Course Syllabus Template

Course Code / Course Name	**DT 212 Techno Economics of Networks**		
Course Instructor Name(s)	**V Sridhar**		
Credits (L:T:P) **(Lecture : Tutorial : Practical)**	**Hours**		**Component**
	45		Lecture (1hr = 1 credit)
	15		Tutorial (1hr = 1 credit)
			Practical (2hrs = 1 credit)
	L:T:P = 3:1:0		**Total Credits = 4**
Grading Scheme *(Choose by placing X against appropriate box)*	**X**	4-point scale (A,A-,B+,B,B-,C+,C,D,F)	
		Satisfactory/Unsatisfactory (S / X)	

Area of Specialization (if applicable)
(Choose by placing X in box against not more than two areas from the list)

	Theory and Systems for Computing and Data		Networking and Communication
	Artificial Intelligence and Machine Learning	**X**	Digital Society
	VLSI Systems		Cyber Security
X	General Elective		

Programme / Branch

Course is restricted to the following programmes / branch(es):
(*Place X appropriately. More than one is okay)*

Programme:		*Branch:*	
X	iMTech	**X**	CSE
X	M.Tech	**X**	ECE
X	M.Sc.	**X**	Digital Society

Course Category

Select **one** from the following:
(Place X appropriately)

	Basic Sciences
	CSE Core
	ECE Core
	CSE Branch Elective
	ECE Branch Elective
	Engineering Science and Skills
X	HSS/M
	General

Course Pre-Requisites

(Where applicable, state exact course code/name)

None

Template Version	1.1
Template Date	April 4, 2021

Additional Focus Areas

Select zero or more from the following and write one sentence explaining the how the focus areas covered as part of the course.[NAAC criteria 1.1.3, 1.3.2].

Focus Area	Yes / No	Details
Direct focus on employability	Yes	Provides students an in-depth understanding of the business models of telecommunication and Internet firms
Focus on skill development		
Focus on entrepreneurship	Yes	Provide an understanding of creating digital start-ups through projects and theories
Provides value added / life skills (language, writing, communication, etc.)	Yes	Provides students with overall understanding of the business models and prepare them to work in the IVCT industry

Course Context and Overview

Information networks of today encompass a wide variety including the traditional telecommunication networks which enable voice and data communication; peer-to-peer social networks that enable messaging and media transfers; content networks that enable linking of web pages and media; and machine-to-machine networks that transfer information across devices.

This course introduces the **technology, business, and economic** aspects of the above networks, reinforced with theories of **network economics, information theory, game theory, auction theory, and theory of contagion**. The course address about **20 practical questions** and provide **stylistic models to analyze the same.**

Course Outcomes and Competencies

[*Course Outcomes are to be stated using appropriate terminology and taxonomy as required by NAAC and/or NBA. For every course credit, about 2-3 outcomes are recommended.*]

Id	Course Outcome	PO/ PSO	CL	KC	Class (Hrs)	Tut (Hrs)
CO1	Understand the dynamics of the network industry, properties of diverse types of networks, and socio economics of networks.	PO3, PO4	U, Ap, An	F, C, P	6	2
CO2	Understand the technology architecture and business models of traditional telecom networks, Internet, social and content networks, OTT services, broadcast networks; adoption in networks; diffusion in networks; critical mass formation in networks through game theory	PO3, PO4	U, Ap, An	F, C, P	9	3
CO3	Understand different types of radio spectrum auction methodologies and their applications in practices in telecom, and search engines using game theoretical models	PO3, PO4	U, Ap, An	F, C, P	6	2

CO4	Analyze the economics of digital platforms, direct, indirect and cross-side network effects and pricing models of information services and network services platforms through theories of diffusion	PO3, PO4	U, Ap, An	F, C, P	6	2
CO5	Understand diffusion of information and influence in Human Networks and Social media networks	PO3, PO4	U, Ap, An	F,C,P	3	1
CO6	Analyze trade-offs in privacy of individuals and associated economics including price conditioning, price discrimination	PO3, PO4	U, Ap, An	F, C, P	3	1
CO7	Analyze the techno economics of data protection including data localization	PO3, PO4	U, Ap, An	F, C, P	3	1
CO8	Analyze the techno-economics of Intellectual Property such as patents, trademarks, copyright, and domain names through economic theories	PO3, PO4	U, Ap, An	F, C, P	3	1
CO9	Understand the techno-economics of digital finance including digital currencies	PO3, PO4	U, Ap, An	F, C, P	3	1
CO10	Understand the economics of automation powered by Artificial Intelligence and Machine Learning and their impact on labour markets	PO3, PO4	U, Ap, An	F, C, P	3	1
	Total				**45**	**15**

Legend: *PO/PSO: Programme Outcomes / Programme Specific Outcomes; CL: Cognitive Level (from Revised Bloom's Taxonomy); KC: Knowledge Category (from Revised Bloom's Taxonomy); Class (Hrs): Number of hours of instruction; Tut (Hrs): Number of hours of tutorial session (where applicable)*

Concept Map of the Course (Optional)

COURSE CONTENTS

1. Information Networks Industry and Market Structure
2. Diffusion and virality in Networks
3. Small world networks; social media networks; network distances
4. Demand for network services and associated pricing models
5. Game theoretic modeling of network strategies: Nash equilibrium, different auction methods, sequential games
6. Methods of assigning radio spectrum to Telcos and associated pricing models
7. Properties of characteristics of digital goods and services
8. Economics of networked industry
9. Platform economics and the start-up industry
10. Two-Sided Markets and associated pricing models
11. Techno-economics of Intellectual Property and standards
12. Economics of Privacy
13. Economics of digital finance and crypto currencies
14. Economics of automation and artificial intelligence

Instruction Schedule

COURSE CALENDAR

Week	Topics
1	**Information Networks Industry and Market Structure:** **Q1) Is the landline dead? What is the economics of VoIP?** **Q2) Why is it economically difficult to provide rural area broadband connectivity?** Basic Economics: Monopoly and Oligopoly markets, price setting equilibrium in competitive and monopoly markets, natural monopoly, Properties and characteristics of Telecommunication Networks: Basic Fixed Line, Cellular Mobile, landline innovations: Digital Subscriber Loop
2-3	**Network Effects and Valuation of Networks:** **Q3) Why are Facebook /Whatsapp/ Hike valued so high?** Network effects: direct and indirect; same side and cross side network effects; Sarnoff, Metcalf and Reed's law of diffusion in networks; Bass model of diffusion – intrinsic and imitation effects, S-shape curves, diffusion of telecom services, adopter distribution **Demand for Networked Products and Services:** **Q4) How does Apple manage to continuously increase the price of iPhones over the years?** Demand pricing of networked products and services, network effect and price effect, inverse demand curve, discrete and continuous cases of demand analysis, pricing of telecom services, individual utility maximization versus social welfare maximization, effects of monoply and new entrants **Discussion Paper:** **[1] Shalf, J. (2020). The future of computing beyond Moore's Law. Philosophical Transactions of the Royal Society A, 378(2166), 20190061.**

4-5	**Game and auction theories** **Q5) How is Game Theory used in solving near-far problem in CDMA networks?** Fundamentals of game theory, Prisoner's dilemma problem, Best Response and Nash Equilibrium, near-far problem in CDMA networks; internalizing noise in CDMA networks for optimal behaviour **Q6) How does Google make money through Advertisements?** Auctions as games, types of auctions, imperfect information and winner's curse, metrics for measuring success of auctions, single product and multi product auctions, sealed bid versus open auctions, Second Price Auction, VCG auction, simultaneous auctions, packaged auction Application of GSP in Google Advertisement auction **Readings:** Games in Normal Form. In Brown, K-L., and Shoham, Y. Essentials of Game Theory: A Concise, Multidisciplinary Introduction. Morgan & Claypoool Publishers. **What makes CDMA work on my Smartphone.** In *Networked Life: 20 Questions and Answers*. **How does Google sell its ad spaces?** In *Networked Life: 20 Questions and Answers*. **Discussion Papers:**

6-7	**Spectrum for Mobile Services:** **Q7) What are the mechanisms used for auctioning radio spectrum for commercial mobile services? How to measure success of auctions?** Technical and economic characteristics of spectrum, history of spectrum auction in India, spectrum allocation: auction, fixed fee, subscriber linked criterion, spectrum management, spectrum charges, productive and allocative efficiency, spectrum liberalization Mobile industry structure, competition levels, spectrum assignment for each operator, licensing arrangements, spectrum and license fees, forthcoming spectrum auction and its implications, trading, sharing and leasing of spectrum Simultaneous Multiple Round Ascending Auction (SMRA) as practiced in India; rules and guidelines; experience from 2012-2016, packaged auction Shared spectrum access, spectrum sharing and leasing Incentive auction mechanisms: US 700 MHz broadcast spectrum auction. **Readings:** ***Hyper competition and excessive spectrum fragmentation***. Chapter 10 from: Prasad, R., & Sridhar, V. (2013). **Dynamics of Spectrum Management: Technology, Economics and Case of India.** **Discussion Papers:** **[2] Nekipelov, D., & Wang, T. (2017). Inference and auction design in online advertising. Communications of the ACM, 60(7), 70-79.** **[3] FCC's spectrum auction: Can the systen be Gamed. Wharton Knowledge Session**
8	**Extensive Form Games and Applications in Telecom:** **Q8) How is the interconnection charges negotiated between telecom operators?** Nash Equilibrium in extensive form games, sub game perfect equilibrium, backward induction methods Pure strategy Extensive Form Games, Conversion to Normal Form Games, Backward induction principles, Nash Equilibrium in Extensive form games, Applications in Telecom: Interconnect Pricing, International settlement rates, 2-stage game application, termination charge and access network pricing **Readings** **Shy, Oz. (2011). Chapter on Telecommunications. The economics of networked industries. Cambridge University Press**

9-10	**Two-Sided and multi-sided markets** **Q3) Why should Amazon and Flipkart give so much discounts?** Characteristics of two-sided markets, analysis of direct and indirect network externalities, cross side network effects, examples from platforms, mobile value added service, pricing asymmetry in two sided markets, price elasticity of demand, pricing in Two-Sided Markets – subsidy and money sides of platforms, surge pricing and its effects, single homing vs. multi homing, water bed effects **Readings:** ***Network Economics*.** Chapter 1 **in** Sridhar, V. (2012). ***Telecom Revolution in India: Technology, Regulation and Policy*.** New Delhi, India: Oxford University Press **[3] Cusumano, M. (2018). The sharing economy meets reality. *Communications of the ACM*, 61(1), p: 26-28.**
	Mid Term Exam
11	**Smart and Dynamic Data Pricing** **Q8) Is it optimal for mobile operators to charge 4 p / 10 Kbytes or Rs. 149/- unlimited voice calling and data usage of 1.5 GB/day for 28 days?** pricing of voice servces vs. data services, flat rate and usage based pricing, personalized data pricing, Time dependent pricing, models for shifting demand: rewards and capacity cost based pricing schemes, effects on Net Neutrality **Readings:** **Why do AT&T and Verizon Wireless charge me $10 a GB?** In *Networked Life: 20 Questions and Answers*. **How can I pay less for each GB of data?** In *Networked Life: 20 Questions and Answers*. **Discussion Papers:** **[7] Sen, S., Joe-Wang, C., Ha, S., and Chiang, M. (2015). Smart Data Pricing: Using Economics to Manage Network Congestion. Communications of the ACM, 58(12), 86-93.**

12	**Wisdom of the crowd: E-Commerce Ratings, Virality on the Internet, Influence Functions** **Q10) How do Amazon and Flipkart provide ratings?** **Q11) How to viralize your Youtube video?** Information cascade, Bayesian analysis, private and public information, viralization and influencing in social networks, the Tipping phenomenon, critical mass, power of crowds, Emperor's New Cloth phenomenon, Small World Networks Rating methods in E-Commerce sites, products review and ratings, ranking influence, average vs. Bayesian rating **Readings:** **How can I trust an average rating in Amazon?** In *Networked Life: 20 Questions and Answers*. **How do I viralize a YouTube video and tip a Groupon deal?** In *Networked Life: 20 Questions and Answers*.
13-14	**Privacy Economics and Economics of Information Security** **Q16) What is privacy economics? What is the trade-off between privacy and personalized services? Why do security breaches occur all the time?** Economics of privacy: Instant gratification, bounded rationality, hyper discounting Market for Lemons of information security products; personalization and price discrimination, temporal price discriminations, purchase history and cookie policies – models and analysis Price conditioning analysis using Game theory, Game theoretic analysis of privacy policies – why do data fiduciaries deviate **Readings:** **[8] Allman, E. (2003). The Economics of Spam: Who pays in the spam game?. Queue, 1(9), 80-80.**
15	**Game theory applications in Broadcasting:** **Q15) Why do all prime shows are broadcast at the same time? How does a landing page in TV affect programme rating?** Overview of the broadcasting sector, scheduling in prime time slots, game theory formulation with 2 and 3 stations and corresponding Nash equilibrium, social welfare equilibrium, one way viewing problem, game theory in program type competition, price based competition, bundling of TV channels, pure and mixed bundling strategies and corresponding equilibria **Shy, Oz. (2011). Chapter on Broadcasting. The economics of networked industries. Cambridge University Press**

15	**Human Networks** **Q12) How does information flow through human networks connected by social media? What is the average network distance in social networks? How does communicable diseases such as COVID-19 propagate through human networks? How to lessen and mitigate reproduction numbers in such networks?** Network of individuals and how it shapes power and influence in social networks; degree centrality and eigen vector centrality; application of influencers in micro finance; small world networks; 6-steps to reach any one; comparison of small world in social networks; contagion and diffusion of infectious diseases; reproduction numbers of contagious diseases such as small pox, SARS and Covid-19; externalities of vaccination and lock-down in containment of diffusion; homophily in networks; Schelling's theorems; effect of homophily in segregation of networks; unemployment, inequality as a result of segregation; examples from urbanization; globalization and its effects on removing homophily. **Readings** **Jackson, Mathew. (2019). The Human Network** **Discussion Papers:** **[9] Kleinberg, J. M. (2000). Navigation in a small world. Nature, 406(6798), 845-845.**
16	**Techno-economics of Intellectual Property** **Q13) What is the economics of Intellectual Property Rights? Why is there dispute and litigation on patents? Should firms invest in IPR?** Economics of Intellectual property such as patents, copyrights, trademarks, trade secrets and domain names. Standard Essential Patents and FRAND conditions **Economics of Technology Upgrades and Standardization** **Q14) When should I upgrade my mobile phone? Should I wait or buy now?** Game theory application in adoption of technology advancements, momentum and inertia of technologies Technology standardization and cross border effects
16	**Economics of Digital Finance** **Q 17) What is impact of digital finance on cash economy? What is the economics of crypto currencies?** Function and Characteristics of Money, Taxonomy of Digital Finance, Cryptocurrencies, Bitcoin economics **[10] Dhar, V., & Stein, R. M. (2017). FinTech platforms and strategy. Communications of the ACM, 60(10), 32-35.**

17	**Economics of AI** **Q18) What is the economics of AI? What is the impact of autonomous systems on labour markets and wages?** Impact of AI on labour supply & demand, wages, and skilling; AI Marketplace as a multi-sided market
18	**End Term Examination**

Learning Resources

[Mention text books, reference books and other learning resources required as part of the course]

Reference Books

1. **Chiang, M. (2012).** ***Networked Life: 20 Questions and Answers*****. Cambridge University Press. (an** abridged version will be made available as pdf file. Two copies of the book will be kept in reserve in the Library)
2. Shapiro, C., and Varian, H. (1999). Information Rules. Harvard Business School Press.
3. Prasad, R., and Sridhar, V. (2014). The Dynamics of Spectrum Management: Legacy, Technology, and Economics. Oxford University Press, ISBN-13: 978-0-19-809978-9; ISBN-10: 0-19-809978-9.
4. Jackson, M.O. (2010). Social and Economic Networks. Princeton University Press.
5. Oz Shy, "The Economics of Network Industries", Cambridge University Press, 2001.
6. Wilensky, U., & Rand, W. (2015). An introduction to agent-based modeling: modeling natural, social, and engineered complex systems with NetLogo. Mit Press.
7. Hamill, L., & Gilbert, G. N. (2016). Agent-based modelling in economics. Chichester: Wiley.

Assessment Plan

[List grade distribution in terms of % across multiple assessment types (assignments, quizzes, mid-term, end-term, project, etc.)]

Discussion Papers

To help anchor the concepts more firmly, student groups will be assigned papers of contemporary issue. Groups will present a critical review of the issues discussed in the paper.

Spectrum Auction

There will be a spectrum auction game in which groups will take on the role of telcos, strategize and bid for spectrum auctioned by the government.

Group Project

Each group will create a techno-business model of a start-up in the area of Information and Communication Technologies. The students will create a schema of technical architecture, business model, financing plan and provide operational strategies of the start-up building up on the theories discussed in the course.

If for some reason, any of the evaluation components could not be conducted, the instructor has the rights to re-allocate marks and the same will be communicated to the students well in advance.

Component	Marks
Class attendance x < 75% -> 0; may not be allowed to take the end term exam; 75%≤x<80% -> 1; 80%≤x<85% -> 2; 85%≤x<90% -> 3; 90%≤x<95% -> 4; x ≥ 95% -> 5	5%
Discussion Paper Presentation	10%
Quizzes & Assignments	20%
Spectrum auction game	10%
Mid Term Exam	20%
End Term Exam	20%
Group Project: First Stage: 5% Final demonstration: 10%	15%
Total	**100%**

Assignments / Projects

[List exact number of assignments or projects included (provide generic description)]

S. No.	Focus of Assignment / Project	CO Mapping
1	Discussion Papers presented by groups of students to help anchor the concepts more firmly, student groups will be assigned papers of business models and applications of concepts in the areas of Game theory, diffusion theory, network effects	PO3, PO5
2	Student projects on developing a techno-business model of a digital start-up	PO3, PO5
3	Students participate in a live auction of radio spectrum for mobile services using an auction platform with assigned roles as respective telecom firms.	PO5

Evaluation Procedures

Provide details of how evaluations will be done, how students can look at the evaluations. Generic evaluation procedures included below. Add additional evaluation procedures / criteria as needed

The course uses one or more of the following evaluation procedures as part of the course:

1. Automatic evaluation of MCQ quizzes on Moodle or other online platforms
2. Manual evaluation of essay type / descriptive questions

Students will be provided opportunity to view the evaluations done where possible either in person or online

Late Assignment Submission Policy

State any penalty policy for late submission
Not Applicable

Make-up Exam/Submission Policy

State if any specific policy derived from institute policy is applicable. Otherwise leave it as given

One make-up quiz is given to accommodate anyone who missed one of the quizzes due to unavoidable circumstances. There are no make-ups for mid or end term exams.

Citation Policy for Papers (if applicable)

[If course includes reading papers and citing them as part of activities, state the citation policy. Mention "Not applicable" if section is not applicable to the course]

Not Appliable

Academic Dishonesty/Plagiarism

State if any specific policy derived from institute policy is applicable. Otherwise leave it as given

As per institute policy

Accommodation of Divyangs

[State any enabling mechanisms for accommodating learners with special needs]

As per institute policy