentecost.

  - Monasteries may eat dairy products and fish (they never eat meat) on the following additional feasts: 8 September, 14 and 21 November, 7 January, 2 February, 25 March, 29 June, and 15 August. However, should these feasts fall on a Wednesday or Friday, only fish, wine, and oil are permitted.

  - Monasteries may consume wine and oil on other feasts (of the third or fourth class). (Couturier, 1912–1930, vol. 1, pp. 126-131; Charon, 1911/2001, pp. 347-363.)

Appendix J: Variable Feasts required for Automation

The following table, Table 9, contains the variable feasts that are required for a complete automation of the Byzantine liturgical calendar.

Some entries appear twice, but these are feasts that may occur at either end of a calendar year; e.g. the Sunday after the Nativity may fall in December or January of the following year.

Table 9: Variable Feasts of the Byzantine Calendar

Feast	Occurs
Sunday of the Fathers of the 6 Ecumenical councils	13 – 19 July
Fathers of the 2nd council of Nicaea	11 – 17 October
Sunday of the Holy Ancestors of Christ	11 – 17 December
Saturday before the Nativity	Saturday before the Nativity
Sunday of the Genealogy of Christ	18 – 24 December
Saturday after the Nativity	Saturday after the Nativity
St Joseph spouse and guardian of Our Lady; James, the brother of the Lord; David, king and prophet	26 December – 1 January
Saturday before Theophany	Saturday before Theophany
Sunday before Theophany	Sunday before Theophany
Saturday before Holy Cross	Saturday before Holy Cross
Sunday before Holy Cross	Sunday before Holy Cross
Saturday after Holy Cross	Saturday after Holy Cross
Sunday after Holy Cross	Sunday after Holy Cross
Monday before Sunday of the Publican and Pharisee	76 days before Easter
Tuesday before Sunday of the Publican and Pharisee	75 days before Easter
Wednesday before Sunday of the Publican and Pharisee	74 days before Easter
Thursday before Sunday of the Publican and Pharisee	73 days before Easter

Feast	*Occurs*
Friday before Sunday of the Publican and Pharisee	72 days before Easter
Saturday before Sunday of the Publican and Pharisee	71 days before Easter
Saturday after Theophany	Saturday after Theophany
Sunday after Theophany	Sunday after Theophany
2nd Sunday after Theophany	2nd Sunday after Theophany
3rd Sunday after Theophany	3rd Sunday after Theophany
4th Sunday after Theophany	4th Sunday after Theophany
5th Sunday after Theophany	5th Sunday after Theophany
Sunday of the Canaanite Woman	77 days before Easter
Saturday before Sunday of Canaanite woman	78 days before Easter
Day after Theophany; Synaxis of St John the Baptist	Day after Theophany; Synaxis of St John the Baptist
Paramony of the Nativity	22 – 24 December
Sunday of Church Unity	18 – 25 January
Leave-taking of the Presentation of Our Lord	3 – 9 February
Leave-taking of the Feast of the Annunciation	26 March (Vespers only)
Paramony of the Theophany	3 – 5 January
Leave-taking of the Theophany	11 – 14 January
Saturday after the Nativity	Saturday after the Nativity in the following year
St Joseph spouse and guardian of Our Lady; James, the brother of the Lord; David, king and prophet	26 December – 1 January in the following year
Saturday before Theophany	Saturday before Theophany in the following year
Sunday before Theophany	Sunday before Theophany in the following year
Memorial Saturday (1st)	Usually 57 days before Easter
Commemoration of the Great-Martyr George the Triumphant	Usually 23 April

Appendix K: Expert System Function to Determine Leap Year

The following CLIPS code is an example of a function that determines whether the

year passed into the function is a leap year according to the Gregorian Calendar.

```
(deffunction isThisALeapYear
    (?baseYear)

    ;We use the Unix Epoch Date for calculations (01 January 1970, 00.00 UTC),
    ;   and we accept no date earlier than that.
    ;We assume the following definition of a Leap Year (or intercalary or bissextile year),
    ;   as defined in the Gregorian Calendar:
    ;       1. February has 28 days each year, but 29 in a Leap Year.
    ;       2. All years, except century years, that are evenly divisible by 4 are Leap Years.
    ;       3. Only century years evenly divisible by 400 are Leap Years.
    ;We may ignore the fact that the Gregorian calendar began in 1582 and in other years for
    ;   some countries, as our system date does not allow dates before 1970.

    ;Check that the argument is numeric
    (if (not (integerp ?baseYear)) then
        (return FALSE)
    )
    ;Check for legal values
    (if (< ?baseYear 1970) then
        (return FALSE)
    )

    ;Check for leap centuries, then leap years that are not centuries.
    (if (= (mod ?baseYear 400) 0) then
        ;We have a Leap Year century
        (return TRUE)
    )
    (if (= (mod ?baseYear 100) 0) then
        ;We have a standar year century
        (return FALSE)
    )
    (if (= (mod ?baseYear 4) 0) then
        ;We have a leap year that is not a century.
        (return TRUE)
    )

    ;If not a leap year, we fall out here.
    (return FALSE)
)
```

Appendix L: Function and Rule to Calculate Eothinon

The following CLIPS code is an example of a function and the rule that uses that function. The function depends on several global variables that have already been passed to the Expert System. These are:

- *PentecostarionEnds*, which has a value of 56 – i.e., the number of days after Easter, which gives the Sunday of All Saints.

- *dayOfWeek* – a digit representing the day of the week, where Monday is 1 and Sunday is 7.

- *daySought* – the date, for which we are seeking liturgical information.

- *easter* – the date of Easter in this calendar year.

- *prevEaster* – the date of Easter, which is earlier than the date sought. This date may or may not be within the same calendar year.

If there is any Eothinon in the Menaion or the Triodion or the Pentecostarion, this information is passed into the rule. The rule determines the cases with this Eothinon – the Eothinon of the Proper – is the correct one, or whether we must calculate the Eothinon of the Sunday according to the formula in the defined (CLIPS) function.

```
(deffunction calculateTheEothinon
        ;Calculates the standard eothinon for Sundays.
        ;Should only be called where a proper eothinon is not required.

        (?wClass)
        (if (< ?*dayOfWeek* 7) then
                ;Not a Sunday.
                (return nil)
        )
        (if (and (> ?*daySought* ?*prevEaster*) (< ?*daySought* (+ ?*prevEaster*
?*PentecostarionEnds*))) then
                ;Between Easter and the Feast of All Saints, special Eothina determined by the
Pentecostarion.
                (return nil)
        )
         (if (< ?*easter* ?*daySought*) then
```

```
                (if (> (+ (mod (div (div (- (div ?*daySought* (* 60 60 24))  (+ (div ?*easter* (*
60 60 24)) ?*PentecostarionEnds*) ) 1) 7) 11) 1) 11) then
                        (return 1)
                else
                        (return (+ (mod (div (div (- (div ?*daySought* (* 60 60 24))  (+ (div
?*easter* (* 60 60 24)) ?*PentecostarionEnds*) ) 1) 7) 11) 1))
                )
        else
            (if (> (+ (mod (div (div (- (div ?*daySought* (* 60 60 24))  (+ (div ?*prevEaster*
(* 60 60 24)) ?*PentecostarionEnds*) ) 1) 7) 11) 1) 11) then
                        (return 1)
                else
                        (return (+ (mod (div (div (- (div ?*daySought* (* 60 60 24))  (+ (div
?*prevEaster* (* 60 60 24)) ?*PentecostarionEnds*) ) 1) 7) 11) 1))
                )
        )

        nil
)


(defrule rEothinon
    ?f1 <- (eothinonFact (eothinon-is ?eothinon))
    ?f2 <- (do-eothinon)
    (classFact (winningClass ?wClass))
    =>
    (retract ?f2)
    (if (< ?wClass 3) then
        ; no change(assert (eothinon-is ?eothinon))
    else
        (if (< ?*dayOfWeek* 7) then
            ;if it is not a Sunday, then no change.
            ;   Leave fact asserted with the data from the proper.
        else
            ;we have a Sunday and no major feasts
            (if (eq ?eothinon nil) then
                (modify ?f1 (eothinon-is (calculateTheEothinon ?wClass)))
            )
        )
    )
)
```

Appendix M: Rule Calculating Date of Leave-taking of Hypapante

The date of this feast is 2 February, however the date of its leave-taking varies

depending on the beginning of the Triodion period.

```
(defrule rVAR031
    ;Leave-taking of the Presentation of Our Lord.
    ?specialDate <- (specialDate (DateSought-is nil)
                       (TypeIndex-is VAR031)
                       (DateFirst-is ?dateFirst)
                       (DateLast-is ?dateLast))
    ;We only want this rule to fire, if the date has not been set.
    =>
    ;?dateLast is the normal day for this feast.
    (if ?*leapYear* then
        (if (> ?*easter* (mkDate ?*yearSought* 4 6)) then
            (modify ?specialDate  (DateSought-is ?dateLast ))
            else
            (if (> ?*easter* (mkDate ?*yearSought* 4 2)) then
                (modify ?specialDate  (DateSought-is (daysAdd ?*easter* -59)))
                else
                (if (> ?*easter* (mkDate ?*yearSought* 3 29)) then
                    (modify ?specialDate  (DateSought-is (daysAdd ?*easter* -61)))
                    else
                    (if (> ?*easter* (mkDate ?*yearSought* 3 26)) then
                        (modify ?specialDate  (DateSought-is (daysAdd ?*easter* -59)))
                        else
                        (if (> ?*easter* (mkDate ?*yearSought* 3 23)) then
                            (modify ?specialDate  (DateSought-is (daysAdd ?*easter* -49)))
                            else
                            (if (> ?*easter* (mkDate ?*yearSought* 3 21)) then
                                (modify ?specialDate  (DateSought-is ?dateLast))
                            )
                        )
                    )
                )
            )
        )
    else
        (if (> ?*easter* (mkDate ?*yearSought* 4 7)) then
            (modify ?specialDate  (DateSought-is ?dateLast))
            else
            (if (> ?*easter* (mkDate ?*yearSought* 4 3)) then
                (modify ?specialDate  (DateSought-is (daysAdd ?*easter* -59)))
                else
                (if (> ?*easter* (mkDate ?*yearSought* 3 30)) then
                    (modify ?specialDate  (DateSought-is (daysAdd ?*easter* -61)))
                    else
                    (if (> ?*easter* (mkDate ?*yearSought* 3 27)) then
                        (modify ?specialDate  (DateSought-is (daysAdd ?*easter* -59)))
                        else
                        (if (> ?*easter* (mkDate ?*yearSought* 3 23)) then
                            (modify ?specialDate  (DateSought-is (daysAdd ?*easter* -49)))
                            else
                            (if (> ?*easter* (mkDate ?*yearSought* 3 21)) then
                                (modify ?specialDate  (DateSought-is ?dateLast))
                            )
                        )
                    )
                )
            )
        )
    )
)
```

Appendix N: TEI Customised Schema for Liturgy

The following (XML) code represents the TEI ODD (i.e., *one document does it all*),

which includes the schema fragments, prose documentation, and reference documentation for

the TEI Guidelines in a single document. The name of this TEI customisation is: *tei_liturgy*,

and is hosted here: http://www.melkites.org/liturgy/ns/1.0.

```xml
<?xml version="1.0"?>
<TEI xmlns="http://www.tei-c.org/ns/1.0" xml:lang="en">
    <teiHeader>
        <fileDesc>
            <titleStmt>
                <title>TEI Liturgy</title>
                <author>Matta</author>
            </titleStmt>
            <publicationStmt>
                <p>To support mark-up of liturgical texts.</p>
            </publicationStmt>
            <notesStmt>
                <note type="ns">http://www.melkites.org/liturgy/ns/1.0</note>
            </notesStmt>
            <sourceDesc>
                <p>created on Monday 20th June 2011 11:17:58 AM</p>
            </sourceDesc>
        </fileDesc>
    </teiHeader>
    <text>
        <front>
            <divGen type="toc"/>
        </front>
        <body>
            <p>TEI Customization starts with modules tei, core, textstructure, and header.
                    Some minor changes to support Liturgical texts.
            </p>
            <schemaSpec ident="tei_liturgy" docLang="en" prefix="tei_" xml:lang="en">
                <moduleRef key="core" except="teiCorpus"/>
                <moduleRef key="tei" except=""/>
                <moduleRef key="header" except="handNote scriptNote typeNote"/>
                <moduleRef key="textstructure" except=""/>
                <elementSpec module="core" ident="mentioned" mode="change">
                    <altIdent>rubrical</altIdent>
                </elementSpec>
                <elementSpec module="core" ident="stage" mode="change">
                    <altIdent>rubric</altIdent>
                </elementSpec>
                <elementSpec module="core" ident="hi" mode="change">
                    <altIdent>prayersheet</altIdent>
                </elementSpec>
                <elementSpec module="core" ident="p" mode="change">
                    <altIdent>RefList</altIdent>
                </elementSpec>
                <elementSpec ident="psalm" ns="http://www.melkites.org/liturgy" mode="add">
                    <desc>Allows special handling of psalms, canticles, etc., that are
                            usually presented centred with narrower lines
                            allowing for chanting.
                    </desc>
                    <classes>
```

```
                        <memberOf key="model.pLike"/>
                    </classes>
                    <content xmlns:rng="http://relaxng.org/ns/structure/1.0"/>
                </elementSpec>
            </schemaSpec>
        </body>
    </text>
</TEI>
```

Figure 2: Monthly Calendar showing Liturgical Data