The Tupinambá: An Exercise in Societal Modeling

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Abstract. *The modeling exercise presented in this paper is a companion to the short papers presented at EMAS 2022 and WESAAC 2022. It illustrates the* societal approach *to multiagent systems by formally modeling some of the main components of the* Tupinambá *society, a tribal society that lived in the territory of Brazil at the time of the first attempts of its occupation and colonization, in beginning the 16th century, by the Portuguese and other Europeans.*
Keywords: *Agent societies. Societal architectures. Society modeling languages.*

Resumo. *O estudo de caso apresentado neste artigo é um complemento dos artigos curtos apresentados no EMAS 2022 e WESAAC 2022. Ele ilustra a* abordagem societal *a sistemas multiagentes através da modelagem formal de alguns dos principais componentes da sociedade dos* Tupinambá*, uma sociedade tribal que vivia no território do Brasil na época das primeiras tentativas de sua ocupação e colonização, no início do século XVI, pelos Portuguêses e outros Europeus.*
Palavras-chave: *Sociedades de agentes. Arquiteturas societais. Linguagens de modelagem de sociedades.*

1. Introduction

This paper presents a modeling exercise illustrating the idea that *agent societies* (i.e., multiagent systems structured in terms of *societal* architectures, not just *organizational* architectures [Costa 2022a, Costa 2022b]) are the appropriate architectural forms for supporting the conception, design, and implementation of *full-fledged multiagent systems*, that is, MAS that are able to computationally model all the essential characteristics of *general* societal systems.

The paper is structured as follows.

Section 2 exposes, in general terms, the features that should be taken as central to any *societal architectural model* for MAS.

Section 3 gives the essential details of the *agent society modeling languages* used in this work, namely: TinySML, for modeling the structural and operational features of the society, and TinyIML, for modeling its ideological features[1].

Section 4 presents the particular modeling exercise which is the subject of the paper: the sketching of a *formal societal model* of the main components of the *Tupinambá*, a tribal society that lived in the territory of Brazil previously to the first attempts of its occupation and colonization, in beginning the 16th century, by the Portuguese and other Europeans.

Section 5 is the Conclusion.

[1]See [Costa 2022c] for some more details on those modeling languages.

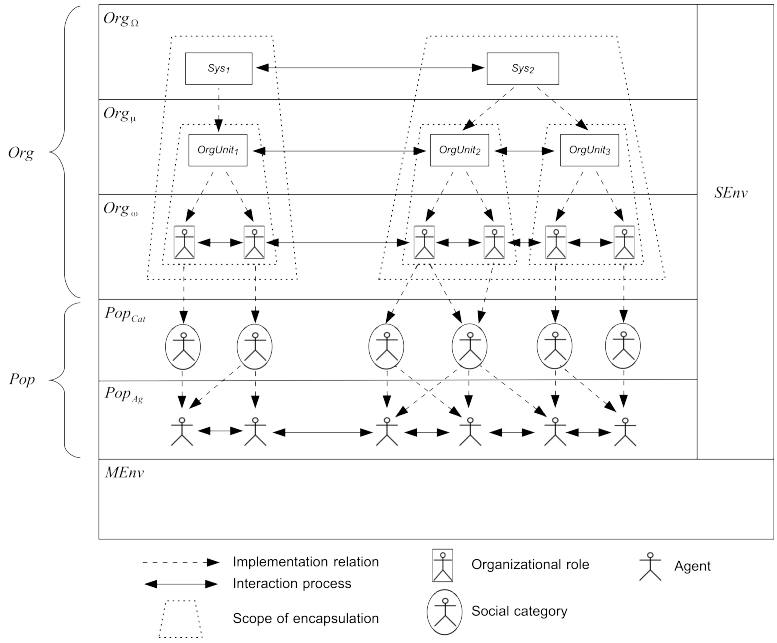

Figure 1. Basic components of an agent society.

2. The Organizational and Societal Approaches to Agent Societies

2.1. The Organizational Approach to Agent Societies

We say that a MAS has an *organizational architecture* whenever it is structured in terms of two core components, Pop and Org, cast as *architectural levels* (see Fig. 1):

- Pop, the *Populational Level*, composed of two sub-levels:
  - Pop_{Ag}, the sub-level of the *Populational Agents*: the very set of *agents*;
  - Pop_{Cat}, the sub-level of the *Populational Categories*: the set of *social categories* (or *strata*) of agents, such as: economic statuses, educational levels, professional experiences, ethnic groups, religious affiliations, gender identities etc.;
- Org, the *Organizational Level*, composed of two sub-levels:
  - Org_{ω}, the *Micro-organizational level*: the network of the *organizational roles* that the agents may perform;[2]
  - Org_{μ}, the *Meso-organizational level*: the network of the (possibly, hierarchically recursive) *organization units* (groups, organizations, institutions etc.), each implemented by a subset of *organizational roles*.

2.2. The Societal Approach to Agent Societies

2.2.1. Structural Features

The concept of *societal architecture* extends the *organizational architecture* with one organizational sub-level, placed above the two previous ones (see Fig. 1):

[2]Notice that *organizational roles* are not *immediately* allowed to be implemented by *agents*, as is often the case in the *organizational approach*, where agents are usually specifically designed to meet the requirements of the organizational roles they will implement. In the *societal approach*, organizational roles are allowed to be implemented by agents only on the condition of the latter's belonging to particular *social categories*. In other words, in the *societal approach* one or more *social categories* are taken to operate as *requirements* that agents have to meet in order to be allowed to perform a given social role.

- Org_{Ω}, the *Macro-organizational level*: the network of the (possibly, hierachically recursive) *societal systems*, each implemented by a (possibly, hierachically recursive) network of *organizational units*.

2.2.2. Functional Features

The following are examples of *societal functions* that *societal systems* may perform in agent societies[3].

• **Ideological System** We call *ideological system* the societal system that comprises *all the cultural elements* present in the society, impacting the behaviors and interactions of the social actors: morality, law, customs, traditional conceptions etc., which are assumed to be symbolically represented in the *Symbolic Environment* (see Fig. 1), as explained in, e.g., [Costa 2015, Costa 2016, Costa 2020, Costa 2021]).

• **Legal System** The *legal system* of an agent society comprises two main sub-systems (the *legislative* and the *judiciary*), responsible for managing the set of *positive norms* (the *legal order*) that *regulates* the social processes of the society.

• **Political System** The *political system* of an agent society can be characterized, in its minimal functionality, in the way proposed in [Easton 1965], namely, as the societal system responsible for the *authoritative allocation of resources* among social actors.

• **Economic System** The *economic system* comprises two main subsystems, the *production* and the *distribution* subsystems. The *production subsystem* can be characterized as the societal system that regiments a set of social actors (the *producers*) in order to continuously generate new objects in the society's *material* and *symbolic* environments, possibly consuming for that purpose some of the objects available, at each time, in those environments. The *distribution subsystem* can be characterized as the societal system that regiments a set of social actors (the *distributors*) in order to continuously distribute, for consumption, among the set of all society's social actors, the objects produced by the production system.

• **Educational System** The *educational system* is the societal system that regiments a set of social actors (the *educators*) in order to capacitate some agents to participate in some of the society's *societal systems* (including the educational system itself).

2.3. Inter-Societal Systems

In the same way that *organization units* are constituted by *networks of organizational roles*, articulated by interation processess, and that *societal systems* are essentially constituted by *networks of organization units*, also articulated by interaction processes, *agent societies* may give rise to *networks* articulated by *societal interaction processes*, thus constituting *inter-societal systems* (see [Costa 2017]).

[3]Notice that we use the concept of *social actor* as a general concept for any of the architectural components of the societal architecture (agents, social roles, organization units, societal system), including the entire *agent society* itself.

Inter-societal systems should be conceived analogously to the way agent societies are conceived, that is, on the basis of a *core structure* given by a *populational component* and an *organizational component*, the latter composed, in an apropriate corresponding way, of three levels: the micro, meso, and macro *inter-societal levels*.

3. The Core Concetps of the Modeling Languages

3.1. The Core Concetps of TinySML

The core concepts of TinySML duplicate formally the *sets of components* that constitute the *societal architecture* of any agent society $AgSoc$ or inter-societal system $InterSoc$, namely:

- $\mathbf{Agents}$, the set of *agents*;
- $\mathbf{SocRole}$, the set of *social roles*:
- $\mathbf{OrgUnit}$, the set of *organization units*;
- $\mathbf{SocSys}$, the set of *social systems*;
- $\mathbf{AgSoc}$, the set of *agent societies*.

Besides, *exchange processes* and other *relations* between those architectural components also belong to this set of core concepts.

3.2. The Core Concepts of TinyIML

The two *basic universes* on which the *ideological system* of an agent society $AgSoc$ operates are: $\mathbf{SocAct}$, the universe of the *social actors* of the society, and $\mathbf{TypeCond}$, the universe of *types of conducts* that those social actors may perform in the society.

The universe of social actors $\mathbf{SocAct}$ is the same universe of social actors of the TinySML language, given by:

$$\mathbf{SocAct} = \mathbf{Ag} \cup \mathbf{OrgRole} \cup \mathbf{OrgUn} \cup \mathbf{SocSys} \cup \mathbf{AgSoc}$$

The universe of *segments* of social actors is given by[4]:

$$\mathbf{Segm} = \wp(\mathbf{SocAct})$$

The universe of *ideological envisagements* is given by

$$\mathbf{IdeoEnvis} = \mathbf{SegmEnvis} \cup \mathbf{NormEnvis} \cup \mathbf{ValuatEnvis} \cup \mathbf{QualifEnvis}$$

where:

- $\mathbf{SegmEnvis}$ is the universe of *segmenting envisagements*;
- $\mathbf{NormEnvis}$ is the universe of *normative envisagements*;
- $\mathbf{ValuatEnvis}$ is the universe of *valuating envisagements*;
- $\mathbf{QualifEnvis}$ is the universe of *qualifying envisagements*.

The formal structures of the various envisagements are given in [Costa 2015], but they are exemplified, intuitively, in the modeling experiment below.

The universe of ideological frameworks is given by:

$$\mathbf{IdeoFrmwrk} \subseteq \mathbf{SegmEnvis} \times \mathbf{NormEnvis} \times \mathbf{ValuatEnvis} \times \mathbf{QualifEnvis}$$

so that for any particular ideological framework:

[4] $\wp(X)$ denotes the powerset of the set X.

$$ideoFrmwrk = (segmEnvis, normEnvis, valuatEnvis, qualifEnvis) \in \mathbf{IdeoFrmwrk}$$

the segmenting envisagement $segmEnvis$ is said to be the *reference segment* of $ideoFrmwrk$, that is, the particular segmenting envisagement which is refered to by each of the other envisagements ($normEnvis$, $valuatEnvis$, and $qualifEnvis$) of $ideoFrmwrk$.

Given any social actor $sa \in \mathbf{SocAct}$ of an agent society, the *ideology* that sa adopts, at any time t, is given by the *set of ideological frameworks* it is adopting at that time, denoted by $Ideo^t_{sa}$.

For any set of social actors $SocAct \in \wp(\mathbf{SocAct})$, the *ideology* of $SocAct$, at the time t, is given by $Ideo^t_{SocAct} = \sqcap\{Ideo^t_{sa} \mid sa \in SocAct\}$.[5]

4. The Tupinambá: A Society of Tribal Groups of Pre-Colonial Brazil

4.1. The Tupinambá Society

The *Tupinambá* was an indigenous tribe, of the linguistic group *Tupi*, that lived near the Brazilian Atlantic shore, between the present states of Rio de Janeiro and Bahia, before the beginning of the Portuguese occupation and colonization of the country, in the 16th century.[6]

The account of the *Tupinambá* society taken here as a reference is that in *The Social Organization of the Tupinambá* [Fernandes 1945], the classical study by the doyen of Brazilian sociology, Florestan Fernandes.

Of that detailed study, plenty of qualitative and quantitive information about the *Tupinambá* society, we use here a meager amount of information, which can only give a rough picture of the complexity of the organization of that society, but which seems to be enough to allow for the illustration of the modeling possibilities of the *societal approach*.

Fernandes' account of the organization of the *Tupinambá* society is divided into five main chapters:

1. The geographical distribution of the *Tupinambá*
2. The organization of the local groups (including their economic system and system of social relations)
3. The kinship system
4. The age categories
5. The council of chiefs

We will make use of the parts dealing with the *local groups* and the *council of chiefs*. After a brief summary of Fernandes' account of the main features of those two parts, we give the TinySML and TinyIML representation of those features. We use *concrete syntaxes* for those languages, for which we give no formal definition here, since they seem well intutive to read.

Some fragments of the societial model of the *Tupinambá* society that can be built on the basis of the information given below are presented in Figs. 2 and 3.

[5]The intersection operator ($\sqcap$) is taken to operate in a component-wise way on the ideological envisagements of the various ideological frameworks of the individual ideologies $Ideo^t_{sa}$, on the basis of the given reference segment.

[6]The occupation and subsequent colonization proceeded essentially through a civil and military war against those tribal groups, which led, by the middle of the 17th century, to the virtual extinction of their organized society, and either the dispersion the defeated Tupinambá groups in the hinterland or their placement as peripheral populations around the villages being founded by the Portuguese settlers.

As will appear, the most general modeling statement about the *Tupinambá* society is that it constitutes an *Inter-Societal System*.

4.2. The Local Groups

4.2.1. Organization

The *Tupinambá* tribe was constituted by a large number of *Local groups*, which were the fundamental integrative elements of the tribe.

Local groups were groups of *families* that lived in local arrangements of collective houses (*Malocas*), each inhabited by several families. *Families* were polygamous, formed by a man and several women.

The *Malocas* were very large constructions, made of palms and straw, inhabited by a considerable number of families[7].

The space within the *Malocas* was parceled among the married men, each men having a separate space for each of his wifes. But there were no walls marking those spaces, so that a *Maloca* was a wide, open collective space, fully visibly accessible to all of its inhabitants.

The *Malocas* of a *Local Group* were placed side by side, next to each other, around a large *Central Square*.

4.2.2. Economic System

The *Local Groups* were self-suficient economic units within their particular territories, with no relevant economic exchanges among them. That is, economic activities (gathering, hunting, cultivation) concerned just the immediate needs of each *Local Group*'s population. Craftmanshipt, specially woodcraft and ceramic, were of practical importance, regarding the manufacturation of tools. The *Local Groups* were located preferably in areas that could guarantee access to: water to drink, wood for making fire, fertile land for crops, rivers plenty of fishes.

The populations of the *Malocas* had practical limits in their number, given the size of the houses. Thus, the growth of the population of a *Maloca* naturally lead to its split into two or more new *Malocas*.

The division of labor in the *Local Groups* was done bascially between men and women: women were responsible mainly for housekeeping and the production of potery and other means for that activity, for cultivating and harvesting crops, and for collecting fruits and roots; men, mainly for preparing the land for cultivation, for hunting, fishing, and warfare, and for the production of tools for those activities. Women were also responsible for the transportation of all kind of objects, inside and outside the *Local Group*, in peacetime and in wartime.

In general, families were free to collect, fish, and hunt, in any area of the territory of the *Local Group*. Only the cultivation of land was submitted to regulation, assinging a particular cultivation terrain to each family.

[7]Fernandes mentions that the *Malocas* had sizes usually around 8-10 meters by 80-100 meters and 4-6 meters high, each inhabited by a usual number of 500-600 people, belonging to around 50-70 families [Fernandes 1945, p.68-69].

4.2.3. Social Relation System

Four levels of *social relations* characterized the social life of the Tupinambá: relations among members of a *Maloca*, relations internal to the *Local Groups*, relations among *Local Groups* (i.e., relations internal to the *Tribe*), and relations among the *Tupinambá* and other tribes.[8]

Kinship relations were the main relations among the inhabitants of a *Maloca*, making it the basis of the social life of the *Local Group*.

Solidarity among the members of a *Maloca* costumarily extended to the members of the *Local Group* and to the members of other *Local Groups*, constituting a strong moral bond among the whole *Tupinambá* tribe, regarding both peace and war issues. Adornments made of bird plumes, were of importance in this connection, both as symbols of status for those that happen to own them, and as symbolic values in the exchanges the *Local Groups* performed to maintain social solidarity both internally, among the members of the group, and externally, with other *Local Groups*.

When a *Maloca* was to be splitted, the man who succeeded in gathering a minimum number of people for the new *Maloca* becomes its *Chief*.

In time of war, local groups that were neighbor to each other formed alliances to face enemies coming from distant places, or to attack them. A system of messengers, running among the *Local Groups*, guaranteed the prompt realization of that alliance.

Winner groups gathered in feasts with anthropophagic rituals, where some of the defeated enemies were eaten by all members of the groups[9]. Often, some other members of the defeated groups were hold captive, to serve as slaves, before being sacrified.

War was, in fact, the main reason for the contact between neighbor local groups which, otherwise, remained quite isolated from each other. Blood revenge, culminating in the ritual anthropophagism of the defeated contender - reassuring the unity and self-steem of the victorious *Local Group* - was the usual war goal, much more frequent than plundering or expansion of territories.

The main collective activities of the group (feasts, ritual sacrifices, meetings of the council of chiefs etc.) occurred in the central square formed by the circle of Malocas.

4.3. The Council of Chiefs

The *Council of Chiefs*, each particular chief from a particular *Maloca*, was the core of the *political system* of a *Local Group*. It was responsible for the authoritative regulation of the interaction between the people of different *Malocas* of the *Local Group* and for decisions about problems that affected the *Local Group* as a whole, including its relationships with other *Local Groups*. The meetings of the council were open to all members of the *Local Group*.

In particular, the *Council of the Chiefs* was responsible for establishing and regulating: the war initiatives; the punishment of offenses between individuals, and between groups of individuals; and the domination of the elders over the youngsters.

[8]Notice the while the *Economic System* was a societal system of the *Local Group*, the *Social Relation System* is a societal system of the whole *Tupinambá* tribe.

[9]The classical reports of those cannibal rituals, which caused great impact in Europe when published in 1557, are those by Hans Staden [Staden 1557].

Additional problems dealt with were: issues arosen in the daily interaction between the members, reports from visiting members of other *Local Groups*, the change of the geographical location of the *Local Group*, articulation of war actions, of attack or defense, with allied *Local Groups* etc.

An important particular chief was the *Pajé*, the religious chief of the tribe. He circulated among the various *Local Groups*, visiting all the *Malocas* in each one, bringing them religious songs. Also, the *Pajé* usually had some type of imunity, that allowed him to also visit *Local Groups* of other tribes, besides the *Tupinambá*, including traditional enemy tribes.

As mentioned above, Figs. 2 and 3 show some fragments of a *societal model* of the *Tupinambá* society that can be built with the information given in the present section.

5. Final Remarks

It should be clear that there is an important drawback to the *societal approach* to MAS, which is of a pragmatical kind: the work has to be based on *general sociological theories*, which are more *complex*, less *complete*, less *consistent*, and more prone to *ideological disputes* than the usual *organizational theories*.

However, it seems that societal approaches that are general enough, such as that presented in, e.g., Jonathan Turner's *Theoretical Principles of Sociology* [Turner 2010], may satisfy the requirement of conceptual transparence and deducibility required from any approach to systems that, like MAS, should in principle be formally specifiable.[10]

Also, the concept of *agent society* is an effective conceptual solution to the problem of the link between the *micro* and the *macro* levels of (full-fledged) MAS, under the proviso, however, that the technical terms *micro* and *macro* refer only to architectural sub-levels of the *organizational structure* of the agent societies. That is, that the term *micro* does not refer to the *agents* of the *populational structure*, as it happens in the usual way of using the expression *micro-macro link*, but to the *organizational roles* performed by those agents.[11]

[10] In particular, its three volumes (1: *Macrodynamics*, 2: *Microdynamics*, and 3: *Mesodynamics*) seem to meet well the basic structure of the *societal architecture* adopted in the present paper.

[11] But, notice that the *implementation relation* between *agents* and *organizational roles* links the organizational roles with the agents, thus indirectly introducing the agents into the micro-level of the architecture.

```
InterSocSys Tupinambá:
    AgSocs = Set(LocalGroup) ∪ Set(LocGrpOtherTribes)
    IdeoFrmwrks = {IntraLocGrpRels, InterLocGrpRels, InterTribesRels}
---
AgSoc LocalGroup:
    Pop ⊆ Tupi
    SocCats = {Man, Woman, Adult, Child}
    SocSys = {HousingSys, EconSys, CouncChiefs}
---
SocSys HousingSys:
    OrgUnits = Set(Maloca)

SocSys EconSys:
    OrgUnits = Set(Family)

SocSys CouncChiefs:
    OrgUnits = {Council}
---
OrgUnit Maloca:
    OrgUnits = Set(Family)
    OrgRoles = {MalocaChief}

OrgUnit Family:
    OrgRoles = {Father, Mother, Son, Daughter}
    OrgRoleRelations = {maybe(Man and Adult, MalocaChief)}

OrgUnit Council:
    OrgRoles = {Member, Pajé, Spectator}
    OrgRoleRelations = {Member isa MalocaChief,
                        Pajé isa Member,
                        ¬(Spectator isa Member)}
---
MatEnv HousingSys:
    Objects = Set(MalocaHouse) ∪ {Square}
    ObjRelations = encircled(Square, Set(MalocaHouse))

MatEnv EconSys:
    Objects = {CultivationArea, FishingArea, HuntingArea,
               GatheringArea, WaterSources, CeramicObjs, WoodcraftObjs}

MatEnv Maloca:
    Objects = {MalocaBuilding} ∪ Set(FamilyHomeSpace) ∪ {FamilyCultivationArea}
    ObjRelations = {Set(FamilyHomeSpace) isa partition(MalocaBuilding)}
---
IdeoFrmwrk LocalGroup:
    SegmEnvisagement:
        Man, Woman, Adult, Child ⊆ Pop
            Man ∩ Woman = ∅
            Adult ∩ Child = ∅
    NormEnvisagement:
        OrgRoleConducts = {becomechief, marry}
            permitted(becomechief, Adult and Man)
            prohibited(becomechief, Woman or Child)
            permitted(marry, Man and Set(Woman))
            prohibited(marry, Woman and Set(Man))
    QualifEnvisagement:
        Woman ≤{landprep,hunting,fishing,toolsprod,warfare} Man
        Man ≤{housekeeping,cultivation,gathering,craftsmanship,transportation} Woman

IdeoFrmwrk Maloca:
    SegmEnvisagement:
        Resident, Family ⊆ Pop
            Family ⊆ Set(Resident)
    NormEnvisagement:
        OrgRoleConducts = {cultivate(FamilyCultivationArea), split(Maloca)}
            if ¬belongs(FamilyCultivationArea, Family):
                prohibited(Family, cultivate(FamilyCultivationArea))
            if size(Maloca) > limit:
                obligated(Residents, split(Maloca))
```

Figure 2. Fragments of a description of the Tupinambá tribe (Part 1).

```
IdeoFrmwrk CouncChiefs:
    SegmEnvisagement:
        Resident, Spectator, Member ⊆ Pop
        Spectator, Member ⊆ Resident
        Spectator ∩ Member = ∅
        Chief, Pajé ∈ Member
    NormEnvisagement:
        OrgRoleConducts = {regulate, conflict, changelocaction, waraction}
            if conflict among Set(Resident))):
                permitted(Council, regulate(conflict))
            if conflict with other(LocalGroup):
                permitted(Council, regulate(conflict))
            if changelocation neededby LocalGroup:
                permitted(Council, regulate(changelocation))
            if waraction neededby LocalGroup:
                permitted(Council, regulate(waraction))
        OrgRoleConducts = {visit(LocalGroup)}
            if visit(LocalGroup) requestedby Pajé of otherLocalGroup:
                obligated(Council, allow(visit))
        OrgRoleConducts = {watch(assembled(Council)}
            permitted(Member, watch(assembled(Council))
---
IdeoFrmwrk IntraLocGrpRels:
    SegmEnvisagement:
        pop(LocGrp) ⊆ Pop
            sameLocGrp(x,y,LocGrp) ⇔ x ∈ pop(LocGrp) and y ∈ pop(LocGrp)
    ValEnvisagement:
        OrgRoleConducts = {besolidarywith}
            if sameLocGrp(x,y,LocGrp):
                ¬besolidarywith(x,y) < besolidarywith(x,y)

IdeoFrmwrk InterLocGrpRels:
    SegmEnvisagement:
        Messenger, OtherPeople, pop(LocGrp) ⊆ Pop
            Messenger ∩ OtherPeople = ∅
            differentLocGrp(x,y) ⇔
                    x ∈ pop(LocGrp1) and y ∈ pop(LocGrp2) and LocGrp1 ≠ LocGrp2
    ValEnvisagement:
        OrgRoleConducts = {besolidarywith}
            if differentLocGrp(x,y):
                ¬besolidarywith(x,y) < besolidarywith(x,y)
    QualEnvisagement:
        OrgRoleConducts = {carrymessage}
            OtherPeople ≤carrymessage Messenger
    NormEnvisagement:
        OrgRoleConducts =
                {carrymessage, bloodoffend, carrywaragainst, defeat, sacrifice}
            if LocGrp1 ≠ LocGrp2 and x ∈ pop(LocGrp1) and
                    y ∈ pop(LocGrp2) and bloodoffend(x, y):
                obligated(LocGrp2, carrywaragainst(LocGrp1))
            if wartime and necessary(carrymessage(msg)):
                obligated(Messenger, carrymessage(msg))
            if wartime and LocGrp1 ≠ LocGrp2 and defeat(LocGrp1, LocGrp2) and
                    x ∈ pop(LocGrp2):
                            permitted(LocGrp1, sacrifice(x))

IdeoFrmwrk InterTribeRels:
    SegmEnvisagement:
        pop(Tribe) ⊆ HumanRace
            memberDifferentTribe(x,y) ⇔
                    x ∈ pop(Tribe1) and y ∈ pop(Tribe2) and Tribe1 ≠ Tribe2
    ValEnvisagement:
        OrgRoleConducts = {solidarywith}
            if memberDifferentTribe(x,y):
                ¬solidarywith(x,y) < solidarywith(x,y)
```

Figure 3. Fragments of a description of the Tupinambá tribe (Part 2).

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