From the attic to the cloud: mobilization of endangered language resources with linked data

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Abstract
As an important example of the need to provide hosting and publication facilities for highly specific data types and the role thematic centres can play, this paper describes a collection of 20k ELAN annotation files harvested from five different endangered language archives. The ELAN files form a very heterogeneous set, but the hierarchical configuration of their tiers allow; in conjunction with the tier content, to identify transcriptions, translations, and glosses. These transcriptions, translations, and glosses are queryable across archives. Small analyses of graphemes (transcription tier), grammatical and lexical glosses (gloss tier), and semantic concepts (translation tier) show the viability of the approach. The use of identifiers from OLAC, Wikidata and Glottolog allows for a better integration of the data from these archives into the Linguistic Linked Open Data Cloud.

Keywords: endangered languages, corpus, ELAN, text mining, Linked Data

1. Introduction
One of the goals of linguistics is to gain insight into human cognition and culture. There are over 7,000 languages spoken in the world (Hammarström et al., 2019), varying wildly in structure, so we must have a large and diverse sample in order to gain any meaningful insight into what all human languages have in common. The amount of data to process is too large for one human brain, so that machine support is required. Unfortunately, NLP largely focuses on a very small number of languages spoken in the industrialized world. The wiki of the Association for Computational Linguistics lists NLP tools for 76 different languages i.e. about 1% of the worlds languages. It is true that there are text, audio, and video resources in other languages available, but these are often small, difficult to access, and even more difficult to reuse. Many of the resources for these lesser studied languages reside in endangered language archives such as TLA, ELAR, or PARADISEC. While much of the content found in these archives is available for inspection in principle, there are significant issues of findability and interoperability, rendering its exploitation for NLP purposes difficult. This paper describes a workflow to identify, collect and query the resources from five different endangered language archives from the DELAMAN network, giving access to 2,500,000 words in a structured format.

2. DELAMAN archives
DELAMAN (Digital Endangered Languages and Musics Archives Network) "is an international network of archives of data on linguistic and cultural diversity, in particular on small languages and cultures under pressure" (www.delaman.org). As such, DELAMAN is a very interesting starting point for the collection of processable resources for lesser studied languages. There are currently 12 member archives and 5 associated members, which hold content in 2420 different languages. For the purpose of this project, 5 archives were chosen for inclusion:
- AILLA (Archive of the Indigenous Languages of Latin America)
- ANLA (Alaska Native Language Archive)
- ELAR (Endangered Languages Archive at SOAS)
- PARADISEC (Pacific and Regional Archive for Digital Sources in Endangered Cultures)
- TLA (The Language Archive at the Max Planck Institute for Psycholinguistics)

These archives vary in size, backend software, funding structure, and coverage of geographical areas. They have in common that their main focus has been on ingestion, and less so on mobilization. There are some query interfaces to identify resources of interest, but none of the archives offers an API or bulk downloads for instance.

3. Research with language archives: The Language Archive at the Max Planck Institute for Psycholinguistics
TLA used to be the “home archive” for the DoBeS program (funded by the Volkswagen foundation), which funded 67 documentation projects for endangered languages. The last project funded started in 2011. In the course of these documentation projects, very interesting and important language data was collected and deposited in the archive. To this day, the researchers from these projects continue using the archive, still funded by the Max Planck Society. However, it is also true that there are only very few “third party” researchers, not involved in the original projects, which interact with the data. The Volkswagen foundation initiated so called phase-2 projects for theoretical research on language data stored in the archive, but only 3 such projects have been awarded and as of today there seems to be no major research community interacting with archive data they have not deposited themselves. A continuation of these phase-2 efforts is the DoReCo project. DoReCo “brings together spoken lan-

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1. https://aclweb.org/aclwiki/List_of_resources_by_language
2. https://archive.mpi.nl/tla
3. https://elar.soas.ac.uk
4. http://www.paradisec.org.au
5. http://dobes.mpi.nl/research-projects
6. http://doreco.info
guage corpora from about 50 languages, extracted from
documentations of small and often endangered languages.”
But for this project, the original corpus creators are typi-
cally involved in the creation of an extra layer of annota-
tion. It thus seems fair to say that the existing language
archives are currently not available for inspection to re-
searchers outside of the core community of language doc-
umenters. Compare this with research on the Switch-
Board corpus (Godfrey and Holliman, 1993) or the Penn
TreeBank (Marcus et al., 1999), where a lively community
has grown around the initial resources and where most re-
searchers are not in direct contact with the initial creators.
Looking at possible reasons as to why the uptake of this
vast resource of endangered language material is slow, we
can come up with an unsurprising set of issues: findability,
accessibility, interoperability, and reusability. For a given
research question, researchers often need a resource which
is a) in a particular format (text, audio, video) b) in a particu-
lar language (family) covering c) particular content and
is d) accessible. The OLAC\(^7\) (Simons and Bird, 2003) ser-
vice provides querying capabilities for language and media
type, but OLAC cannot guarantee that the resources it lists
are indeed available. Since OLAC does not host the files,
querying for content strings is not possible either.

A clear desideratum would be the possibility to query lan-
guage resources based on metadata (region, language for-
mat, genre, as currently already possible via OLAC), but
also on content. Content includes grammatical categories
(give me all files with antipassive in them) but also se-
matic categories (give me all texts relating to agriculture).
This paper will discuss a prototype which allows for such
queries. OLAC is already part of the Linked Open Data
Cloud (Chiarcos et al., 2012). The task is now to comple-
ment the metadata available from OLAC with information
about grammatical categories and lexical and topical in-
formation which can be extracted from the transcriptions
found in the archives. In order to do that, the relevant files
have to be retrieved from the archives. An understanding
of the structure of these archives is a prerequisite for that.

4. Structure of endangered language
archives: PARADISEC

Endangered language archives share very similar under-
lying structures. An archive consists of several collections.
Each collection is about one project, most often covering
one particular language, but occasionally, more than one
language can be part of a documentation project. A col-
lection in turn consists of session bundles, which contain a
coherent set of files (audio, video, transcription, photos).
Files found in a session typically share the same time, lo-
cation and participants. There can be multiple files of the
same type, e.g. very long sessions might have several au-
dio files, with associated transcriptions. The levels of col-
collection, bundle, and file may or may not have their dedi-
cated landing pages, where metadata is displayed. Meta-
data relevant for a given text is thus often distributed
across the various levels. The separation between collec-
tions and bundles is not always very clear-cut and is some-
times only available via implicit file naming conventions.
The content typically offered consists of audio files, video
files, and transcription files. Less common file types in-
clude photographs, pdfs, FLEX\(^2\) Toolbox\(^3\) praat\(^4\) and MS
Office files. There are typically several levels of access con-
tral, which we can enumerate from 1-4:

1. freely available
2. registration and acceptance of terms and conditions
   required
3. available upon request from depositor
4. unavailable (privacy or other legal issues) (Figure 1.

Figure 1: Access levels at PARADISEC.

Turning to findability and reusability, the following pic-
ture emerges: The querying possibilities for selected meta-
data are good. PARADISEC for instance offers nice faceting for country, language, and depositor (Figure 2).
Other archives are similar. However, there are no ways
to search for a particular language other than scrolling,
and the value of metadata fields such as “depositor” or
“source university” is not obvious. Other potentially rel-
vant fields are absent from the querying interface, such as
“access level” or “media type”. I have not been able to
formulate a query for “give me a collection which has at
least one ELAN file and to which I have access”. The only
way to perform this query is to visit each and every col-
collection, see whether there are ELAN files and try to download
them.

Most archives provide an OAI-PMH\(^5\) interface or have
done so in the past. This allows for a uniform query via OLAC\(^6\).
Interestingly, while a query via media type is not possible on the PARADISEC site itself, it is possible on
OLAC. The query https://bit.ly/39HueQE returns all sound
files for the Namakura language which are available on-
line. Unfortunately, the first bundle listed (Two Namakura
stories) does indeed contain sound files, but they are not
accessible.

Access to linguistic data is a sensitive topic. Next to the
domains of privacy and copyright, there are also issues pertaining to language ownership and colonialism, which

\(^7\)The MultiCAST project (https://multicast.aspra.
uni-bamberg.de) is similar in setup to DoReCo.
\(^2\)http://search.language-archives.org
\(^3\)http://software.sil.org/toolbox
\(^4\)http://software.sil.org/fieldworks
\(^5\)http://search.language-archives.org/index.html
\(^6\)https://software.sil.org/toolbox
\(^7\)http://www.openarchives.org/pmh
\(^8\)http://www.language-archives.org/archives
\(^9\)http://search.language-archives.org/index.html
made available together with this paper, but access terms require each researcher collect the data individually from the archives (See §4).

6. Description of the resources

In the context of this project, data satisfying the following criteria were considered:

1. The data must be programmatically accessible via command line tools. Many files in the archives are available “upon request”, which means that a formal email has been written to the depositor. This setup does not scale and cannot be handled with the resources currently available. Authentication can be accomplished via the command line so that resources on the “registered user” level could be included.

2. The data must be interoperable. For all practical purposes, this means that data has to be in ELAN format\(^\text{13}\) Other file types are found in the archives, but they are either not suitable for data extraction (pdf), or their numbers are too low to justify the time to write an import script.

Current technology does not allow us to search directly in audio (e.g. by humming a melody), let alone in video. This means that querying audio or video boils down to querying transcriptions. The ELAN format is again very suitable, as the text content contained in ELAN is time-linked to multimedia files.

Of the 12 existing DELAMAN archives, 5 were chosen, as they show a variety of setups while at the same time providing a large enough sample of ELAN files to allow for an evaluation of the generic structure of the scripts developed. Table 6 gives a breakdown of the files which could be retrieved from the archives. ELAN as a file format links audio and video files to transcriptions. Transcription is organised in so-called tiers. Tiers are of a certain type (“translation”, “gloss”, “POS”, etc.) and are hierarchically organised. The hierarchical relation between tiers is typically one of 1) time subdivision (a text is split into time-aligned sentences); 2) symbolic subdivision (a sentence is split into n words, but the words are not time-aligned themselves); and 3) association (a gloss is associated to a word). ELAN can accommodate multiple speakers. These then typically all have their own set of tiers. von Prince and Nordhoff (2020) contain more information about the ELAN file format as used in endangered language projects. Figure 3 shows the XML representation of an ELAN file. The tier with the TIER_ID “ref@dam” is of the type “ref” and establishes time subdivisions. The tier with the TIER_ID “ut@DAM” references “ref@dam” and is of type “ut” (like ‘utterance’). Annotations in tiers of the type “ut” are symbolically associated to the annotations in the parent tier. The tiers of type “ut” have further child tiers, which contain tokenized words (“tx”), morpheme segmentations (“mb”) and glosses (“ge”). The tier “ref” contains a free translation for each utterance.

Unfortunately for our purposes, the tier types and tier hierarchies are not defined in a specified standard, but are de-
Table 1: The accessible holdings of the five DELAMAN archives surveyed.

| Archival Code | Total Files | File Size | Total Transcriptions | Total Transcription Time | Total Translations | Total Translation Time | Total Words |
|---------------|-------------|-----------|----------------------|--------------------------|-------------------|------------------------|-------------|
| AILLA         | 2867        | 801M      | 2402                 | 1054:59:29               | 1120              | 14:28                  | 1120059    |
| ANLA          | 196        | 14M       | 48                   | 12:49:40                 | 6906              | 45                     | 6463        |
| ELAR          | 12955       | 3.1G      | 7189                 | 1470:28:23               | 1074             | 153                    | 298457     |
| PARADISEC     | 888         | 167M      | 706                  | 132:56:03                | 9462             | 153                    | 15335      |
| TLA           | 3473        | 1002M     | 1062                 | 217:20:54                | 155476           | 1497                   | 72014      |

Figure 3: The XML structure of ELAN files with tiers referencing each other. Orange lines show references to timeslots, the green line shows the reference to a parent tier, purple shows reference to tier type definitions.

fined on a per-file basis at the very bottom of the XML-file. While ELAN makes sure that annotations are syntactically interoperable, semantic interoperability is not enforced by ELAN. The tier type containing the translation could be called any of “Translation”, “English”, “ft” (for free translation), “translation (eng.)” etc. The same goes for transcriptions and glosses. I have compiled a set of all names for tier types (several hundred) and have sorted them into the categories of translation, transcription, gloss, and unknown. This gives some hints about the content in a given tier, but this is not sufficient. The types as indications have to be complemented by information from the tier hierarchy. The tier hierarchies used in ELAN files are also very heterogeneous. Some files have 3 tiers, some have 4, some have more than 20, and the parent-child relations can be of time subdivision, symbolic subdivision or association. We can establish a fingerprint of the hierarchy via a graph representing the parent-child relations with labelled edges. Table 2 gives an overview of the different configurations found. Among 7189 ELAN files with transcriptions in ELAR, we find no less than 1564 different ELAR tier hierarchies. Note that these hierarchies are agnostic of the names given to the tier types; if we included the names, the number would be much higher still.

Finally, some additional tests can be used to ascertain the status of a tier. A tier with English translation should pass
Table 2: Number of different tier hierarchies per archive and the distribution of 7,189 files from ELAR on 1,564 hierarchies.

| Archive | Rank |
|---------|------|
| AILLA   | 171  |
| ANLA    | 21   |
| ELAR    | 1,564|
| PARADISEC | 162 |
| TLA     | 537  |

7. Analysis of the resources

Up to now, this article has described the structure of the archives, the structure of ELAN files and the strategies for identifying, retrieving and analyzing ELAN files. In the remainder, I will show some small analyses which can be performed via the uniform access. The analyses presented here have as their main goal the proof-of-concept of a programmatic and uniform access to a large number of ELAN files from diverse locations. They are very simple (even simplistic) on purpose, as the goal here is not to further our understanding of linguistics, but to further our understanding of research infrastructure.

7.1. Proof-of-concept: accessing the transcription tier

As a proof of concept, I have computed the most frequent graphemes found in each archive. The plot of the findings is given in Figure 4. The total number of graphemes is 46.5 million. We find, unsurprisingly, that <a> is the most frequent grapheme, and <n> is the most frequent nasal. The order of <e> and <i>, however, is different between archives, suggesting that the languages contained in the respective archives use different orthographies. This is particularly obvious for ANLA, which includes <1> in the top list.

7.2. Proof-of-concept: accessing the gloss tier

Within the gloss tiers, a total number of 3,274,394 morphemes could be retrieved. Figure 3 gives a breakdown of the most frequent grammatical glosses, while Figure 6 gives a breakdown of the most frequent lexical glosses. ANLA is excluded from both statistics because the amount of gloss material was not sufficient.

Some interesting observations can be made about the most frequent categories here: the number categories singular (sg) and plural (pl) are the most frequent grammatical glosses in ELAR, PARADISEC and TLA. This is not the case for AILLA, where apparently different conventions hold, and p is presumably used for plural instead. This highlights the need for a shared vocabulary, e.g. the Leipzig Glossing
conventions, the languages observed, or the types of text collected, but it is an interesting observation warranting further inspection.

Another obvious use of these resources would be the extraction of word-gloss-pairs for dictionary bootstrapping, which would be a particular type of text-mining. Table 3 gives words which have been glossed as ‘sun’ and ‘moon’ in languages of the corpus, respectively. These translation data can further be included in a bridge towards Lemon. The full interlinear representation of texts will also be made available in LIGT in due course. Data refinements can be achieved with the pyigt library.

7.3. Proof-of-concept: accessing the translation tier

The proof-of-concept for the extraction of the translations from an ELAN tier involves Named Entity recognition via the NERD/GROBID online service. Table 3 gives a breakdown of the entities retrieved. Tables 4 and 5 show the most frequent entities retrieved and the entities retrieved exactly 20 times. Taking a look at the concepts retrieved, we find a strong focus on agriculture, and on the Svan people from Georgia. The latter is a clear indication that the corpus is skewed and that there is an exceedingly large amount of well-transcribed files from a documentation project in the Caucasus, from where entities could easily be retrieved. But while this shows that one cannot simply run a quantitative analysis on the archives and be done, it also shows that the very high quality of the Caucasian data make the data much more findable and interoperable, giving them automatically a greater weight in scientific knowledge production. The “Caucasus bias” is obvious from the data, but at the same time, the “agriculture bias” is also something to take into account. Apparently, documentation projects more often focus on rural communities and crops/livestock than on urban settings and technology for instance. This must be borne in mind when drawing conclusions from the files stored in endangered language archives.

NERD/GROBID returns a Wikidata-ID (Vrandečić and List and Sims, 2019) which allows to include the endangered language data in the wider Linked Open Data Cloud. This can be leveraged for semantic queries of the sort “give me all texts with a passive in them which deal with crops”.

For this query, we do not have to query for “maize”, “rice”, “wheat”, “millet”, etc. since Wikidata stores the information about the plants as a tag in the entities retrieved. Taking a look at the concepts retrieved, we find a strong focus on agriculture, and on the Svan people from Georgia. The latter is a clear indication that the corpus is skewed and that there is an exceedingly large amount of well-transcribed files from a documentation project in the Caucasus, from where entities could easily be retrieved. But while this shows that one cannot simply run a quantitative analysis on the archives and be done, it also shows that the very high quality of the Caucasian data make the data much more findable and interoperable, giving them automatically a greater weight in scientific knowledge production. The “Caucasus bias” is obvious from the data, but at the same time, the “agriculture bias” is also something to take into account. Apparently, documentation projects more often focus on rural communities and crops/livestock than on urban settings and technology for instance. This must be borne in mind when drawing conclusions from the files stored in endangered language archives.

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Table 5: Most frequent retrieved entities across all archives.

| #  | Wikidata-ID | meaning                |
|----|-------------|------------------------|
| 537| Q830        | cattle                 |
| 281| Q144        | dog                    |
| 271| Q11575      | maize                  |
| 270| Q5090       | domestic sheep         |
| 239| Q383126     | chronic condition      |
| 230| Q34067      | Svan                   |
| 212| Q5113       | bird                   |
| 209| Q2934       | goat                   |
| 204| Q19044      | Svaneti                |
| 204| Q1364       | fruit                  |
| 187| Q626136     | Arapaho people         |
| 184| Q8495       | milk                   |
| 184| Q532        | village                |
| 177| Q190        | God                    |
| 166| Q7802       | bread                  |
| 163| Q13187      | Cocos nucifera (coconut)|
| 159| Q43238      | Poaceae (grass)        |
| 158| Q503        | banana                 |
| 154| Q10798      | pig                    |
| 146| Q670887     | Bambusoideae (bamboos) |
| 145| Q11254      | table salt             |
| 144| Q10998      | potato                 |
| 131| Q127980     | fat                    |
| 129| Q35808      | firewood               |
| 120| Q846578     | Svan people            |
| 117| Q1029907    | stomach                |
| 115| Q10943      | cheese                 |
| 113| Q780        | chicken                |
| 113| Q35409      | family                 |
| 101| Q41415      | soup                   |

formation all of these concepts are subclasses of https://www.wikidata.org/wiki/Q12117 “cereal”, which in turn is subclass of https://www.wikidata.org/wiki/Q235352 “crop”. Wikidata can furthermore be utilized for localization of queries: The data available about the concept https://www.wikidata.org/wiki/Q5090 “rice” contain translations into 171 languages, among which we find the translation into Swahili, wali. A constantly resurfacing requirement for archive mobilization is the accessibility to the speaker communities themselves. Being able to accept queries in a local language of wider communication, such as Swahili, is a crucial step for making the data about an ethnic group also being usable by that ethnic group.

8. Discussion

I have surveyed the existing language archives, and I have shown how a large corpus of ELAN files can be retrieved from these archives. These ELAN files are amenable to programmatic access, allowing to aggregate transcriptions, translations, and glosses, which can then be further analyzed with regard to graphemes, grammatical categories or semantic fields. Two strands of research can be distinguished here. The first one is linguistics proper (“Which categories are used?”). The other one is closer to the sociology of science (“Which categories are used in which archives, and why? Which archives have more transcriptions, which ones have more translations, and why?”). Linguistics is often seen as a science bridging the gap between the natural sciences and the humanities. The first strand mentioned above is closer to the empirical approach, while the second strand is more a question typically asked within the humanities. The language resource assembled here can be used for both.

For purely quantitative research, the resource is obviously not suitable in its current state, as the “Caucasian bias” discussed in §7.3 shows. But a parametrization taking into account collections, languages, or even language families via genealogical data available from Glottolog is reasonably trivial.

But what can we do with the data? As mentioned above in §4, the ELAN files themselves cannot be shared due to the terms of access. In a linked data context (Chiarcos et al., 2012), however, this is not necessary. Once we have proper URIs which resolve to a given resource, we can use these as variables in our predicates. We can say that https://catalog.paradisec.org.au/collections/DLGP1/items/053 is a session which is about glottolog:nama1268, the URI for Namakura on Glottolog. We can say that a given session includes a file, which includes a tier, which includes a gloss which is the same as one of the Leipzig Glossing Rules glosses. The structures of the archives with collections, bundles, and files were discussed in §4. In a linked data context, each collection, bundle, and file should have a different URI, but not all archives provide landing pages for all of those (Simons and Bird, 2020). Things get more difficult when using tiers or their parts (annotations) in Linked Data predicates, as the tiers and annotation will have to get URIs as well. A good solution for a resolver service will have to be developed, which will allow the use of these elements in assertions without requiring read or write access to the archives where the primary resources are hosted. This resolver will also help make the data findable by being citable, with exact location of the element in question in archive, collection,
file, and tier. Using such a resolver service will also allow the incorporation of sensitive data into the Linguistic Linked Open Data Cloud. We can say that the session with a given URI contains information about human sexual activity (https://www.wikidata.org/wiki/Q608), but we do not have to provide the session itself. This has obvious use cases in linguistics, but also in related fields of the humanities, such as anthropology or musicology. In the field of material culture, for instance, anthropologists look at items and appliances produced and used by given groups. Depending on the nature of the research question, broader or narrower concepts will be appropriate. In the domain of boat building, some researcher might be interested in all seafaring vessels, while for another one, only boats, only canoes, or only dugouts are relevant. A well-defined and ontologically grounded vocabulary for material culture can help the formulation of sensitive queries then (see e.g. eHRAF). What we can share, however, are download scripts for harvesting the archives. These scripts can be run by third party researchers and will provide the same files we have on our computers, but the third party researchers themselves have to agree to the terms and conditions before the download.

Interested researchers can request access from the relevant archive. Using Wikidata as a “semantic broker” also helps discoverability via the different language labels provided for the concepts, as described in §7.2.

9. Outlook

Nordhoff et al. (2014) describe the Alaskan Athabascan Grammar Database (AAGD), which is also concerned with the findability of resources for endangered languages. For that project, texts from a number of native Alaskan languages were collected and made retrievable via a SOLR store. This SOLR store allowed faceted searches for metadata, but also for content categories such as semantic concepts and grammatical categories contained. While background and technology used are different, the requirements for the AAGD and this project are very similar. At the time of writing, the main focus is still the data model and the backend, but the repurposing of some of the frontend materials from the AAGD project should not be too difficult. The next step ahead will be the adaptation of the AAGD frontend to the QUEST datamodel. This adaptation will also allow for an easy integration of a “recommendation system”. Such as system can use the texts a researcher has stated their interest in and propose new transcribed texts based on similarity in grammatical or semantic categories contained.

The main challenge ahead is the minting of URLs which adequately identify collections, sessions, files and tiers. This must be complemented by a useful ontology. Dublin Core isPartOf is used as an umbrella term for the time being, but more explicit relations would be useful.

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For instance in the context of CLARIN Federated Content Search architecture.
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