CAA2014
21st Century Archaeology
Concepts, Methods and Tools

Proceedings of the 42nd Annual Conference on Computer Applications and Quantitative Methods in Archaeology

Edited by
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Archaeopress Archaeology
Contents

Foreword .................................................................................................................................................. v

Computers and mathematics in Archaeology, anatomy of an ineluctable success! ........................................ 1
François DJINDJIAN

Chapter 1 Historiography

Towards a History of Archaeological Computing: An Introduction .............................................................. 9
Paola MOSCATI

A retrospective on GIS and AIS platforms for Public Archaeology in Italy. Searching backward for roots and looking
onwards for new methodological road-maps .................................................................................................. 17
Mirella SERLORENZI, Ilaria JOVINE, Giorgia LEONI, Andrea DE TOMMASI, Andrea VARAVALLO

Art History of the Ancient Near East and Mathematical Models. An Overview ........................................... 29
Alessandro DI LUDOVICO and Sergio CAMIZ

Archaeology and Computer Applications: the automatic cataloging of Italian archaeological heritage ............ 35
Alessandra CARAVALE

Chapter 2 Field and laboratory data recording

Practical Assessment of a Multi-Frequency Slingram EMI for Archaeological Prospection ............................ 43
François-Xavier SIMON, Alain TABBAGH, Apostolos SARRIS

Utilizing Magnetic Prospection and GIS to Examine Settlement Organization in Neolithic Southeastern Europe ...... 53
Alexis NIEKAMP, Apostolos SARRIS

Historic Forest Change: New approaches to Land Use Land Cover .................................................................. 65
Charlotte E. STANCIOFF, Robert G. PONTIUS Jr, Scott MADRY, Elizabeth JONES

Challenges and Perspectives of Woodland Archaeology Across Europe .......................................................... 73
Hauke KENZLER, Karsten LAMBERS

Archaeological Mapping of Large Forested Areas, Using Semi-Automatic Detection and Visual Interpretation of High-
Resolution Lidar Data ....................................................................................................................................... 81
Øivind Due TRIER, Lars HOLGER PILØ

Laser scanning and Automated Photogrammetry for Knowledge and Representation of the Rupestrian Architecture
in Cappadocia: Sahinefendi and the Open Air Museum of Goreme ................................................................ 87
Marco CARPICECI, Carlo INGLESE

Advantages and Disadvantages of Digital Approach in Archaeological Fieldwork ........................................ 95
Carlo BIANCHINI, Francesco BORGOGNI, Alfonso IPPOLITO

From Survey to Representation of the Model. A Documentation of Typological and Chronological Sequences of
Archaeological Artefacts: Traditional and Innovative Approach ...................................................................... 107
Alfonso IPPOLITO, Luca J. SENATORE, Barbara BELELLI MARCHESINI, Gabriella CEROLI

Archaeology in the Third and Fourth Dimensions: A Case Study of 3D Data Collection and Analysis From Prince
Rupert, BC, Canada ......................................................................................................................................... 115
Alyssa PARKER, Morley ELDRIDGE

Integrated RTI Approaches for the Study of Painted Surfaces ...................................................................... 123
Eleni KOTOULA, Graeme EARL

Survey, Documentation and Analysis of the Archeological Architecture: the House of the Knights of Rhodes in the
Forum of Augustus ........................................................................................................................................... 135
Carlo BIANCHINI, Gaia Lisa TACCHI

Digital Research Strategies for Ancient Papyri: A Case Study on Mounted Fragments of The Derveni Papyrus .... 145
Eleni Kotoula, Graeme Earl
Chapter 3. Ontologies and Standards

Towards Linked-Data in Numismatics: How the DIANA Approach can Improve the Diachrony Integrating Heterogeneous Pieces of Data ................................................................. 157
Maria CALTABIANO, Mariangela PUGLISI, Antonio CELESTI, Grazia SALAMONE

Celtic Coins in context, a new database ............................................................ 165
Katherine GRUEL, Agnès TRICOCHE, Philippe CHARNOTET

Uncertainty handling for ancient coinage ......................................................... 171
Karsten TOLLE, David WIGG-WOLF

Interoperability of the ArSol (Archives du Sol) database based on the CIDOC-CRM ontology ............................................................. 179
Emeline LE GOFF, Olivier MARLET, Xavier RODIER, Stéphane CURET, Philippe HUSI

Find the balance - Modelling aspects in Archaeological Information Systems ................................................................. 187
Franz SCHWARZBACH, Felix F. SCHÄFER, Alexander SCHULZE

Integration of Archaeological Datasets through the Gradual Refinement of Models ................................................................. 193
Cesar GONZALEZ-PEREZ, Patricia MARTIN-RODILLA

Linked Open Greek Pottery .............................................................................. 205
Ethan GRUBER, T.J. SMITH

The Digital Archaeological Workflow: A Case Study from Sweden .................. 215
Marcus J. SMITH

Exploring time and space in the annotation of museum catalogues: The Sloane virtual exhibition experience ...... 221
Stephen STEAD, Dominic OLDMAN, Jonathan Whitson CLOUD

Building comprehensive management systems for cultural – historical information ................................................................. 227
Chryssoula BEKIARI, Martin DOERR, Dimitris ANGELAKIS, Flora KARAGIANNI

Managing Time Dimension in the Archaeological Urban Information System of the Historical Heritage of Rome and Verona ......................................................................... 235
Alberto BELUSSI, Sara MIGLIORINI, Piergiovanna GROSSI

Towards an Archaeological Information System: Improving the Core Data Model ................................................................. 245
Muriel van RUYMEKE, Cyril CARRE, Vincent DELFOSSE, Pierre HALLOT, Michelle PFEIFFER, Roland BILLEN

Chapter 4. Internet and Archaeology

Archaeological open access journals: the case of ‘Archeologia e Calcolatori’ ................................................................. 257
Alessandra CARAVALE, Alessandra PIERGROSSI

Massive Open Online Opportunity: MOOCs and Internet–Based Communities of Archaeological Practice ........ 265
Jeffrey P. EMANUEL

Moving Instruction Beyond the Museum’s Walls: Priorities in Online Public Education at the Oriental Institute .... 271
Kathryn GROSSMAN, Catherine Kenyon, Megaera LORENZ, Brittany HAYDEN

Crowd- and Community-Fuelled Archaeology. Early Results from the MicroPasts Project ................................................................. 279
Chiara BONACCHI, Andrew BEVAN, Daniel PETT, Adi KEINAN-SCHOONBAERT

The ACCORD project: Archaeological Community Co-Production of Research Resources ................................................................. 289
Stuart JEFFREY, Alex HALE, Cara JONES, Sian JONES, Mhairi MAXWELL

Chapter 5. Archaeological Information Systems

12000 years of human occupation, 3 meters deep stratigraphy, 12 hectares... A geographical information system (GIS) for the preventive archaeology operation at Alizay (Normandie, France) ................................................................. 299
S. MAZET, C. MARCIGN, B. AUBRY, I. COMTE, P. BOULINGUEZ

Records and spatial representations in the context of a rescue excavation: the case of Quincieux (Rhône-Alpes, France) ......................................................................... 305
Ellebore SEGAIN, Veronique VACHON, Bernard MOULIN, Cécile RAMPONI, Wojciech WIDLAK
Cartography and heritage: past practice and future potential for mapping Scotland's cultural heritage
Peter MCKEAGUE

Visualization based on the Norwegian University Museum Database
Espen ULEBERG, Mieko MATSUMOTO

An Inventory of Lucanian Heritage
Alain DUPLOUY, Vincenzo CAPOZZOLI, Alessia ZAMBON

Integrating complex archaeological datasets from the Neolithic in a web-based GIS
Kai-Christian BRUHN, Thomas ENGEL, Tobias KOHR, Detlef GRONENBORN

Enhanced 3D-GIS: Documenting Insula V 1 in Pompeii
Giacomo LANDESCHI, Nicolò DELL’UNTO, Daniele FERDANI, Stefan LINDGREN, Anne-Marie LEANDER Touati

MAPPA Open Data Metadata. The importance of archaeological background
Francesca ANICHINI, Gabriele GATTIGLIA

A simple way to formalize the dating of stratigraphic units
Bruno DESACHY

Recognizing temporalities in urban units from a functional approach: three case studies
Julie GRAVIER

OH_FET: A Computer Application for Analysing Urban Dynamics Over Long Time Spans
Laure SALIGNY, Ludovic GRANJON, Thomas HUET, Gaël SIMON, Xavier RODIER, Bastien LEFEBVRE

An ‘alphabet’ to describe the spatio-temporal dynamics of settlement systems: a relevant representation of time?
Marie-Jeanne OURIACHI, Frédérique BERTONCELLO, with the collaboration of Pierre NOUVEL, Laure NUNINGER, Elise FOVET, Stéphane ALIX

Chapter 6. GIS and spatial analysis

ArkeoGIS, Merging Geographical and Archaeological Datas Online
Loup BERNARD, Damien ERTLEN, Dominique SCHWARTZ

Counting Sheep Without Falling Asleep: Using Gis to Calculate the Minimum Number of Skeletal Elements (Mne) And Other Archaeozoological Measures At Schöningen 13II-4 ‘Spear Horizon’
Alejandro GARCÍA-MORENO, Jarod M. HUTSON, Aritza VILLALUENGA, Elaine TURNER, Sabine GAUDZINSKI-WINDHEUSER

Looking for the best. A comparison between GIS and PageRank based algorithms for preventive archaeology in urban areas
Dubbini NEVIO, Gabriele GATTIGLIA, Augusto PALOMBINI

Analyses of bone modifications on human remains: a GIS approach
Elsa CIESIELSKI, Hervé BOHBOT

Territorial organisation of the Terramare culture (Bronze Age, Italy): use of GIS methodology to tackle societal issues
Julie BOUDRY

From the excavation to the territory: contributions of GIS tools to the study of the spatial organization of the archaeological site of Argentomagus (France, Indre, Saint-Marcel/Argenton-sur-Creuse)
Emeline LE GOFF, Laure LAÜT, Yoann RABASTÉ, Françoise DUMASY

The integration of landscape processes in archaeological site prediction in the Mugello basin (Tuscany/Italy)
Elmar SCHMALTZ, Michael MÄRKER, Hans-Joachim ROSNER, Adrew-Williams KANDEL

The use of Burgundy stone from ancient times to the present day
Stéphane BÜTTNER, Delphine MONTANGE, Laure SALIGNY, Marion FOUCHER with the collaboration of Eric LECLERCQ, Marinette SAVONNET

Exploring Intervisibility Networks: A Case Study From Bronze and Iron Age Istria (Croatia and Slovenia)
Zoran ČUČKOVIĆ
Chapter 7. Mathematics and statistics in archaeology

Intentional Process Modeling of Statistical Analysis Methods ......................................................... 481
Charlotte HUG, Rebecca DENECKÈRE, Ammar AYMEN

Ancient Mesopotamian Glyptic Products, Statistics and Data Mining: A Research Proposal ...................... 489
Alessandro DI LUDOVICO, Sergio CAMIZ

Intrasite spatial analysis applied to the Neolithic sites of the Paris Basin: from the archaeological feature to global analysis .................................................................................................................. 497
François GILIGNY

Statistical and mathematical models for archaeological data mining: a comparison ........................................ 509
Nevio DUBBINI, Adam LODOEN

Chapter 8. 3D Archaeology and virtual Archaeology

Measuring and describing 3D texture .................................................................................................. 519
Vera MOITINHO DE ALMEIDA, Juan Antonio BARCELÓ

Old versus new – introducing image-based 3D modeling into the general documentation workflow of archaeological rescue excavations. Case studies: the Čachtice and Bratislava castles, Slovakia .......................................................... 529
Jan ZACHAR, Seta ŠTUHEC

Beyond spreadsheets: digitising the archaeological artefact inventory process .............................................. 541
Arianna TRAVIGLIA, Stephen WHITE, Andrew WILSON

Potentialities of 3D Reconstruction in Maritime Archaeology .......................................................... 549
Elisa COSTA, Carlo BELTRAME, Francesco GUERRA

Cultural Heritage Documentation in Cave Environment Using Low-Cost Means for Archaeologists. Case Study of the Larchant Caves in the Fontainebleau Forest in France .................................................................................. 557
Aurelia LUREAU, Mehdi BELARBI, Pascal RAYMOND, Régis TOUQUET

Forum Romanum: A 3D Model For Self-Service Educational Purposes ...................................................... 569
Philippe FLEURY, Sophie MADELEINE, Nicolas LEFÈVRE

The Virtual Reconstruction of a Small Medieval Town: The Case of Briviesca (Spain) ........................................ 575
Mario ALAGUERO, Andres BUSTILLO, Blanca GUINEA, Lena IGLESIAS

The Virtual Reconstruction of a Small Medieval Town: The Case of Briviesca (Spain) ........................................ 575

25 Years of Experience in Virtual Reconstructions - Research Projects, Status Quo of Current Research and Visions for the Future .............................................................................................................. 585
Mieke PFARR-HARFST

Chapter 9. Multi-agent systems and complex system modelling

A Density-Based Simulation Approach for Evaluating Prehistoric Population Fluctuations in Finland .......... 595
Tarja SUNDELL, Juhana KAMMONEN

Multi-Agent Modelling of the Neolithic LBK .......................................................................................... 595
Jean-Pierre BOCQUET-APPEL, Richard MOUSSA, Jérôme DUBOULOZ

Explaining the Adoption of ‘Innovations’ in Western Europe during Bronze Age: Towards an Agent-Based Simulation ....613
Juan A. BARCELÓ, Florencia DEL CASTILLO BERNAL, Giacomo CAPUZZO, Berta MORELL, Joan NEGRE

Spatial Interaction Simulation Methods for Ancient Settlement Distributions in Central Italy .......................... 621
Taylor OSHAN, Carson FARMER, Eoin O’DONOGHUE

Interactions and network analysis of a rock art site in Morro do Chapéu, Bahia, Brazil ........................................ 631
Carlos ETCHEVARNE, Grégoire VAN HAVRE
Towards Linked-Data in Numismatics: How the DIANA Approach can Improve the Diachrony Integrating Heterogeneous Pieces of Data

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Abstract
The Digital Iconographic Atlas of Numismatics in Antiquity (D.I.A.N.A.) aims to perform an in-depth analysis of the coin iconography according to time and space through digital maps. The project has been designed with an eye toward the possibility of a future integration with other digital archives. The basic idea is to enable DIANA to analyze, besides ancient mints and coin iconographies, even other related data. An objective of DIANA is to link and integrate its datasets with others coming from different digital archives in order to improve a particular study aggregating different pieces of information to better understand the diachrony and the cultural context. In this paper, we analyze the main aspect involved for the integration of DIANA with other digital archives in a scenario of linked data.

Keywords: ancient coins, iconography; diachrony, digital maps, linked data

1. Introduction
Nowadays, in the field of science of antiquity, there are a lot of digital archives and web applications that allow displaying ancient entities and artifacts on digital maps. Entities may include, e.g., gods, abstract personification, historical personages, etc. Artifacts may include coins, weapons, architecture, etc. In particular, ancient coins represent also out-and-out documents that need to be properly studied and analyzed. From the point of view of numismatics, there are not so many web applications enabling researchers to perform an in-depth analysis of the coin iconography.

The Digital Iconographic Atlas of Numismatics in Antiquity (D.I.A.N.A.) aims to fulfill such a gap. DIANA is part of the LIN project, aimed at compiling the Lexicon Iconographicum Numismaticae Classicae et Mediae Aetatis, a dictionary whose entries record all the principal and secondary images found on ancient and medieval coins. It is a web platform that allows researchers to analyze the ‘coin iconography’ according to time and space through digital maps. The DIANA’s digital archive is based on a relational Data Base Management System (DBMS). The web application is developed combining both server-side and client-side programming languages. The server-side is developed using the PHP language, whereas the client-side is developed using JavaScript. In order to provide users a good degree of reactiveness, DIANA has been developed adopting the Asynchronous JavaScript and XML (AJAX) programming technique. In order to build digital maps, the system uses the Cloud Computing Google Maps Platform as a Service (PaaS). A mint can be searched on DIANA considering a target coin iconography through a web form. A request to the Google Map PaaS that return a digital map displaying the mint and ancient coins.

With DIANA it is possible to study the ‘diachrony’ with a new innovative approach starting from ancient coins. The project has been designed with an eye toward the possibility of a future integration with other digital archives. The basic idea is to enable DIANA to analyze, besides ancient mints and coin iconographies, even other related data. Currently, in DIANA, places are located according to ancient mints. In other digital archives places can be located according to ancient artefacts, locations, and names, as well as in Pleiades (http://pleiades.stoa.org). An objective of DIANA is to link and integrate its datasets with other ones coming from different digital archives in order to improve a particular study aggregating different pieces of information. For example, an artefact such as a ‘phiale’ (a pot used to make sacrifices) depicted on a coin coming from DIANA, can be related to artifacts coming from other digital archives. Such a data linking enables researchers to better understand the diachrony and the cultural context. Linking data of different digital archives it is possible to exploit different data integration techniques, e.g., importing datasets in XML, JSON, CSV, KML or RDF format, or by means of web service (e.g., REST, SOAP, etc) interactions.

In this paper, we discuss the main aspects involved in the design of a software system able link heterogeneous data coming from different digital archives. In particular, subsequently we have highlighted the advantages of integrating heterogeneous data related to ancient artifacts, we will discuss how such integration can be possible from a technical point of view considering the DIANA system. The rest of the paper is organized as follows. Section 2 discuss related works. A discussion regarding the approach used in DIANA to classify the iconography of ancient artifacts is presented in Section 3. A few technical details
about how the DIANA system works are discussed in Section 4. In Section 5, we discuss the advantages of linking data related to ancient artifacts coming from different digital archives. In particular, we will discuss how it is possible to design a system for linked data using DIANA, considering as a study case a possible integration with Pleiades (http://pleiades.stoa.org/), a digital archive storing data on ancient places, locations, and names along with Geographical Information System (GIS) metadata. Section 6 concludes the paper with lights to the future.

2. Related Works

In the recent years, many efforts have been conducted to represent and distribute knowledge about archeological artifacts through the Web. In the field of Numismatics, several sites exist, that allow to visualize, query and share data about ancient coins. In this Section, we briefly describe the most significant web applications that provide access to ancient coin collections, in order to give a background to our work.

The American Numismatic Society (ANS, 2014) at present publishes more than 600 thousands objects from its collection, giving access to their information through a project named MANTIS (MANTIS, 2014). Accessing the website of MANTIS, it is possible to query a money database, specifying search words for all the attributes associated to the object, e.g., authority, mint, locality, material and so on. For many of the coins represented, two images for obverse and reverse types are given, otherwise only a brief description is displayed. An interesting feature of the site is the possibility of comparing coins (or money in general) on the basis of their attributes. MANTIS also provides a map representation of coin distribution, by visualizing the result of queries on a map provided by the Google Maps service (Google Maps, 2014): data related to the coins are not displayed directly on the map, but the user can follow a link that opens a description frame on the bottom of the page. Moreover, the online numismatic catalogue of Staatliche Museum (Staatliche Museum Numismatic Catalogue, 2014) in Berlin has about 20,000 objects (coins and medals), and it is possible to search coins on maps, although with a very simple interface and limited interactivity. Other websites aim to store data about coins of specific historical periods, as the Roman Provincial Coinage Project (Roman Provincial Coinage Project, 2014). Also in this case, the maps are used to give a simple representation of the cities related to the coins. The same happens for OCRE (Online Coins of the Roman Empire) (OCRE, 2014), a joint project of the American Numismatic Society and the Institute for the Study of the Ancient World at New York University to create a digital corpus of the coinage of the Roman Empire. OCRE is a numismatic tool based on the stable numismatic identities established by the Nomisma project (NOMISMA, 2014) which intends to host the Numismatic Description Standard (NUDS), a set of suggested field names for recording numismatic information in a column-oriented database (NUDS, 2014). NUDS has not yet expanded to define the contents of fields and does not suggest how to describe coin types. The space dedicated to the coin Obverse or Reverse types is in fact a free-text container, holder for undifferentiated description.

Other web sites use a map representation (Bracey, 2009; Amandry & Bateson, 2009) to display money data, even if the location of ancient places is often imprecise and uncertain, since modern cities are not always located in the same place of their ancient corresponding place. A very significant effort to face this issue is represented by Pleiades (Pleiades, 2014). Pleiades gives the possibility to create, query, share and represent historical geographic data in digital form, with an extensive coverage of Greek and Roman worlds. This is indeed a helpful tool for researchers, since this project promotes an open community with the intent to share information of historical geographic data.

Related to this, the Nomisma project (NOMISMA, 2014) is a very interesting effort in the direction of providing stable digital representations for numismatics concept and entities, both for geographical and money-related data. The use of Semantic Web principles (Berners & Hendler & Lassila, 2001), KML (KML, 2013) language for geographical data and XML for representing the resources of the project, has the explicit intent to encourage querying, sharing and reusing of these data.

3. The DIANA Approach

Coins, as public and official documents of a homogeneous nature, are ideal for identifying the subjects and themes of the figurative culture of antiquity. Through coin images the issuer achieves a process of clear and concise communication, directed at a wide public. The presence of one or the concentration of more iconographic subjects, helps us to view coin images as historical documents of the cultural environment which produced them, and to identify culturally homogeneous geographical areas.

The wide-ranging collection of data, performed on documents which cover vast periods of time and geographical areas, makes it possible to verify phenomena of continuity or irregularity in the meaning of the coin iconographies and their belonging to categories which are also defined in terms of cultural ‘continuity’ and ‘discontinuity’. The Digital Iconographic Atlas of Numismatics in Antiquity (DIANA, 2014) was designed to reconstruct the ‘history of the coin type’, or the ‘stratigraphic representation’ of its meaning, which strips the structure of iconic bare language and, using a multidisciplinary method, retrieves the relationship between the image, the realities which they represent, and that between the images and the cultural context in which they are used. Moreover, DIANA is part of the LIN project, aimed at compiling the Lexicon Iconographicum Numismaticae Classicae et Mediae Aetatis (Universities of Messina, Bologna, Genoa and Milan), a dictionary whose entries record all the principal and secondary images found on ancient and medieval coins.

DIANA allows researchers to analyze ‘coin iconography’ according to time and space through digital maps. Our archive highlights the geographical distribution of the
issuing cities and their diachronical activity in striking coins in order to:

- create a digital INDEX of the ancient Mediterranean mints (Greek and Roman Periods);
- codify their NAMES;
- display their TOPOGRAPHICAL DISTRIBUTION on digital maps;
- identify the PERIODS OF MINTING ACTIVITY;
- simplify the INTERPRETATION OF COIN ICONOGRAPHY;
- reconstruct the RELATIONS AND INFLUENCES BETWEEN PEOPLES in the Mediterranean.

Compared to other existing web applications, strength is the standardization of all the ‘voices’ to be used for the description of the coin iconographies. The entries are the types surveyed within the Lexicon Iconographicum Numismaticae (Universities of Messina, Bologna, Genoa and Milan), including Personages, Animals/Monsters, Flora and Objects. All the other search options are standardized.

The creation of the digital Atlas DIANA, referring to the figurative culture of ancient coins presented on diachronic maps, is useful for the following reasons:

- it simplifies the interpretation of meanings of coin iconography to promote and increase awareness of the numismatic heritage;
- it views coin images as historical document of the cultural environment which produced them and identify culturally homogeneous geographical areas;
- it reconstructs the relations, influences and relationships between peoples on the basis of the ‘journeys’ of coin images in the Mediterranean;
- it offers to students and researchers of other fields of the Ancient Age an overview of the distribution of the iconic subjects and of cultural areas to which they belong.

The DIANA’s iconographic classification is based on a General Index (Salamone & Caltabiano, 2007) created by consulting the indexes of the main catalogs of Greek and Roman coinage, and for mythological figures by considering the documents already collected inLexicon Iconographicum Mythologiae Classicae (LIMC). The coin types have been organized into four large macro-categories or groups. Group I includes human figures: individual mythical figures (Dei, heroes, heroines, etc), personifications of abstract concepts (Nike, Victoria, Tyche, different Virtutes as Aequitas, Iustitia, Pietas, etc), personifications of geographical entities (Cities or Rivers), or legal bodies (Demos, Koinoboulion, etc), but also common types (athlete, heros equitans, etc), considered as generic because they lack a specific proper name or because they have not yet been identified. For each subgroup it is important to highlight the denotative iconic elements, which are indispensable for recognizing each deity (e.g., which elements identify Aphrodite? and which aspects, found in the connotative iconic elements, does Aphrodite have in common with Hera, Demeter or another personage?). Group II includes animals and fantastic creatures. Group III includes flora (trees, flowers, fruits). Group IV contains res: architectural types, arms, astronomic images, honoris et imperii signa, fishing and hunting tools, musical instruments, ships, vases, etc.

There is also the macro-category Themata that includes coin types, mainly Roman ones, which do not fall into any of the four afore mentioned groups due to their complexity. They are often identified by their coin legend, e.g., adventus, consecratio, gaudium, ludi, rupe, propuntes iuventutis, propago imperi etc, and in most cases these are complex scenes.

Figure 1 shows the possible codification of the mythical figure of Apollo. For further details about the codification of the other groups see (Salamone & Caltabiano, 2007).

Figures 2 and 3 show examples of output on digital maps. Figures 2 and 3 depict the mints that have coined coins whose iconography present a female personage, standing, with a ‘phiale’ (a pot used to make sacrifices). The common iconographic scheme is related to the standing figure almost always at an altar, dressed, holding the ‘phiale’ in

![Figure 1: Example of possible ‘codification’ of the mythical figure of Apollo.](image-url)
her hand. It is the iconography of libation, well codified and documented in ancient imagery also on other media (ceramics, reliefs, statues) in relation to Nikai figures or figures of uncertain identity. In the case of money it is possible, however, to reconstruct the identity of these figures through the name that sometimes accompanies them and thanks to the typological context in which they appear.

The diachronic distribution of the data, highlighted by the colors of the markers (from white to blue), shows that invention of the type of the female figure performing a libation belongs to Western Sicily and to the category of ‘nympha’ eponymous (Simon, 1998; Salamone, 2013): at Himera the ‘nympha’ appears around 465 BC; shortly after, around 460 BC, the scheme switches to Eryx, to represent the great local goddess, Aphrodite; from the mid-fifth century BC the iconography spreads in the Elime area in order to represent the ‘nympha’ of Entella and, finally, that of Segesta (ca 410 BC). The branch held in her hand by the ‘nympha’ Segesta, in addition to the ‘phiale’, appears later in the hands of the goddess Aphrodite represented performing a libation on a stater of Paphos in Cyprus (ca 385 BC). To these Sicilian figures are added the ‘nympha’ Terina (Magna Graecia, 440–425 BC) and the Thessalian Trikka (second half of the 5th century BC), depicted with the same iconography, although in arms. In the view of a figurative and semantic continuity, at the end of the 3rd century BC, the representation of the Tyche of Thermai Himeraiai, the site founded after the destruction of Himera in 409 BC, is significant: the goddess is full length, standing, veiled, turreted and with the cornucopia of Tyche, but with the ‘phiale’ in her right hand, as already in the ‘nympha’ type of two centuries before.

4. Design Principles of the DIANA System

New emerging web technologies are rapidly changing the way of conceiving web applications. At the same time, more and more services are available over the Internet that can be used to build new innovative applications. This paradigm is known with the term ‘Cloud Computing’. Cloud Computing provides three different services, i.e., Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). Services over the Cloud Computing can be build integrating other services available over the Internet whose data can be exchanged through the Dataweb[10]. According to such a philosophy, sophisticated web applications can be defined as SaaS.

DIANA is a SaaS built using the Google Maps PaaS [3]. As previously discussed, our approach consists in studying the diachrony starting from the concept of ancient coin iconography. More specifically, from a particular iconography, we find the coins in which it is drawn, the mints where the coins were minted, and finally their geographical locations.

The DIANA database has been designed according to a hierarchical data model. The first layer of the hierarchy is the ‘Authority’. It can be a king, a city, a State, etc. Each authority is responsible for one or more ‘Mint(s)’, i.e., the entity responsible for issuing coins. Such an entity also stores the data related to the geographical location in terms of latitude and longitude. Each Mint is related to one or more ancient ‘Coin(s)’. In turn, each ‘Coin’ can be bound to one or more ‘Bibliography’ entities in which the ‘Coin’ is cited. In addition, each ‘Coin’ entity can be bound to [0,2] iconography entities. We defined four types of iconography, i.e., ‘Personage’, ‘Animal/Monster’, ‘Flora’, and ‘Object’.

The system includes four main components: the user, the DIANA web application, the DIANA database, and the Google Maps PaaS. Figure 4 summarizes the components involved in the DIANA system. The user is the subject who wants to access the DIANA services through his/her web browser via the Internet querying the DIANA web application. The latter is responsible for processing the user’s requests and for providing output data related to authorities, mints, and coins in form of digital geographical maps. In order to do so, the web application interacts with both the DIANA’s database and Google Maps PaaS.

In particular, when the web application receives a request from a user, by means of server-side mechanisms developed in PHP language, it queries the DIANA’s database and it retrieves the needed data. After that it parses the data formatting them in an XML document describing the retrieved data. In the end, using the Asynchronous JavaScript and Xml (AJAX) programming technique, the XML document is sent to the client-side JavaScript code on users’ web browser. The latter processes the XML.
document, it extracts data, and it builds a request form map
drawing to the Google Maps PaaS through the Internet.
In the end, the output map, displaying mints and ancient
coins is sent to the user’s web browser.

In the following we report the main steps required to
generate a digital map. In step 1, the user requests the PHP
page for querying the system. So, he/she types the DIANA
web address in address bar of his/her web browser and
push the ‘go’ button. In step 2, the DIANA web application
sends to the user’s web browser the web content (including
both HTML and JavaScript codes) dynamically build
processing the PHP code. We remark that the JavaScript
code implements the client-side logic of DIANA. In step 3,
the JavaScript client-side code is processed by the browser
and sends a request for maps service to the Google Maps
PaaS. In step 4, the google maps services and software
libraries are loaded on the web browser. In step 5, the user
submits a web form and an asynchronous request is sent
querying the system according to a given iconography.
In step 6, the system processes the request and queries the
database. In step 7 the system builds an XML document
according to the retrieved data. Figure [XML] show how
data are formatted using an XML document. According
to the XML scheme, each ancient mint corresponds to a
marker in the digital map, and each mint includes several
coins, each one identified by a Unique Identifier (UID),
used to retrieve additional information when required.

In step 8, the DIANA server-side system sends the XML
document to the DIANA client-side code on the user’s web
browser. In step 9, the Javascript interpreter of the web
browser, reads the received XML document and build a
map request according to the received data and it sends
a map request to Google Maps PaaS. Finally, in step
10, the DIANA client-side code displays the map on the
user web browser. The mints are represented by markers
displayed from the oldest one to the latest one according to
their colors. Colors are assigned varying the gradient: the
oldest white and the latest one is blue. The other markers
are colored varying the gradient progressively from the
clearest color (i.e., white) to the darkest color (i.e., blue)
according to the mint chronology. Such a mechanism
allows the user to easily recognize the evolution of an
iconography according to both time and space. By clicking
on a marker it is possible to display both data concerning
the mint (authority, chronology, and so on) and the ancient
coins of such a mint according to the iconography looked
for in step 1.

5. Towards Linked Data to Improve the Diachrony in
Numismatics

The DIANA project responds to a real need, since there
is no general work providing organized documentation
in the field of coin iconography and also to the well-
known need in the archaeological field for a concise and
immediate picture of the figurative subjects and themes
adopted in official contexts, to verify their appurtenance
and coherence with the cultural heritage of a country. As
previously discussed, DIANA makes it possible to study
the ‘diachrony’ with a new innovative approach starting
from ancient coins. The project has been designed with an
eye toward the possibility of integration with other digital
archives for the support to linked data. The basic idea is to
enable DIANA to analyse, besides ancient mints and coin
iconographies, even other related data coming from other
digital archives. However, this process of integration is not
trivial at all, because the current digital archives are based
on different technologies that often are not compatible.
Moreover, several digital archives are often updated to
the last Information Technologies, others are based on old
systems. Figure 6 shows a list of the major digital archives
related to ancient coins, artefacts, and places

We can observe that the only web digital archive that
allows third party system to link its data is Pleiades
that provides data export features in CVS, KML, RDF
format. Moreover, web digital archive has offered public
cloud computing services yet. This means that currently
promoting a web environment where communities,
organizations, universities, and museums can cooperate
integrating their data is very hard. In addition, from a technological point of view, the major digital archives are quite antiquated. In fact, no web digital archive reported in Figure 6 supports any form of cloud computing PaaS and SaaS.

In order to better explain the advantages of linking heterogeneous data to improve the diachronic study in Numismatics, in the following we will discuss a possible integration between DIANA and Pleiades (i.e., the only digital archives listed in Figure 6 supporting public data export). Currently, in DIANA, places are located according to ancient mints, but in other digital archives places can be located according to ancient artefacts and names, as well as in Pleiades.

Pleiades gives scholars, students, and enthusiasts worldwide the ability to use, create, and share historical geographic information about the ancient world in digital form. At present, Pleiades has extensive coverage for the Greek and Roman world, and is expanding into Ancient Near Eastern, Byzantine, Celtic, and Early Medieval geography. Currently Pleiades stores over than 30,000 places, locations, and names.

Considering the example described in Section 3, if we try to look for the word ‘phiale’ in Pleiades, we can observe two results in a geographical location near to the mint ‘Trikka’, ‘Larissa’ and ‘Paphos’ found in DIANA (see Figure 3). Considering DIANA, the ‘phiale’ attribute is depicted in the reverse side of three ancient coins (see Figures 7, 8 and 9) respectively coined in ‘Trikka’, ‘Larissa’, and ‘Paphos’ from 470 B.C. to 380 B.C.

Instead, looking at the two occurrences found in Pleiades (see Figure 10), the term ‘phiale’ corresponds to a geographic name (Phiale/Phiale), dated in late antique (300 A.D. - 640 A.D.), accurate, certain, and complete (see Figure 11) and to a geographic name (Phiale Limne) related to a crater lake located in the Golan Heights, dated in the early Roman Empire (30 B.C. - 300 A.D.).

Observing the results found in DIANA and in Pleiades, from the iconography of ancient coins we can speculate that the term ‘Phiale’ was originated in a period from

480 B.C. to 200 B.C. Moreover, from Pleiades, we have evidence that the term was used in a period from 30 B.C. to 640 A.D.

Since Pleiades does not provide any form of real time interactive query (for example, by means of web services), the integration with DIANA presents several issues. In fact, in order to link data between the two systems, the dataset of Pleiades should be periodically downloaded, parsed, processed, and stored in the DIANA system causing an evident overhead. This problem would be easily mitigated using web service mechanisms provided by cloud computing services. In addition, in order to allows DIANA to display, besides data related to mints, also related data

**FIGURE 6: SUPPORT TO DATA EXPORT AND CLOUD COMPUTING SERVICES OF THE MAJOR COIN ARCHIVES.**

**FIGURE 7: ICONOGRAPHY OF THE REVERSE SIDE OF A COIN BELONGING TO TRIKKA.**

**FIGURE 8: ICONOGRAPHY OF THE REVERSE SIDE OF A COIN BELONGING TO LARISSA.**

**FIGURE 9: ICONOGRAPHY OF THE REVERSE SIDE OF A COIN BELONGING TO PAPHOS.**
coming from Pleiades, it is require to develop a software adapter in order to build ‘on-fly’ XML documents such as the ones used by DIANA (see Figure 5) for ancient mints and coins. Such XML documents are indispensable to build a digital map according to the Google Maps PaaS.

4. Conclusion and Future Work

Thanks to the new information and communication technologies, DIANA allows researchers to study diacrony according to an approach to classify the iconography of ancient coins. The objective of the DIANA project is to extend its scope supporting the integration with data coming from other digital archives. In fact, the objective of DIANA is to become a very useful tool to represent the diachrony of coin types stored according to the Lexicon Iconographicum Numismaticae and link this data with other related information coming from other digital archives. Nevertheless, there is a long way to go for a complete integration between different digital archives. In fact, the major digital archives do not provide any data export mechanism and any interactive query system. Even though cloud computing technologies are emerging embracing different scientific fields, currently this is not true also for digital heritage. We hope we will succeed in stimulating the scientific community regarding the need to update digital archives for the support to the possibility to link their data. In future work, we plan to integrate the DIANA system with other digital coin archives starting from a dialogue with researchers responsible for other digital heritage projects.

References


References


